THE GEOCHEMISTRY AND EVOLUTION OF THE LIZARD COMPLEX, CORNWALL.

- BY -

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ABSTRACT

The Lizard Complex consists of a poorly exposed assemblage of serpentinites, gabbros, amphibolites, basic dykes, metasediments and gneisses. As an alternative approach to conventional mapping of the inland area, the geochemistry of the residual soils of the area are used to identify the underlying lithologies.

Using multi-element geochemical data obtained by X-ray fluorescence spectrometry, an identification scheme is established which allows the recognition of over a dozen mappable units with a high rate of success. This scheme evolved from a training set of samples collected during an orientation survey from areas of <u>undisputed</u> geology immediately adjacent to coastal exposure. At approximately 250 sites it has been possible to confirm the geological predictions directly against material obtained from the base of power auger holes.

A non-hierarchical K-means clustering technique is developed and used to recluster data from over 800 samples into gabbroic and ultrabasic groups. The results of this classification produced more sensitive discriminatory parameters which in turn are used on 1500+ samples collected during the project.

The soil identification procedure combines the use of a variety of numerical techniques and the algorithm designed to use them operates in a sequential manner. The most distinct units are identified at an early stage whilst those samples which are less distinct chemically take longer to isolate and

as a final stage of treatment are separated using a modified K-means technique.

This approach to mapping has allowed the recognition of units not found outcropping on coastal sections and for an improved geological map of the Lizard Complex to be drawn. In particular the Crousa gabbro is shown to be a smaller body than previously considered and to comprise several different bodies. As a result of this work the evolutionary history of the Complex is revised.

CHAPTER 1

INTRODUCTION

1.1 Aims of this research

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1.3.1 Univariate and multivariate statistics

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1.1 Aims of this research

The aim of this research was to attempt to provide an improved map of the geology of the Lizard Complex in southwest England. This was achieved by studying the geochemistry of the largely residual soils of the area which previous work (Smith and Leake, 1984) had suggested would reflect that of the underlying bedrock.

The need for an improved map of the Complex can be best justified by a brief description of some of the problems encountered by orthodox mapping techniques. The area consists of an assemblage of serpentinites, gabbro, amphibolites, basic dykes, metasediments and gneisses covering an area of some 100 square kilometres. Difficulties with cliff access and an almost total lack of exposure inland (Plate 1) has meant that nearly all of the previous work has been concentrated along only about half of the 43km of coastal exposure. It is largely due to these problems that there has been no major revision of the geological boundaries since work carried out by the British Geological Survey prior to 1912 (Flett and Hill, 1912; Flett, 1946). At this time the inland geological boundaries were largely based on float mapping. The presence of quartz-rich gravels of exotic origin clearly undermines the validity of much of this early work and in consequence at least some of the geological interpretation. The gravels reach a thickness of several metres over the topographically highest part of the Complex and boulders of gabbro (Plate 2), previously described and mapped as residual by Flett (op.cit),

Plate 1. Goonhilly Downs (Earth Satellite Station in the background). Typical topography over the ultrabasic interior of the Lizard Complex.

Plate 2. Numerous gabbro boulders overlying the Crousa gravels at the Three Brothers of Grugith (GR.762198).

are enclosed in and underlain by gravels.

Following work initiated by the BGS in the mid-late 1970's, which led to the discovery in inland drillholes of a previously unrecognised cumulate complex (Leake and Styles, 1984), it was decided to approach the problem of mapping the inland area using soil geochemistry. In order to achieve this a large training set of rock and soil samples was collected from areas of undisputed geology and analyzed for a wide range of major and trace elements. Based on this training set an identification scheme was constructed which allowed for the identification of the various lithological and exotic units. Once the identifying parameters were established the procedure was then applied to other soil samples collected from inland areas. In order to identify these units efficiently a number of statistical techniques were used. The selection of the technique would reflect the degree of difficulty in recognizing any particular unit. A major aim in constructing this algorithm was that it should be capable of identifying a large number of samples in an efficient manner; that it should be easily altered as and when the need arose; and that it should be sufficiently versatile to be easily used for other identificatory tasks.

Finally as a result of the large number of elemental determinations (>100,000) required by the project, it was necessary to build a sizeable library of computer programs and subroutines.

1.2 Lizard Peninsula

The Peninsula of which the Lizard Complex is a part forms the southernmost tip of the British Isles (Fig.1). It covers an area of some 140 km^2 to the south of a line between Looe Pool to the west and the Helford River to the east. The boundary of the Lizard Complex follows a sinuous course across the Peninsula between Polurrian Cove and Porthallow, to the south of the Meneage Crush Zone and the shales and grits of the Devonian Gramscatho Group.

The major physiographic feature of the area is the Pliocene (?) marine platform. This has an average height of 85 metres O.D. with very little ground below 60 metres O.D. even near to the cliffs. The highest points are in the central part of the district extending from Roskruge Beacon, near St.Keverne towards Dry Tree on Goonhilly Downs (115 and 113 metres O.D. respectively). While the land over the ultrabasic is very level (average 100 metres O.D.) and commonly windswept, small scale ridges and valleys have developed over the gneisses, schists and some of the gabbros.

The coasts on the western side of the Peninsula are in excess of 60 metres in height and sheer, whilst the eastern coast is generally more gentle with low cliffs and raised beaches preserved (eg. Lowland Point).

The drainage system of the area was described by Flett (1946) as being generally post-Pliocene with a few small streams occupying channels on the level surface of the platform. There is a marked tendency for valleys to follow

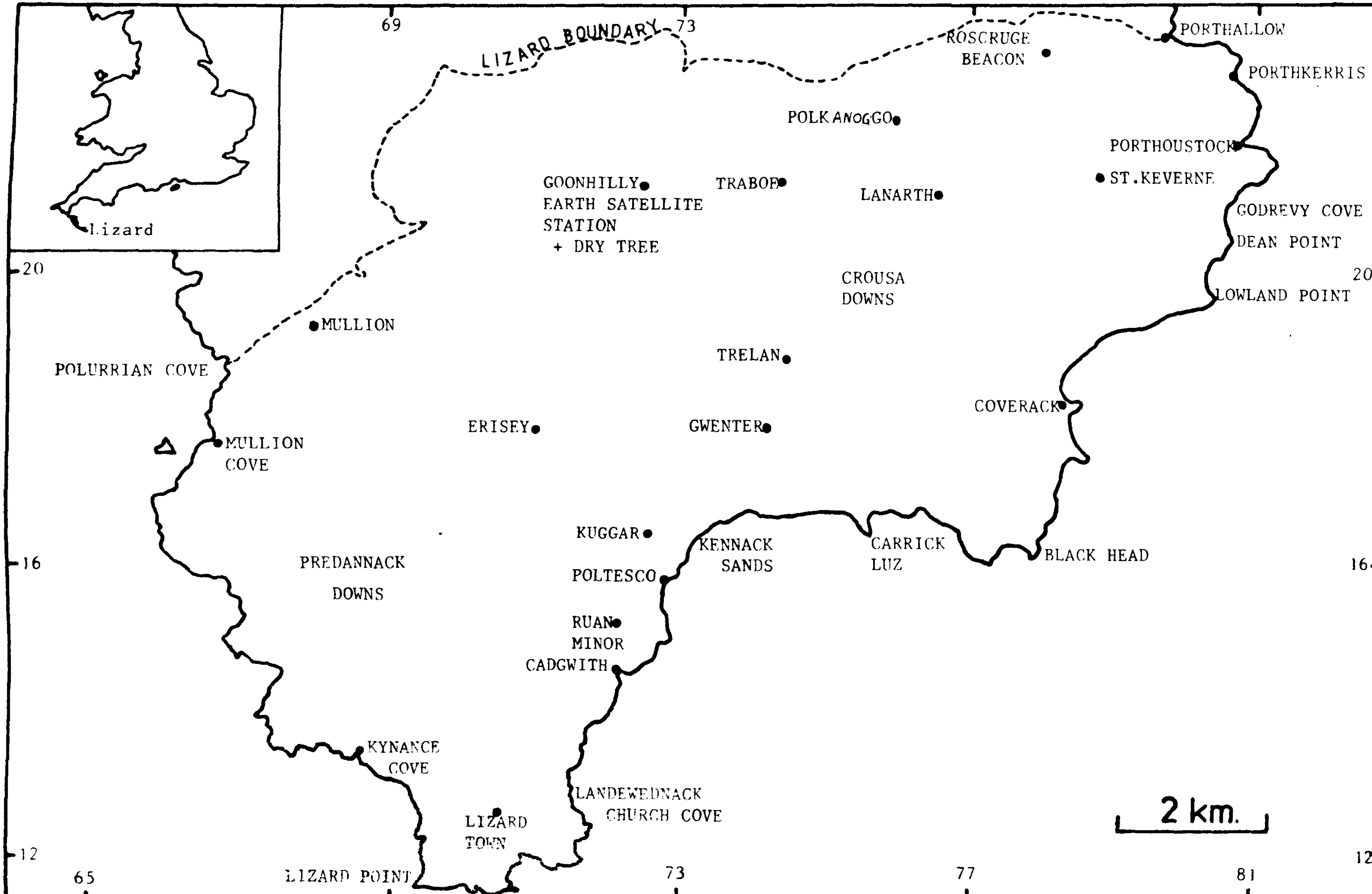


FIGURE 1. LIZARD PENINSULA.

natural lines of weakness such as geological contacts (eg. the streams at the Lizard, Mullion Cove and Gwenter) many of which may also be affected by faulting. Only near to the coast are there deeply incised streams in narrow valleys, the gneisses in particular are often the site of important valleys (eg. Kennack Sands, Cadgwith and Poltesco).

The Peninsula has a maritime climate with temperatures ranging from 6.3-15.7°C and an average rainfall of 886mm pA. This together, with the fact that frosts and snow are rare, provides a growing season that lasts nearly all the year. The area is regularly exposed to strong winds with an average of 42 days of gales pA.

The whole Peninsula is designated as an Area of Outstanding Natural Beauty and there are numerous stretches of National Trust land. There is a wide variety of archaeological sites in the area with tumuli and hut circles dating from middle to late Bronze Age, and cliff castles (eg. Carrick Luz) which are thought to date from the Iron Age. Several areas have been designated Sites of Special Scientific Interest because of the presence of rare plant species and communities that have developed in response to the wide variety of rocks and superficial deposits and to the climate.

The economy of the district is dominated by agriculture with tourism being important during the summer months. Dairying is the most important local activity particularly to the north over the schist and the gabbro. Sheep are becoming more important over the reclaimed heathlands in the central area. Horticulture is also practiced with early potatoes, spring cabbages, bulbs and cut flowers all taking advantage of the maritime climate. Fodder crops such as kale are of increasing importance.

There is some inshore fishing from the beaches on the eastern side of the Peninsula and small harbours at Coverack and Mullion. Quarrying has been an important industry with stone being taken from the schists and gabbro around Porthallow and Porthoustock and from the serpentinite on Goonhilly Downs. Dean Quarry is the only one still in operation in the area. On a smaller scale, small pits are dug in the serpentinite around Kynance by independent workers who cut and polish the stone for the tourist trade.

There are numerous small villages and hamlets scattered across the area; the largest being St.Keverne, Mullion and Lizard Town.

1.3 Statistics and computing

A number of statistical techniques have been used in this research (both univariate and multivariate), and numerous computer programs were developed to aid in the application of these techniques. The design philosophy of these programs is described and a brief description of the computer system used.

1.3.1 Univariate and multivariate statistics

Univariate statistical techniques are a necessary forerunner to the interpretation of any geochemical data, and are essential in attempting to understand the nature of individual variables prior to the evaluation of results gained from multivariate methods. They are generally simple procedures which are often under-utilized by many workers in the rush to use the more complex and powerful multivariate techniques. They include the common descriptive statistics, histograms and test statistics for hypothesis testing.

In contrast, multivariate methods may be used to study several variables simultaneously and allow for far greater evaluation of numerical data. As a group they are generally either complicated mathematical operations or very repetitive, or both. Some examples include multiple regression, cluster analysis, discriminant analysis, principal component analysis and factor analysis.

Any attempt at the interpretation of geochemical data should follow a specific sequence of events. The process should begin with the use of simple statistical techniques such as the calculation of univariate statistics, correlation coefficients, etc., and an examination of histograms and probability plots. By using these methods a feeling for the data may be developed. At this stage outlying or anomalous data may be recognized and removed, either for further investigation or because they may lead to a severe distortion of the results later in the interpretation. If further detail is required a variety of more complex techniques may be used to help with interpretation. The selection of these should depend on the needs of the investigation and on the user having a knowledge of the techniques selected (including the drawbacks and assumptions).

1.3.2 Computing

The need for a computer to manipulate data was a direct consequence of both the volume of data generated during the course of the project, and the decision to use a number of multivariate methods to aid in the interpretation of the data. All the computer programs and subroutines used were run on a DEC PDP 11/73 computer system in the Geology Department at Nottingham University, using an RSX 11M (Ver.4.2) operating system. The PW1400 X-Ray Fluorescence Spectrometer from which most of the analytical determinations were obtained is also connected to the 11/73. This meant that the data was already in machine-compatible form, and therefore there was no need to rekey in most of the data. (A serious source of error in building a database, Le Maitre, 1973).

In order to cope with the large number of elemental determinations a package of computer programs and subroutines was built. This package was comprised of a series of interactive compatible programs designed to assist in the handling, interpretation and presentation of geochemical data. All the programs and subroutines were written in Fortran IV and listings of those used in this work together with some descriptive detail may be found in Appendix A. The theoretical basis of the statistical techniques used in some of the programs are described in the relevant chapters (eg.

Multiple regression, Chapter 3.3; Identification algorithm, Chapter 5.4). Others are referred to periodically throughout the remainder of this work.

Many of the programs written have a variety of options which must be selected depending on the requirements of the user. These may include such things as the option to use a variety of alternative methods of analysis, whether any variables are to be removed from the calculation, or if the results are to be sent to screen or file.

Extensive use is made of subroutines as these prevent the need for repetitive writing. Many of these also have options which are selected in accordance with the requirements of the main program.

Full use is made of the storage capacity of the computer with data being held in a variety of forms. These include the use of one-dimensional arrays (with or without EQUIVALENCE statements), formatted and unformatted scratch files, and Direct Access files. This allows, where required, for a large number of samples to be manipulated (eg. the K-means clustering technique and the discriminant function referred to in Chapter 5 are both capable of handling upto 50 elements and a near infinite number of samples).

A major requirement of any software written to help interpret or handle data is that it should be <u>user-friendly</u>. To satisfy this criterion it should have the following features;

a) The program listings should be well documented to aid both other users and the original programmer should modifications be required at a later date.

b) The program should prompt the user for instructions and provide assistance if required.

c) There should be extensive checking carried out by the program. For example, if a file exists, if the filename is valid, if numerical data has a valid range, or if a valid program instruction has been given. If an incorrect response has been given the program should be relatively forgiving.

A feature of any such package is the requirement that raw data are held in standard format files. The structure of these was developed within the Geology Department and details are given in Appendix A. They are easily accessed both by both computer programs and by the user directly. The files relevant to this project were indexed so that specific data items can be rapidly located when required. A modified version of this may be found in Appendices D-G.

1.4 Format of the remainder of this thesis

The remainder of this work is organized in such a way that it follows the logical sequence that was taken in attempting to re-map and re-examine the geology of the Lizard Complex.

A thorough review of the previously recognized geology and the geological interpretation of the Complex is described in Chapter 2, together with a description of some of the mapping techniques previously used. Some of the alternative approaches to mapping which could be used to map or help interpret the geology of the poorly exposed inland area are then also introduced.

Chapter 3 describes in detail the various stages of sample collection (rocks, soils and rock fragments), their preparation and the analytical techniques used. Sampling and analytical errors are then studied.

As a necessary precursor to the mapping of the geology based on the residual soils, the nature and geochemistry of the soils of the area are described in Chapter 4. This section is sub-divided into three broad topics; the processes responsible for soil development with particular emphasis on the behaviour of the various elements analysed; the classification of soils and their distributions over the Lizard Complex; and a review of some of the results obtained during a power auger programme carried out by the British Geological Survey in the Trelan-Traboe area. The power auger programme allowed a test of the validity of the technique of using residual soils to identify the underlying lithologies.

Chapter 5 describes some of the pattern recognition techniques applied to the evaluation of the vast amount of data collected over the duration of this project. This includes full and detailed descriptions of the theory and the various algorithms used.

Having described the previously recognized geological and exotic units, the soils of the area and the statistical techniques used in the evaluation of the data, Chapter 6 describes the actual task of mapping based on soil geochemistry. It outlines the different stages and problems encountered in developing this novel method of mapping in the sequential manner in which the stages occurred.

Chapter 7 is very general in its nature and attempts a re-appraisal of the geological interpretation of the Complex in the light of the mapping based on soil geochemistry and other complimentary work carried out. Much of the discussion relates to the ophiolite and mantle diapir models which have been suggested by previous workers as responsible for the origin of the Complex. There is also significant discussion concerning the early Tertiary history of the area, in particular the influence of glaciation(s). This section also includes a description of mineralization discovered as a result of soil sampling in the area.

Chapter 8 concludes this work by providing a summary of the geological conclusions reached as a result of this work. It also summarizes the statistical techniques used and their potential use in the field of applied geochemistry and pattern recognition.

The various Appendices contain supplementary work including listings of the various computer programs and subroutines referred to in this work; machine details of the X-ray fluorescence spectrometer and electron microprobe; a simplified example of the workings of the K-means non-hierarchical clustering technique; and finally the various data collected during the course of this project.

CHAPTER 2

PREVIOUS GEOLOGICAL INTERPRETATION OF THE COMPLEX

2.1 Introduction

The Lizard Complex comprises a wide variety of igneous and metasedimentary rocks. Serpentinized peridotite is the dominant lithology, although it is very variable with a number of distinct types of peridotite recognized. In addition there are subequal amounts of gabbro and various hornblende schists, together with lesser amounts of metasediments (Old Lizard Head series and Treleague quartzite) and acid/basic gneisses (Kennack gneiss). Superficial deposits include Pliocene (?) gravels capping the topographically highest part of the Complex and a large number of loess sheets, particularly on Goonhilly Downs. Raised beaches of Pleistocene age are found on the more protected east coast together with head deposits.

The southern part of the peninsula is considered to be a marine-cut platform which developed in early Pliocene or Miocene times (Flett, 1946) when the district stood at or just above sea level. Since the last glacial period relatively few changes have taken place in the district. These are restricted to the accumulation of alluvium on valley floors and the deposition of wind-blown sands (eg. Kennack Towans).

It has been an area of great geological interest and controversy for the past 75 years with many different theories being suggested as to its origin. It is currently considered to be a part of a dismembered ophiolite sequence.

The Complex is bounded on its northern margin by a major southerly dipping thrust which runs between Polurrian Cove on the west coast and Porthallow on the east coast. To the north of this is a group of rocks which are considered to be a middle to late Devonian sedimentary melange of greywackes, quartzites, limestones and greenstones (Barnes, 1984). Debris in these sediments is not considered to have a Lizard source and is therefore probably not associated with the ophiolitic sequence (Barnes, op.cit).

The remainder of the southwest England peninsula is dominated by Devonian and Carboniferous argillic and arenaceous sediments which developed in predominantly deltaic or flysch environments. Some limestones are also developed in the clear shallow seas that existed between Plymouth and Torquay in middle and upper Devonian times. A number of granitic intrusions of Carboniferous age can be seen on the geological map shown in Figure 2. These are part of a single large granitic batholith which extends from the Isles of Scilly to Dartmoor. Some volcanic activity also occurred in middle Devonian and early Carboniferous times. This formed submarine lavas and tuffs which are known locally as greenstones. This term includes any basic igneous rock which has been slightly altered that may be found in southwest England. The Permian and Triassic were characterized by desert conditions with non-marine sandstones, mudstones, breccias and conglomerates forming. Further details as to the stratigraphic succession may be found in Reading (1973). The overall structure of the region was described by Sanderson and Dearman (1973).

With the exception of the rocks of the Lizard Complex,

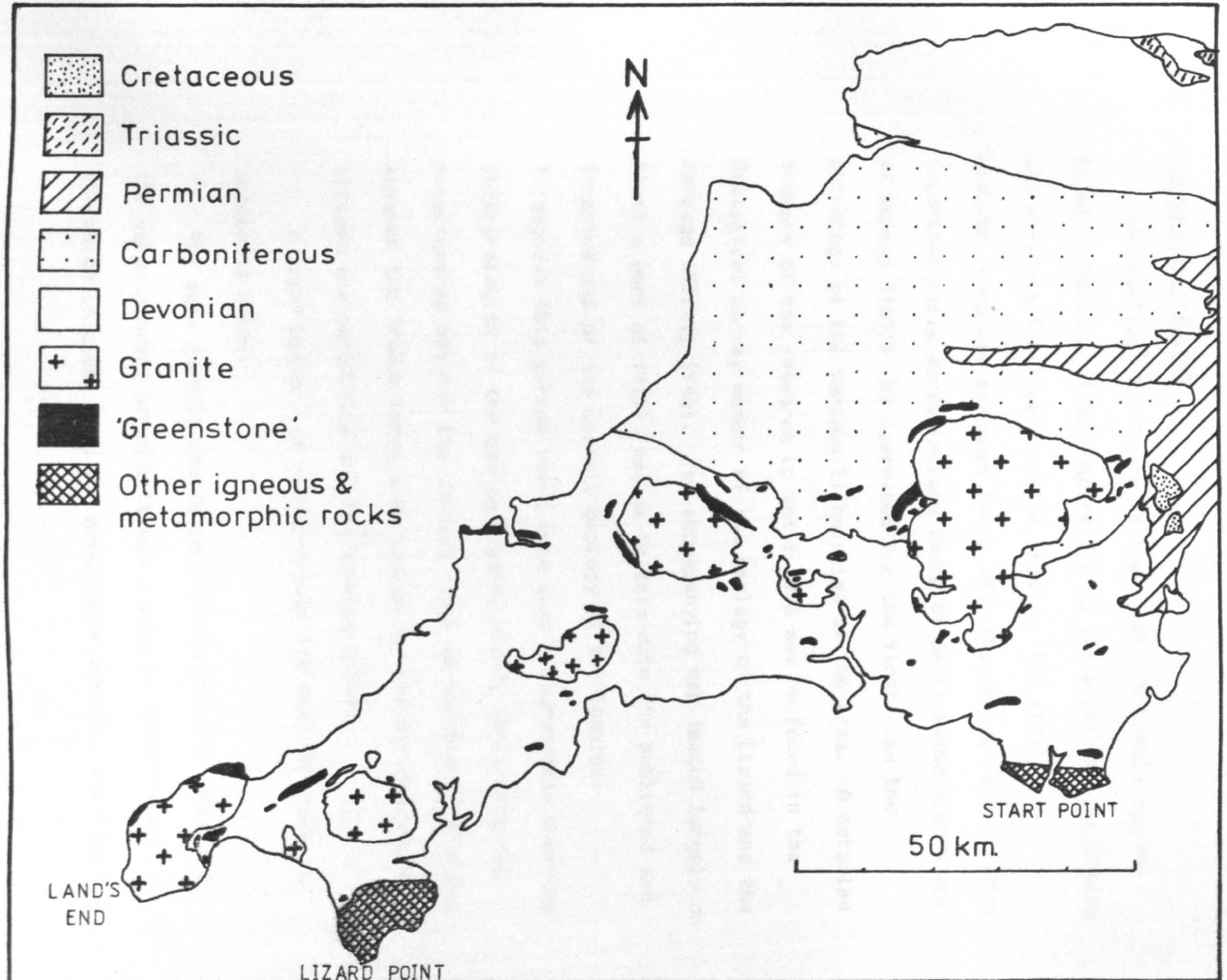


FIGURE 2.
Generalized geology of southwest England.

the oldest rocks of the Peninsula are considered to be the relatively small exotic masses of Ordovician quartzite and Silurian limestone lying within the Meneage Formation.

2.2 History of research

The earliest reference to the Lizard Peninsula may be found in Borlase (1758) who refers to the steatite, serpentine and asbestos found near to the Lizard. The first maps, however, were not produced until 1818 (Majendie, 1818). Other important early works include those of De la Beche (1839) and of Bonney (1877) who described for the first time the petrology of the various lithologies of the area. A detailed summary of the research up until 1946 may be found in the Geological Survey memoir of the geology of the Lizard and the Meneage (Flett, 1946). The accompanying map (based largely on Flett's work of 1912) remains to this date the published and accepted map of the overall geology of the Complex. Throughout this period there were many disagreements over the interpretation of the geology, particularly concerning the relationship between the various types of hornblende schists, between the Traboe hornblende schist and the peridotite, and between the peridotite and the Kennack gneiss.

A brief history of research over the past 50 years is presented below:

The main genetic conclusions of Flett (1946) were that the serpentinized peridotite was a plug or dome-shaped intrusion into the mica and hornblende schists, and that the

Kennack gneiss were later intrusions into the peridotite. He also sub-divided the hornblende schists into the Landewednack and Traboe variety. The gabbro was considered to be intrusive into the serpentinite.

In contrast to the opinion of Flett, Sanders (1955) suggested, on the basis of detailed mapping on the south-eastern corner of the Peninsula between Kennack and Landewednack Church Cove, that the ultrabasic body was a shallow sheet of limited thickness which had been thrust over the Landewednack schists. He also regarded the Kennack gneiss as being the locally migmatized equivalent of the Landewednack hornblende schist formed during emplacement of this serpentinized peridotite sheet.

A series of papers by Green (1964 a,b,c) comprised the next major piece of work to follow that of Flett. This work covered all the lithologies of the Complex, although it concentrated on the peridotite, the hornblende schist and to a lesser extent on the Kennack gneiss. A revised map of the Complex was presented with the peridotite sub-divided into three varieties. These were a primary peridotite surrounded by a recrystallized anhydrous variety with subordinate amounts of a recrystallized variety. He rejected the conclusions of Sanders suggesting instead that the peridotite was a hot diapiric intrusion into the Landewednack hornblende schists. The Traboe schists were regarded as the metamorphosed product of the Landewednack hornblende schists. It was also suggested that the gabbro was a later intrusion into the peridotite forming a part of a ring intrusion. Finally the Kennack gneiss ~~were~~ was considered to have been formed by the intrusion of microgranite along sheared basic dykes in the peridotite.

In the early 1960's a number of age-dating studies were carried out (Dodson, 1961; Miller and Green, 1961a; Miller and Green, 1961b). These analyzed biotites, muscovites and hornblendes and mostly used the K-Ar method (two biotite analyses used the Rb-Sr method). Muscovite ages from the metasediments averaged around 360my. The Kennack gneiss gave mineral ages by both Rb-Sr and K-Ar of about 370my. The age dates from the hornblende schist showed a large range from 363my to 499my. The slightly younger muscovite ages from the metasediments were not consistent with the geological evidence at the time and were rejected by Green (1964c) as incorrect due to argon loss as a result of later retrogressive metamorphism. The older dates have since been rejected by Styles and Rundle (1984) for several possible reasons. They considered that they had been "protected from later events" that they were "due to the presence of a small amount of excess or inherited ^{40}Ar".

Although plate tectonic theory first developed in the mid-1960's (Wilson, 1965) it was not until 1969 that Thayer (1967) made a direct comparison between the rocks of the Mid-Oceanic Ridges and those of the Lizard Complex. In particular he considered the gabbro at Coverack to be genetically related to the peridotite.

Since then a number of workers have argued for an ophiolitic origin. Bromley (1973) identified the dyke swarm to the south of Porthoustock as the base of a sheeted dyke complex. Strong et al (1975) compared the geology with other well documented ophiolite complexes. Later, in another major development, Bromley (1975) reinterpreted the ring fracture circumscribing the main Lizard gabbro as an arcuate thrust running between Porthoustock and Kennack. He suggested this separated an upper unit of peridotite, gabbro and sheeted dykes from a strongly contrasting lower unit. Other works of importance during the mid-late 1970's include that of Rothstein (1971, 1977, 1981), Badham and Kirby (1976), Bromley (1976,1979), Kirby (1978 a,b), Vearncombe (1979) and Styles and Kirby (1979).

Between 1976 and 1978 five boreholes were drilled by the Geological Survey and these have helped to clarify the geology in some areas. It should be noted, however, that the information from several of the boreholes provided for an unexpected insight into the geology, and have been responsible for much discussion.

In a borehole drilled on Predannack Downs the peridotite was found to be a sheet of approximately 300 metres in thickness underlain by hornblende schist (Institute of Geological Sciences report, 1978).

Drilling at Kennack Sands (Institute of Geological Sciences report, 1982) showed interlayered peridotite and gneiss to a depth of 43 metres. Beneath this to the base of the hole (150 metres) were variable acid and basic gneiss with small peridotite bodies at several horizons. These results were completely unexpected as it was generally accepted at the time that the Kennack gneiss was a localized phenomenon caused by the obduction of a hot ophiolite slab over the Landewednack hornblende schists.

In 1978, three boreholes were drilled to the west and southwest of Traboe. These holes led to the discovery of the previously unrecognized cumulate complex (Leake and Styles, 1984) which had formerly been referred to as the Traboe hornblende schists.

The oceanic-derived igneous material from which much of the Complex is formed is now thought by most workers to have had a relatively short history. Davies (1984) concluded, on the basis of a plagioclase - clinopyroxene - whole-rock Sm-Nd isochron, that crystallization of the magmatic rocks occurred during the early to middle Devonian times (375$\pm$12my). A Rb-Sr whole rock isochron age of 369$\pm$12my (late Devonian) was described by Styles and Rundle (1984) for an acid vein from the Kennack gneiss. It was suggested that this date represented a phase of high temperature thrusting which immediately preceeded obduction. This interpretation was, in turn, based largely upon the conclusions of Barnes and Andrews (1984) that the final emplacement of the Lizard Complex over the Meneage Formation took place at low temperatures. They noted that there was no increase in metamorphic grade towards the Complex and that there was no evidence of local thermal overprinting.

2.3 Lithological and superficial units

The various lithological and exotic units of the Lizard area and their distribution are described below. Most are as defined by the 1946 Geological Survey Memoir, although some additional sub-divisions are used to distinguish lithologically similar but structurally distinct units. Figure 3 shows a simplified version of the geological map of the Complex.

2.3.1 Peridotite

The serpentinized peridotite is the dominant lithological unit of the Complex. It consists of one main and several smaller bodies. It is surrounded on its northern, western and southern margins by a discontinuous girdle of hornblende schists and to the east by the Crousa gabbro. Like many of the other lithological units of the area, a number of fundamentally different interpretations have been advanced over the past 50 years to account for its presence.

Flett (1946) regarded it as a zoned intrusion of three "serpentine" magmas with steep contacts which were commonly faulted. It had a central core of "bastite serpentine", a median "tremolite serpentine" zone and an outer "dunite serpentine" zone. This classification reflected differences in the grain size, the degree of granulation and the effects of serpentinization.

Later, Green (1964 a,b,c), in relating the peridotite to progressive recrystallization, recognized three distinct mineral assemblages:

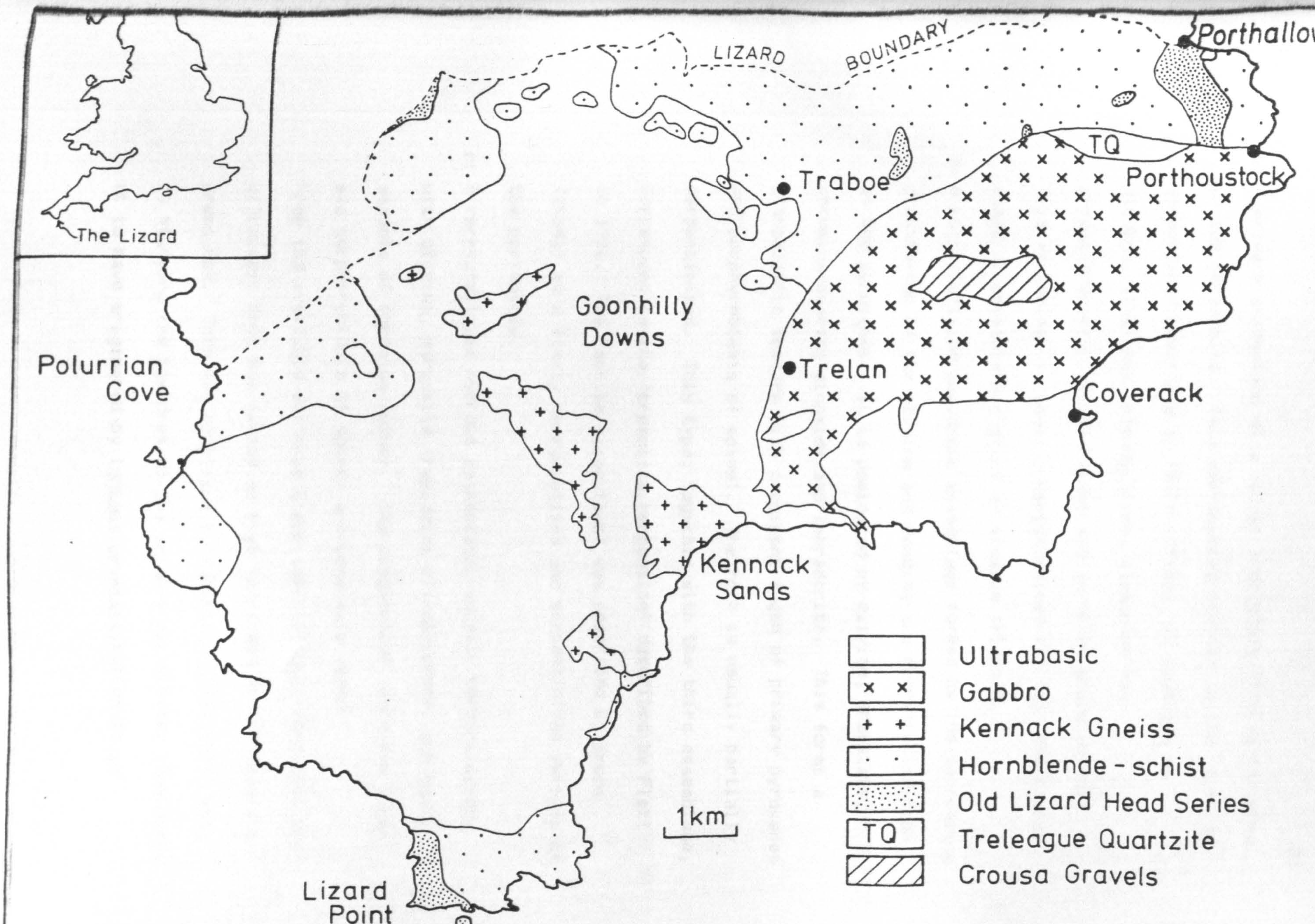


FIGURE 3. Geology of the Lizard Complex.

a) A primary assemblage of a spinel lherzolite forming the core of the peridotite. This corresponds roughly to the "bastite serpentine" described by Flett (1946). It consists of olivine, aluminous orthopyroxene, aluminous and chromium-bearing clinopyroxene and an olive green spinel. This assemblage is usually serpentinized although the coarse anhedral crystals may still be visable (Plate 3).

b) A recrystallized anhydrous assemblage formed by the increasing granulation of the olivine and bending and recrystallization of the pyroxenes. It is dominated by olivine, enstatite, chromium-bearing diopside and labradorite. This forms a granoblastic texture with prominent augen of primary pyroxenes and porphyroblasts of spinel. The rock is usually partially serpentinized. This type, together with the third assemblage, correspond to the "tremolite serpentine" described by Flett in 1946. The "dunite serpentine" was described by Green (1964a) as a finely recrystalized and serpentinized variant of the peridotite.

c) A recrystallized hydrous assemblage, usually serpentinized, with olivine, pargasite (replacing clinopyroxene) and small amounts of chromium spinel. The plagioclase, pyroxene augen and porphyroblasts of spinel are generally absent.

From the available evidence Green (op.cit) concluded that the ultrabasic body was formed at high temperatures and moderate pressures. This was confirmed by Rothstein (1971,1981) who, in studying the textures of the primary peridotite, considered it to have originated by igneous crystallization in an

Plate 3. Relatively unaltered lherzolitic peridotite. Moderately large laths of clinopyroxene (inclined extinction with high 1st order and 2nd order birefringence) and orthopyroxene (1st order grey). Small olivine crystals (2nd order blues). Minor alteration to serpentine minerals and development of magnetite particularly along fractures. (Crossed nicols; magnification X10).

Plate 4. Typical thin section of serpentinized peridotite. Slightly altered clinopyroxene lath visable in top left. Similarly sized, completely altered, crystal of olivine present in lower part of section. (Crossed nicols; magnification X10).

olivine-rich melt developed within the spinel lherzolite facies of the upper mantle. Vearncombe (1979) suggested the spinel lherzolite equilibrated at a depth of approximately 24km (8kb pressure) and at temperatures between 1200 and 1400°C. If this is correct then it must have been raised rapidly in order that the primary assemblages were partially preserved.

The horizontal contact between Landewednack Church Cove and Poltesco described by Sanders (1955) is considered to be a zone of major thrusting. The vertical N/S trending foliation, which is found throughout the main peridotite body, persists to within 1 or 2 metres of the contact where it is replaced by intense shearing with variable thicknesses of talc and serpentine schists. The borehole drilled on Predannack Downs (Institute of Geological Sciences report, 1978) showed similar alteration products around the contact between the peridotite and hornblende schist.

The foliation described above is the first of two phases of deformation. It is restricted to the peridotite and predates the gabbro. Peridotite xenoliths in gabbro may be seen at Coverack to possess randomly orientated foliations. This foliation is described by Rothstein (1977) as foliation banding analogous to solid state flow and upper mantle deformation. The second phase of deformation, which predates the emplacement of the sheeted dyke complex, has caused the creation of a number of flat-lying shear zones in the serpentinite and gabbro. These have been described by Bromley

(1979) as the result of the thrusting of an upper unit over a strongly contrasting lower unit (Chapter 2.3.2).

The peridotite was originally considered by Flett (1946) and Green (1964 a,b,c) to be largely lherzolitic. However, chemical analyses by Kirby (1978a) have shown that there are substantial amounts of harzburgite and dunite, particularly in the upper unit which outcrops on the coast between Carrick Luz and Coverack.

Frey (1969) studied the rare earth element patterns of the peridotite and the gabbro. He concluded that they were genetically related and have a light REE depletion. On the basis of this he considered the peridotite to be the residue left after the derivation of a tholeiitic partial melt.

The serpentinization process which affects much of the ultrabasic body is generally regarded to be a late stage metasomatic event. The mineralogy is briefly described as having a mesh-texture consisting of bastite, cross-fibre chrysotile and antigorite. Wicks and Whittaker (1977) take many specific examples from the Lizard Complex in describing the various textures of the serpentine minerals and the process of serpentinization. Plate 4 shows a typical thin section of the serpentinized peridotite. Although considered by Green (1964a) to be an isochemical reaction with an increase in water content only, the presence of rodingites (Hall, 1979) implies the removal of calcium and magnesium from the peridotite.

2.3.2 Gabbro

Gabbro principally occurs as a large body outcropping on the east coast between Porthoustock and Coverack. It also occurs as numerous small dykes between Coverack and Kennack Sands and as isolated masses around Poltesco and Polbarrow (between Cadgwith and Landewednack Church Cove).

It is considered to be bounded on its northern and eastern margins by an arcuate thrust running between Porthoustock and a point just to the east of Kennack Sands (Bromley, 1975). The evidence for this thrust is, however, limited. A near continuous valley exists along this line, although there is a 500 metre stretch of flat land around Lanarth. Immediately inland from Porthoustock, which marks the boundary between the gabbro to the south and the Upper Landewednack hornblende schists to the north, are some highly silicified and haematized breccias. Just to the east of Kennack Sands are a number of gently dipping south-easterly trending shear zones cutting the peridotite. Many of these were subsequently intruded by a number of basaltic dykes.

South of Trelan the nature of the contact with the peridotite changes from a well defined line to a sinuous course. It also thins considerably in outcrop emerging at Carrick Luz as a dyke approximately 40 metres in width. In the Memoir it was suggested that whilst the former may be a tectonic boundary, this sinuous contact may be intrusive in nature. Several later workers have suggested that this tongue-like extension to the main gabbro body may be a feeder

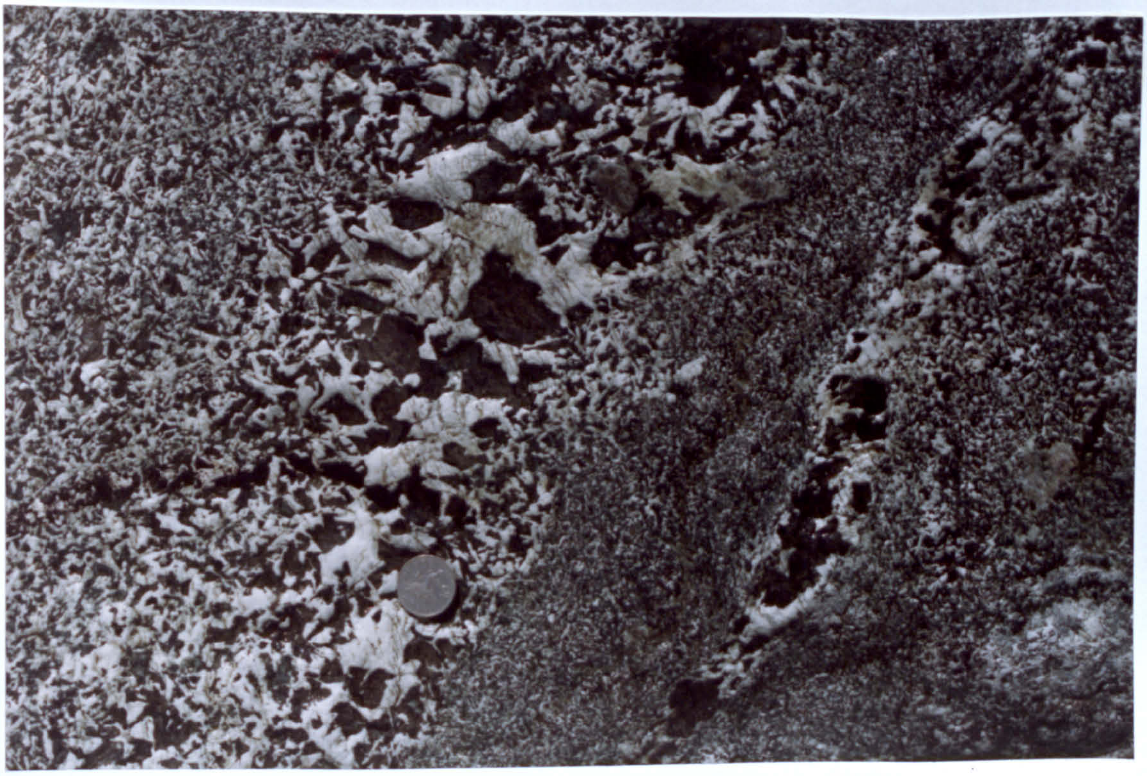


Plate 5. Highly variable gabbro from south of Dean Point.

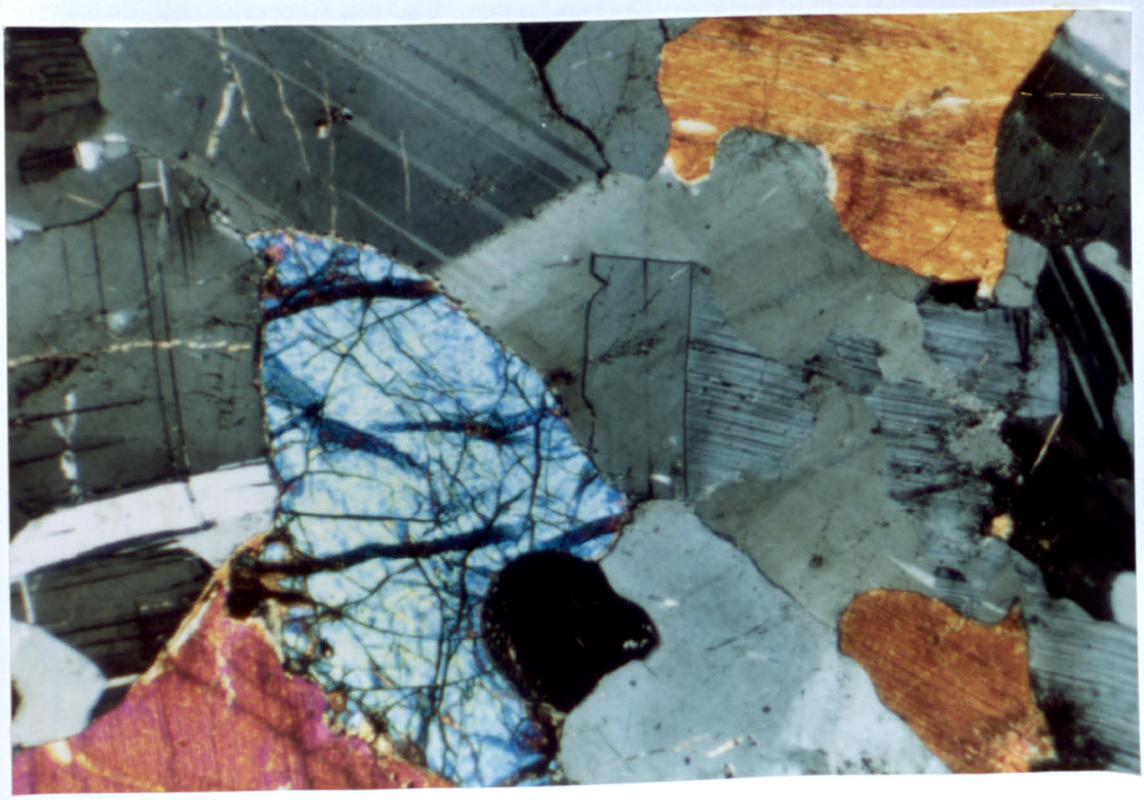


Plate 6. Thin section of a fresh olivine gabbro from coast north of Coverack (ISO-8). Predominantly labradorite feldspar (1st order greys, lamellae twinning), clinopyroxene (high 1st order and 2nd order birefringence) and olivine (2nd order blues, heavily fractured with development of magnetite). (Crossed nicols; magnification X10).

the gabbro north of Godrevy Cove.

Secondary processes include sericitization and sausseritization of the feldspars and uralitization of the clinopyroxenes. They are particularly active in zones of deformation. The uralitization, which is most common in the north, ranges between the complete alteration of the clinopyroxene to amphibole to the development of rims around the clinopyroxene.

Small scale igneous layering and lamination, particularly around Lowland and Dean Points were recognized by Kirby (1978a,b) who suggested a cumulate origin. This layering results from variations in the relative proportions of plagioclase and olivine. The laminations run parallel to the layering and are due to allignment of plagioclase laths. Some of the gabbro in this area is considered by Kirby (1978b) to show evidence of mineral grading with sharp basal contacts to the south and gradational contacts facing north. On the basis of the near-vertical orientation of the layering, which was taken to represent the palaeohorizontal, it was suggested that the top of the Complex was to the north. To achieve this the Complex must have been rotated 90° down towards the north about an approximately E/W axis. Bromley (1979) in rejecting this latter hypothesis suggested that the "cumulate layers" were due to deformation.

The area around the contact with the peridotite in the south at Coverack is a broad zone which, although largely unexposed, is dominated by olivine-rich gabbros, troctolites, dunites and rotated xenoliths of ultrabasic material. There is no evidence of faulting between the gabbro and the ultramafic material. They show both gradational and intrusive relationships, and no chilling can be seen at the margins of the intrusive contacts. The gabbro around Coverack and further to the south towards Kennack Sands, forms numerous small dykes which cut the peridotite. The troctolite occurs as veins intruding the peridotite and as irregular masses. It shows a weak foliation which is parallel to and apparently continuous with the peridotite. It is composed of olivine (often serpentinized), altered plagioclase and clinopyroxene (often in excess of 20%). The troctolite is, however, in turn cut by gabbro dykes.

A problem with the ophiolite hypothesis is that the zone of ultramafic cumulates that commonly exists between the gabbro and the mantle tectonites is missing. These represent the earliest precipitates from the gabbroic magma. As there is no evidence of faulting it has been suggested that a large proportion of the mafic minerals may have been removed from the gabbro before it left the peridotite. If this is correct then the dunite-spinel pods and the troctolite may represent this fraction.

2.3.3 Basaltic dykes

A variety of undeformed basic dykes may be found on the east coast, particularly between Porthoustock and Landewednack Church Cove, although they are relatively infrequent away from the gabbro. They also occur, although less commonly, in the peridotite on the west coast and in the Traboe hornblende schists. Deformed fine grained basic dykes may also be found in the Landewednack hornblende schists and the Old Lizard Head Series.

The dykes in the gabbro are concentrated in two main areas. The larger swarm may be found between Porthoustock Point and Godrevy Cove, whilst a smaller group occurs just north of Coverack. The existence of these implies a tensional environment with a large degree of crustal extension.

Bromley (1973) divided the northern dyke swarms into three groups on the basis of field evidence:

a) The earliest being a suite of discontinuous approximately N/S trending olivine-porphyritic dolerites or metadolerites. They show no chilled margins and are commonly backveined by gabbro. They were considered to have either been emplaced whilst the gabbro was still hot or to be dyke "xenoliths" formed by a later generation of gabbro.

b) The second set dip at approximately 60° to the southwest and trend NW/SE. These generally have phenocrysts of plagioclase with chilled- and phenocryst-free margins. Some are net-veined by fine grained hornblende-diorites or leucodiorites.

c) The youngest are considered to be a part of a sheeted dyke complex. They have vertical or near vertical dips and consistently trend NW/SE. They are fine grained rocks consisting of plagioclase and green hornblende with rough columnar jointing. Although rare to the south of Godrevy

Cove, they become increasingly important northwards where they occupy about 80% of the exposure. Against the gabbro and earlier dykes they show a chilled margin although where several dykes occupy the same fissure this chilling does not occur.

On the basis of their geochemistry, Kirby (1984) has divided the basaltic dykes which may be found at Coverack and Porthoustock into three chemically distinct groups. No comparison with the groups identified by Bromley (1973) was provided. By the use of discriminant diagrams (Pearce and Cann, 1973; Pearce et al, 1975) the dykes were shown to have broadly oceanic and tholeiitic affinities. The above results are, however, at variance with those of Floyd (1976) and Floyd et al (1976).

The present orientation of the dyke swarm to the south of Porthoustock does, however, cause some problems. If, as Kirby (1978b) suggested, the upper unit has been rotated about an E/W axis towards the north, either this complex was originally emplaced as a series of inclined sheets which have been reorientated to a near vertical position or it was intruded after the gabbro and peridotite rotated through 90°. The alternative hypothesis (Vearncombe, 1979) is that virtually no rotation has occurred and therefore the evidence for mineral graded beds is incorrect.

This larger zone of sheeted dykes was not sampled during the orientation survey as its extension inland was uncertain. It is considered, however, that although the chemistry of the dykes is similar to that of the gabbro, it would be identified in inland areas by the soil sampling if it were the dominant rock unit.

2.3.4 Hornblende schists

The hornblende schists of the Lizard Complex have four principal areas of distribution. To the north of the serpentinite they form a broad discontinuous belt extending from Porthoustock to Mullion Cove. They also occur on the west coast around Predannack, on the south coast around Lizard Point, and to the east between Cadgwith and Polbarrow.

They were divided into two types, the Landewednack and Traboe variety, by Flett (1946). The former was interpreted as a series of metabasalts and tuffs, whilst the Traboe schists were attributed to small gabbro intrusions that preceded the intrusion of the peridotite.

The Traboe hornblende schist was described by Flett (1946) as "a grey feldspathic, non-epidotic and more coarsely crystalline hornblende schist". In comparison with the Landewednack hornblende schists it has an irregular foliation which is generally poorly developed. This foliation averages sub-vertical with an approximately N/S trend. Its main area of outcrop is the broad NW/SE trending zone about Traboe and Polkerth around the northern margin of the peridotite. This is broadly coincident with the area mapped and described by Flett as "ultrabasic material incorporating inclusions of hornblende schist" (Fig.3). Additional smaller bodies exist just north of Porthkerris Cove, to the north of the Kennack-Porthoustock thrust at Porthoustock and on the west coast around Predannack Head.

Green (1964b) in contrast concluded, on the basis of the similarity in chemistry between the two groups, that the Traboe schists were an almandine-amphibolite and granulite facies derivative of the Landewednack hornblende schists. These had formed in response to the intrusion of the Lizard peridotite.

In contrast to the opinion of Green, Bromley (1976), in describing the entire truncated ophiolite pseudo-stratigraphy of the eastern Lizard, regarded the Traboe schist as being genetically unrelated to the Landewednack schist. He considered them to be derived from a series of gabbroic intrusions immediately preceding the emplacement of the peridotite diapir.

Kirby (1978a, 1979) also showed, on the basis of geochemical data, that although the two groups have similar final products, they were of totally different origins. Both groups were identified as tholeiitic in nature. The Traboe schists showed a large scatter of data and were interpreted as more primitive than the Landewednack schists. On the basis of field evidence the Traboe schists were described as dominantly intrusive and cumulate gabbroic rocks.

Vearncombe (1979) described the northern area of the hornblende schists as a transition zone between the cumulate gabbroic portion in contact with the peridotite and the basaltic rocks to the north east.

In the series of boreholes drilled by the British Geological Survey in 1978 (Leake and Styles, 1984) a layered basic-ultrabasic cumulate complex was recognized which showed an overall NE-dipping stratigraphy. Plate 7 shows some of the typical banding found within the Traboe schists. Although the holes were affected by a number of tectonic contacts a generalized stratigraphy could be seen. This was described from the base as:

a) Massive dunite with minor harzburgite.

b) Finely layered dunite with plagioclase wehrlite horizons.

c) Finely layered dunite, pyroxenite, gabbro and anorthosite with minor wehrlite.

d) Gabbro with wehrlite and clinopyroxenite horizons.

e) Gabbro.

For the the purpose of the orientation survey the Landewednack hornblende schists were divided into an upper and lower group. The Lower Landewednack sub-division includes the most southerly exposure of the hornblende schist and the narrow coastal strip exposed discontinuously between Polbarrow and Kennack. The cumulate complex around Traboe was not initially sampled due to the very wide range of lithologies present over a very small area. This zone is identified later on the basis of its highly variable chemistry.

The lower and upper units of this series consists primarily of hornblende and andesine plagioclase. They have a medium grained, nematoblastic texture with sub-euhedral blue-

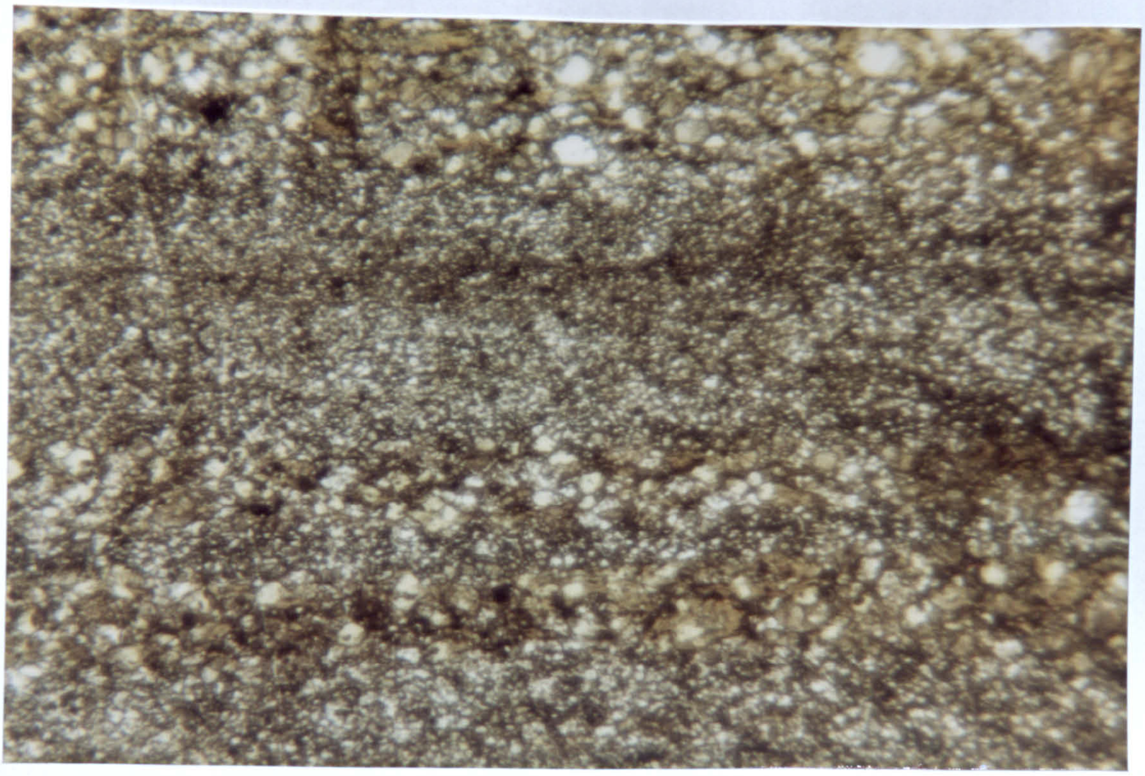


Plate 7. Traboe hornblende schist from Traboe area. Rounded crystals of colourless plagioclase feldspar with finer amphibolitic material displaying typical banding. (Plane polarized light; magnification X4).

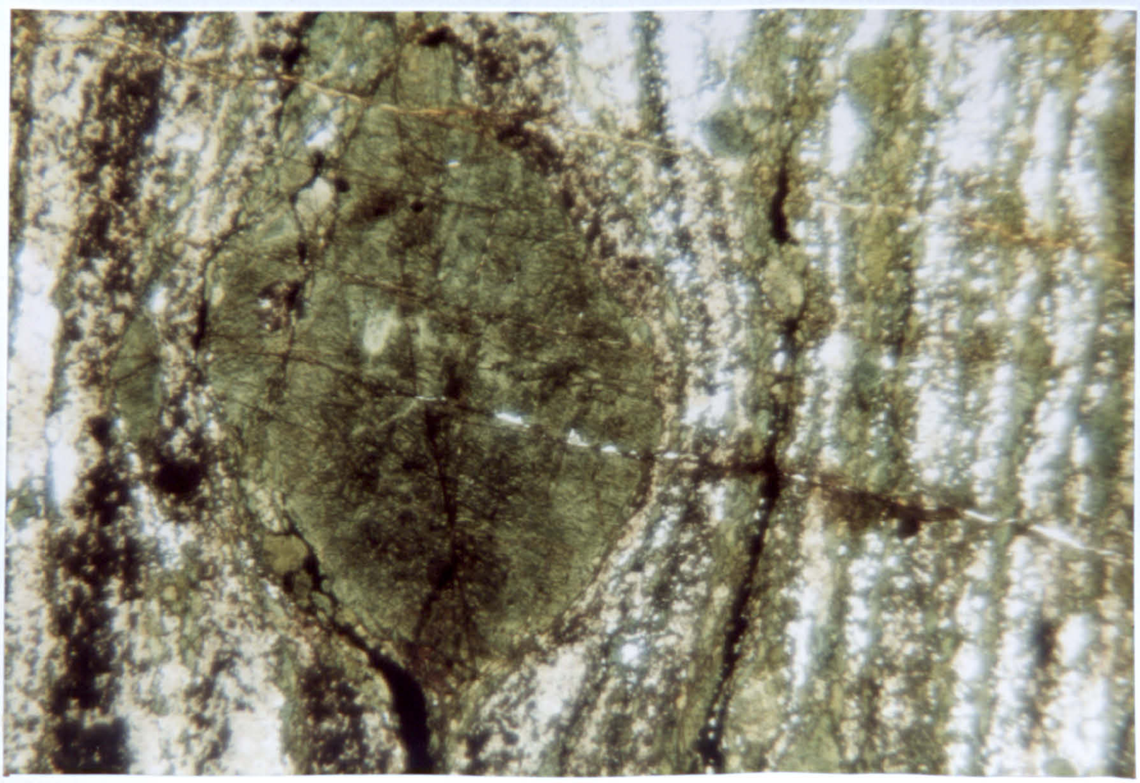


Plate 8. Upper Landewednack hornblende schist. Large augen of hornblende in finely banded hornblende and plagioclase schist. Minor opaque ilmenite also present (particularly in fractures). (Plane polarized light; magnification X4).

green hornblende, anhedral and frequently untwinned plagioclase and accessory granular sphene and magnetite (Plate 8). They show a regular, near horizontal foliation with a pronounced mineral lineation due to allignment of the hornblende crystals.

The Lower Landewednack schist may often be rich in colourless salite, yellow-green epidote and, less commonly, streaks or lenses of grossular. The epidote varies considerably in quantity and may sometimes occur in thick lenses or more continuous bands parallel with the schistosity. This calcium enrichment is considered to reflect either original calcic bands, or the introduction or redistribution of calcic solutions. It is considered to represent fine grained basic and locally gabbroic rocks. These may represent ancient rocks unrelated to the Lizard ophiolite or an earlier obducted slice of ophiolite, deformed and interfolded with continental metasediments, which were subsequently overridden by the main ophiolite unit. It is distinguished from the Upper Landewednack schists on the basis of its structural position and on its association with metasediments.

The Upper Landewednack hornblende schists, in comparison, lack the calcic rich bands and have a more complex deformation history. Much of this deformation is considered to be late or postobduction (Vearncombe, 1979) as acid veins, similar to those found in the Kennack gneiss, are also deformed. The schists are locally highly variable, passing transitionally from highly deformed gabbros at Porthoustock into deformed fine grained basic rocks to the south of Porthkerris. In contrast, Kirby (1979) interpreted them as highly tectonized basaltic lavas.

2.3.5 <u>Old Lizard Head Series</u>

This series is located in the southwest corner of the Complex to the north and east of Lizard Point. They are also described as occurring near Polkanoggo and in a strip to the east of Porthallow and Porthkerris.

They are a metamorphosed sequence of mica schists, quartzo-feldspathic granulites and volcanics (green schists). They are considered to underlie the Lower Landewednack hornblende schists with which they are interbedded, particularly at the margins. They show good minor folding and a well developed crenulation cleavage (Plate 9). The volcanics consist mainly of feldspar and chlorite whilst the metasediments are comprised of quartz, sericitzed feldspar, muscovite and biotite. The metasediments are reported by Tilley (1937) to show some higher grade assemblages:

Cordierite ± almandine

Anthophyllite, cordierite ± almandine

Anthophyllite, cordierite, staurolite

Cordierite, staurolite, andalusite

Additionally, kyanite and sillimanite are described as occurring near Polkannogo and sillimanite in quartzo-feldspathic segregation lenses (Plate 10). The latter have been described by Styles and Kirby (1979) as a possible

Plate 9. Well developed crenulation cleavage in mica schist of the Old Lizard Head Series rocks at Polpeor Cove.

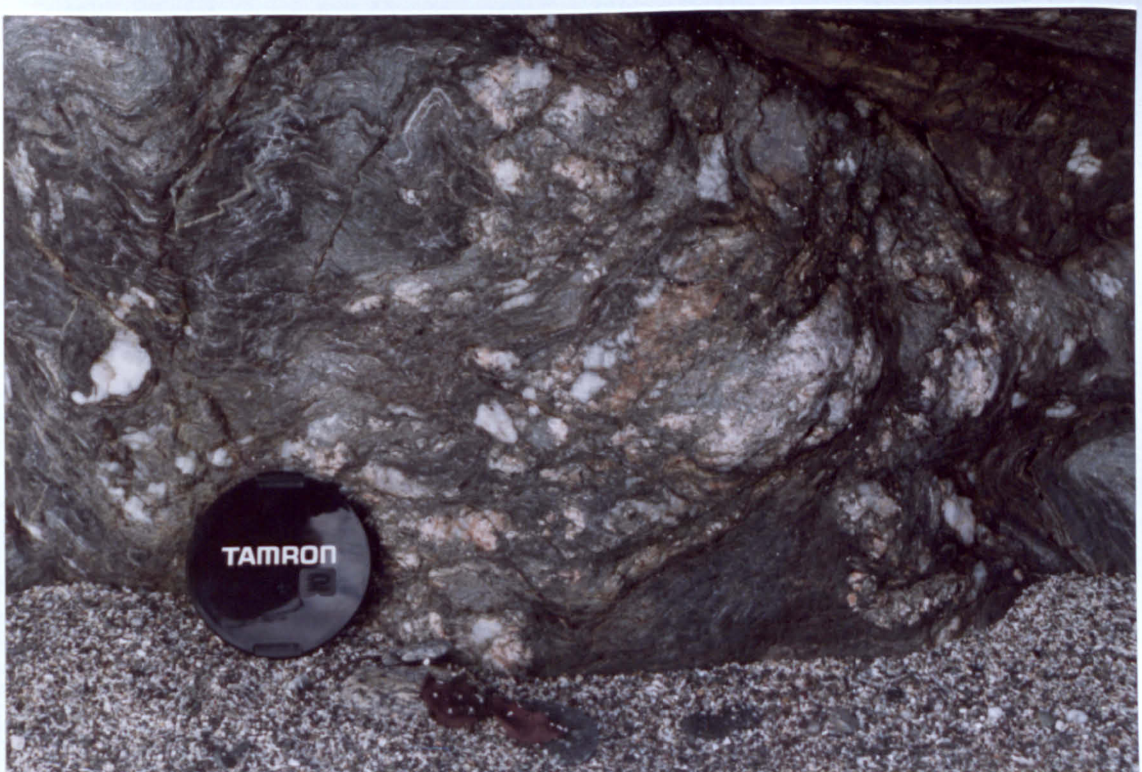


Plate 10. Quartzo-feldspathic segregations in the Old Lizard Head Series rocks at Polpeor Cove.

intermediate stage of migmatization prior to the development of the Kennack gneiss.

2.3.6 Kennack gneiss

This is a general name given to a highly variable group of acid and mixed acid/basic intrusives. They are shown on Figure 3 as outcropping over large areas near Kennack, St.Ruan, Erisey and Goonhilly Downs. They occur on the coast discontinuously between Kennack and Landewednack Church Cove. Smaller outcrops may also be found on the west coast. Additionally, smaller bodies may be found in the peridotite (at Kynance, Gew Graze, Vellan Head), in the gabbro (Pen Voose Cove) and in the Traboe schists (George's Cove). They are generally considered to be absent from the upper Crousa Downs unit.

In thin section the gneiss have an extremely varied mineralogy. The acid portion consists predominantly of quartz, sodic plagioclase, orthoclase feldspar, subordinate biotite or hornblende with minor apatite, epidote, sphene and zircon. The larger crystals of plagioclase show good lamellar twinning and are often zoned. The basic portion is amphibolitic and is comprised largely of green hornblende and highly sericitized plagioclase together with biotite and minor quartz.

A wide range of textures and relationships with the peridotite, gabbro and basaltic dykes have been described by several workers (Flett, 1946; Green, 1964c; Kirby, 1978a).

They include:

a) Veined gneiss, in which the dark basic portion is veined by the acid material.

b) Flow-banded gneiss, which shows good parallel bands of acid and basic material.

c) Blocky gneiss, where both regular and irregular blocks of variable sizes (1-50cm) are embedded within a matrix of banded gneiss or the acid portion.

d) Blotched or streaky gneiss, in which the basic portion forms elongated streaks lying parallel to the foliation.

Its mode of formation still remains uncertain. Various opinions have been advanced over the last century. Bonney (1877) believed it to be an Archean migmatite pre-dating the intrusion of the peridotite. Flett (1946) considered it to be a composite acid/basic intrusion post-dating the intrusion of the peridotite. Sanders (1955) suggested it to be a migmatite derived from the Landewednack hornblende schist during the intrusion of the peridotite sheet. In a slight modification of Flett's theory, Green (1964c) suggested the acid component to be a later intrusion, which had followed the same path as the intrusion of the earlier basaltic sills. More recently it has been suggested that the gneiss are a composite acid/basic intrusion which subsequently suffered intense deformation (Bromley, 1979). Styles and Rundle (1984) preferred the theory of Styles and Kirby (1979) which involved migmatization and partial anatexis of the Old Lizard Head series and Landewednack hornblende schists. It was, however, concluded that this occurred during a widespread phase of high temperature thrusting that preceded the emplacement of the ophiolite.

2.3.7 Treleague quartzite

This lithology is reported to occur as a narrow 2km long lensoid body along the contact between the gabbro and hornblende schist. It was assumed by Carr (1960) to be a downfaulted block of lower Palaeozoic sediments unconformably overlying the Lizard Complex. No exposures are at present found although a number of exposures are described in the Memoir in some detail. As well as quartz, feldspar and hornblende were identified together with minor garnet, zircon and epidote. In re-examining the specimens collected by Flett (1946), Styles and Kirby (1979) considered them to be cataclastites which had undergone annealing after brittle deformation.

It is reported (Carr, 1960) to be intruded by dolerite dykes and not regionally metamorphosed to the same degree as the Old Lizard Head series. The presence of clastic sediments have been interpreted by Bromley (1979) as evidence for the generation of the igneous material of the Complex close to a continental margin.

Due to its limited and uncertain extent this unit was not sampled during the orientation survey. If at any time later during the mapping process this unit was sampled, it should be easily identified on the basis of the unusual soil geochemistry it would generate.

2.3.8 Crousa gravels

The gravels occupy a small area (about $1km^2$) at approximately 100m OD overlying gabbro on Crousa Downs. They have also been recognized on Goonhilly Downs between Dry Tree and Traboe Cross. It has been suggested that they once covered a far more extensive area.

Very little work has been carried out on them with the most important recent geological references being in the 1946 Memoir. They are also referred to briefly in assorted works on the possible effects of glaciation in the area (for example, Kidson, 1977). They are often compared to the Polcrebo gravels around St.Agnes to the north of the county.

They are quartz-rich gravels which, although containing no fossils, are considered to be Pliocene in age and of marine origin (Flett, 1946). The quartz is of the vein variety such as that found in veins in the killas to the north. The term "killas" was originally a local mining term used to describe slates and low-grade phyllites developed in southwest England. Gabbro fragments may also be found. The area covered by this unit has, in the past, been characterized by the presence of large numbers of gabbro boulders. Many of these have been cleared by farmers. These boulders were considered to be largely *in situ* by Flett (1946), a fact which was discounted earlier. Further reference will be made to these boulders towards the end of this work.

2.3.9 Loess

This unit forms a patchily preserved mantle of fine sandy soils over the central parts of the ultrabasic. The loess sheets of Cornwall were first recognized by Coombe and Frost (1956) on the Lizard Peninsula in a study of the botany of the heath communities found upon the serpentinized peridotite. The source of the loess was suggested at the time as being the Hercynian granites to the north. Thermoluminescent techniques have recently given a late Devensian age (Wintle, 1981). Recently Catt and Staines (1982) observed, on the basis of particle size distribution and mineralogical composition (primarily quartz, alkali feldspar and white mica), that they differ from the loess sheets of south Devon and other parts of southern England. They concluded that most of it was blown from glacial outwash deposits in the southern parts of the Irish Sea basin.

Staines (in press) mapped the thicker units on the Lizard Peninsula as being generally confined to flat or gently sloping gabbro. Due to its potential affect on the mapping programme, this widespread and highly variable unit was sampled during the orientation survey.

2.4 Economic geology

This may be divided into two main aspects, quarrying and mining. Historically the quarrying industry was an important source of employment in the area. Most of the various lithologies have been quarried for roadstone, although the serpentinite is too soft for anything but the most minor tracks. The hornblende schist and gabbro have been the most commonly used materials and a number of old disused quarries may be found on the east coast. Dean Quarry is the only one still in operation.

The principal building stone over most of this area has, in the past, been the serpentinite with many quarries being opened on the downs. The serpentine was also worked on a large scale during the last century at Poltesco for facing slabs. It is presently only worked by independent workers in the district who cut and polish stone, obtained from the Kynance area, for the summer tourist trade.

Additionally the serpentinite was worked, particularly in the Mullion area, for steatite (soap rock) and green earth. Steatite was formerly an important constituent in the manufacture of porcelain. Green earth is the local name given to a decomposed variety of serpentinite which was dug during the World Wars and was used in the manufacture of distemper. It was also worked between 1818 and 1822 from the Devil's Frying Pan, just to the south of Cadgwith, where it was used in the manufacture of Epsom Salts ($MgSO_4$).

There has been a history of mining in the area that extends back over 300 years although there have been no major successes. Whilst copper has been the most important, many other elements have been recovered (Flett, 1946; Hamilton Jenkins, 1967).

The most important copper workings have been located just to the south of Mullion Cove. These have existed under a variety of names; Wheal Unity, Wheal Providence, Mullion Mine, Trenance Mine, etc. They were worked intermittently between 1741 and 1915, and provided in 1850 a sheet of native copper weighing 1568lb. This is the largest mass ever mined in Britain. The metal occurs mostly in its native form in veins within brecciated serpentinite. These are often found close to the contact of the serpentinite and hornblende schist. It has also been mined at West Fenwick (south of Polurrian Cove) and at Beagles Point just to the east of Carrick Luz. This latter site is considered to be the oldest known working in the district dating back to the 18^{th} century (Sedgwick, 1822). Other sites of mining trials have included Goonhilly Downs (early 19_{th} century), Landewednack Church Cove, Bass Point (southeast of Lizard Town), Downes Valley (between Kennack and Black Head) and Coverack.

Iron ores have been worked around Polurrian Cove and Porthallow. The associated gossans have also been used as a pigment.

The titanium mineral ilmenite was first discovered to the north of this area at Manaccan in 1791 where it was originally called manaccanite. It is also described in the Memoir as occurring around Lanarth, Gwendra (near Coverack) and Porthallow.

Additionally rarer minerals have been recorded in the district. These have included silver (Flett, 1946) and platinum (Davison, 1925).

2.5 Alternative approaches to mapping

A serious problem with mapping in this area is the scarcity of surface exposure away from the coast. Throughout the Memoir are references to the use of rock debris used for mapping. This approach, although undoubtably carried out with great care, was taken largely out of necessity and may well have led to serious errors if the presence of a widespread gravel sheet was not recognized. Additionally not all the lithologies of the Complex weather to give readily identifiable fragments. The recent discovery of the cumulate complex around Traboe perhaps underlines the potential for inconsistencies in the original 1946 map.

It is only in recent years that alternative approaches to mapping have become viable. Some of these alternatives are outlined below:

a) Soil geochemistry. This is the approach taken throughout the course of this project. By working under the assumption that the soils of the district are largely residual in origin, it should be possible to identify the various lithological units on the basis of the geochemistry of the residual soils. Any soil sample taken will represent a composite sample of the rotted bedrock that surrounds that point. The assumption is made that there has been little or no movement of the soils. It is considered here that this assumption is broadly correct as there are few steep slopes in the area. The few that exist are generally relatively short in extent and so any movement would be limited. During sampling any such slopes were avoided wherever possible.

A simple example of the use of geochemistry in distinguishing soils derived from different lithological units would be the gabbro and peridotite. Ignoring the effects of preferential leaching of certain elements from the soil, the soils developed over the ultrabasic would show levels of Mg, Co, Cr and Ni several orders of magnitude higher than the gabbroic soil.

Whilst this approach might not be as successful on more similar rock units, they might still be distinguished on the basis of their multivariate chemistry. This approach is used later for several units which have very similar geochemistries (for example the gabbro and the upper Landewednack hornblende schists). The soil forming process (described in Chapter 4.2) might also cause different varieties of soil to be created. These different soil groups may have different adsorption capacities, and so again rocks of similar chemistry may be separated.

Sampling is extremely rapid and causes no disturbance to farming operations. Also with the development of low-cost, fast and precise multi-element analytical techniques such as X-ray fluorescence spectrometry, which are capable of an exceptionally high degree of automation, it is now a relatively easy task to analyze large numbers of soil samples.

b) Power augering. A Minuteman power auger (Plate 11) was used as part of a project involving the Metalliferous Minerals and Applied Geochemistry Unit of the British Geological Survey.

Plate 11. Minuteman power auger in use near to Trelan.

Plate 12. Loess sheet on Goonhilly Downs. The slightly elevated and better drained loess sheet is clearly shown in the distance by the development of a darker variety of vegetàtion.

This approach permitted the collection of deep overburden samples at or very close to the base of the soil profile. Many of these samples still retained remnants of the original crystals and the structure of the underlying lithologies. The geochemistry of these basal samples could provide more direct evidence as to the identity of the underlying rocks. Additionally any fragments obtained would represent weathered material which could subsequently be studied in thin and polished section. The technique is relatively cheap and fast in its operation causing very little disturbance to the farmland.

c) Boreholes. This, together with digging pits and trenches, remains the only way of obtaining in situ samples from most of the inland area. As mentioned earlier a number of boreholes have been drilled. They have permitted a valuable insight into the overall structure of the Complex. However, they provide only a localized sample and are of no great use in general mapping. They are also extremely expensive, time-consuming and cause considerable disruption at the drillsite. Short drillholes, possibly drilled by a Minuteman power auger with a drillbit attachment, would however be very useful as a check on the results gained by residual soil geochemistry.

d) Stream sediments/Water geochemistry. Both of these approaches, particularly the former, are commonly employed in mineral exploration. They are, however, of limited use in the area as there are few streams and they tend to follow geological boundaries. The interior of the Complex generally has a low relief and is waterlogged for much of the year. The anaerobic conditions that exist on most of the Downs would also lead to problems with Fe- and Mn-scavenging. Moderately high titanium levels in stream sediments, derived from the Crousa gabbro, extend well onto the hornblende schist to the north and so could cause a serious problem with mixed sources.

e) Geobotany and biogeochemistry. In many countries there exists a great deal of interest in these techniques. They are generally considered to be a viable alternative to soil geochemistry (Brooks, 1972). Geobotany involves a visual survey of the vegetation of an area whilst biogeochemistry involves the collection and chemical analysis of whole plants or selected parts of deep-rooted plants. The latter approach would not be particularly successful due to an absence of deep-rooted plants and the fact that much of the area, particularly over the gabbro and hornblende schist has been converted to grassland for cattle and sheep. Geobotanical techniques have been employed on a limited scale, although again farming makes this approach impractical over most units. A remote sensing project carried out by the BGS has had some success in tracing vegetation differences in the Traboe area which have been related to differences in source rock.

Coombe and Frost (1956) studied the plant communities over the serpentinized peridotite and the loess. "Rock" and "Mixed Heath" (<u>Festuca ovina-Calluna and Erica vagans-Ulex europaeus</u> heath respectively) were found to develop over serpentinite, the former found particularly in shallow rankers (Chapter 4.2) near to the coast. "Short Heath" (Agrostis setacea heath) was found over the loess. Finally "Tall Heath" (Erica vagans-Schoenus heath) occurs where a mixture of both serpentinte and loess are found.

Over large areas of Goonhilly Downs the loess sheets may be readily located using vegetation type and elevation (Plate 12). The vegetation over the loess appears from a distance as slightly darker in colour. On closer examination the plant community may be readily identified as the "Short Heath" variety which is generally less than 5cm in height when compared to the other varieties which are usually in excess of 50cm in height. Additionally the loess sheets tend to be slightly elevated and very well drained in comparison with the soils developed over the ultrabasic. This approach was originally used to locate one such sheet for sampling purposes during the orientation survey.

f) Geophysics. A wide variety of techniques have been employed by the British Geological Survey between 1976 and 1984. These have included aeromagnetic and ground magnetic surveys, together with Induced Polarization, Very Low Frequency, gravity and resistivity methods. These have been carried out by the Applied Geophysics Unit as part of the Department of Industry Mineral Reconnaissance Programme (Rollin and Tombs, 1977 and Rollin, 1978). Surveys were carried out in several areas in an attempt to identify in greater detail a number of aeromagnetic anomalies and also to attempt to map geological contacts. However, the ultrabasic Rocks and gabbros are noted by Rollin (1978) to have similar geophysical properties and there appears to have been little progress in revising the positions of geological boundaries. More recently Rollin (in press) has summarized the results obtained from the magnetic surveys. Additionally an interpretation of the three-dimensional structure has been provided using the results from the gravity surveys. Some of these results are discussed in Chapter 7 in conjunction with the results arising from the residual soil geochemistry.

CHAPTER 3

SAMPLE COLLECTION, PREPARATION AND ANALYSIS

3.1 Sample collection

3.2 Sample preparation

3.3 Sample analysis

3.4 Sampling and analytical errors

3.1 Sample collection

Collection of the soil samples for the project took place in three stages spread over a two year period:

a) An orientation survey was first carried out with 256 soil samples being taken from areas of undisputed geology immediately adjacent to coastal exposure. Chip samples (232) were also taken from nearby outcrops at these localities. Some additional soil samples from over the loess and the Crousa gravels were taken from Goonhilly Downs and Crousa Common respectively. Figure 4 shows the location of these sample sites together with the number of soil samples and rock samples (in brackets) collected.

The soil samples (approximately 200 grams in Kraft envelopes) were collected along traverse lines at 10 metre intervals with a hand auger. All samples were collected from below the A horizon at a depth of approximately 70 centimetres. All the soil samples collected by hand augering during the project were given the prefix "S". Similarly all chip samples were prefixed "R".

The aims of the orientation survey were to study the compositional ranges of the known units, to assess which elements would be most useful in identifying those units, and to ascertain whether or not this technique of mapping was likely to be feasible.

b) A power auger programme was carried out by the British Geological Survey in 1984. At each sampling site, samples were taken from both one metre (prefixed "BXS3___" or

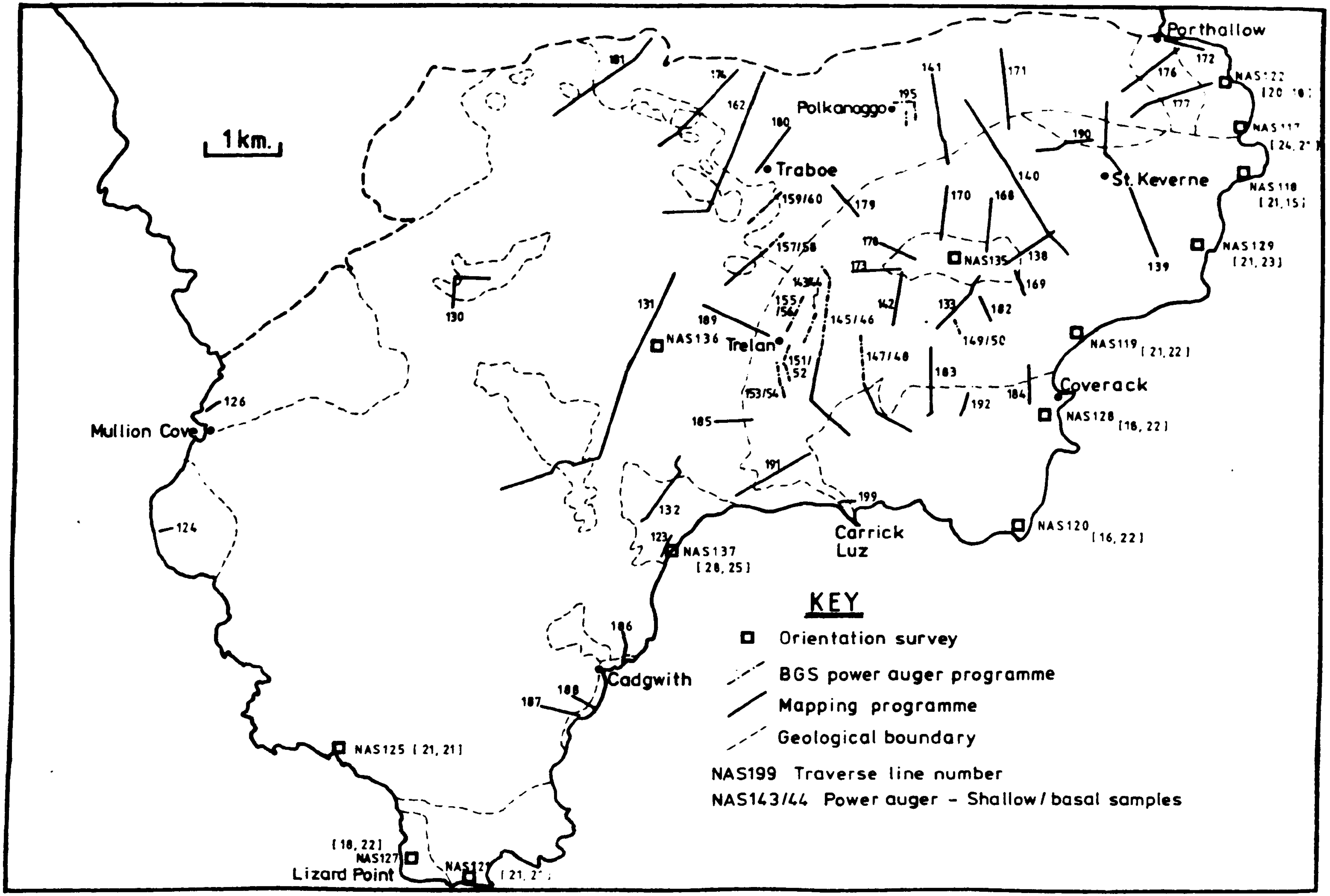


Figure 4. Sample location map for traverse lines on the Lizard Complex.

"BXS4___") and from the base of the hole (prefixed "BXB"). The Trelan area was most extensively sampled (212 sites), although the Polkanoggo and Traboe areas were also visited (25 and 21 sites respectively). Most of the samples were collected along traverse lines at 20 metre spacing. The one metre samples were used also for mapping purposes. Figure 4 shows the location of these lines.

Many of the basal samples retained a good structure with individual crystals of the rotted bedrock still visable. The availability of these basal samples enabled a check to be made on the geological predictions made from the one metre soil samples. These were compared directly against material obtained from the base of power auger holes.

In a few holes, profile sampling at one metre intervals was carried out. It was hoped that this would give some insight into the behaviour of the major and trace elements in the soil profile.

Bulk samples (>2 kilogrammes) were also collected from the base of each power auger hole. The fine clay fraction was removed by panning in the field and the coarse fragments retained. These were given the prefix "BXA".

c) The remainder of the soil samples referred to in this work (approximately 1500) were collected along pace and compass traverse lines at 50 metre intervals. These were all for mapping purposes with the traverse lines generally running perpendicular to the expected geological contacts. Figure 4 shows the locations of these lines. The sampling technique was the same as for the orientation survey.

3.2 Sample preparation

All the soil samples collected were first dried in ovens at 105°C and then ground in a hardened chrome steel Tema mill for between 5 and 30 seconds. Contamination was considered to be insignificant. Previous work has indicated that the Cr concentration of a granite tends to be increased by approximately 10-15ppm after grinding. The contamination effect of iron is unknown but is not considered to be severe. Vegetation and large or well-rounded pebbles were removed prior to grinding, no sieving was carried out. The reason for this was two-fold; firstly by studying the full size fraction rather than the -80 mesh fraction the geochemical signature of any residual primary minerals would be taken into account; and secondly, it removed an additional time-consuming stage from the sample preparation. By initially running an orientation survey, it was possible to see if all the main units could be identified without the need for sieving prior to the bulk of the samples being prepared.

After grinding, approximately 10 grams were used to make pressed powder pellets for analysis by X-ray fluorescence spectrometry (XRFS). These were made by mixing the dry powder with a few drops of PVP/Methyl Cellulose binder. The mixture was then pressed between tungsten carbide plattens at 10 tonne pressure in a 32mm die. The resulting pellet was then dried at 105°C for at least 15 minutes to evaporate the excess binder. The final dilution is less than 1% (Harvey and Atkin, 1983) and may be ignored. The remainder of the powder was stored for future use. After analysis of the basal samples from the power auger programme, some of the coarse fragments collected from the base of the holes were set in thermoplastic and made into polished thin sections and polished ore mounts for further examination.

3.3 Sample analysis

All the soil samples collected during the project were analysed on a PW1400 wavelength dispersive X-ray fluorescence (XRF) spectrometer at the Geology Department of Nottingham University.

The basic principles of the technique are described in detail by a number of authors (Jenkins, 1974; Tertian and Claisse, 1982). Appendix B gives the machine operating conditions for the 31 elements which were analysed during the project. Four of the elements (Ce, Cs, La and Nb) were rejected after the orientation survey. Analyses for S, Sn and W were only carried out for part of the project and were not used in the mapping process.

Both major and trace element determinations were made on pressed powder pellets. Fused beads were not used for the major elements as they are extremely time-consuming to make. Also accuracy was not a principal requirement of the mapping programme; precision was far more important and will be referred to again in the next section.

The processing of data obtained from the XRF spectrometer may be separated into several discrete stages; these are shown diagrammatically in Figure 5. The flow chart shows both computer program names and files which the computer must access (either to read or write). The program names (eg. RGN, SPT, MXX) are usually three letter mnemonics and will be referred to periodically throughout this work. The filenames are referred to in Figure 5 by the three letter extension which is found at the end of the filename (eg. xxx.XDT). They may also be referred to in the text as, for example, an XDT-file or a RAW-file. Processing of the X-ray data is carried out off-line after all the count data for a batch of samples (including monitors and standards) have been stored on the computer disc. This allows a check to be made on instrumental drift and elemental accuracy and precision. Most of the computer programs in the flow diagram have been written by Dr.P.K.Harvey and their function will be only briefly outlined here.

Preparation stage

This involves the use of the run-time command file generator (RGN). This program must be run prior to analysis and creates two files:

a) Request file (.REQ)

This initially contains the user's name and address which is extracted from the registered user's file (.USR), the names of the elements to be analysed taken from the specific analytical processing file (.SAP), and the addresses of those elements in

```
     .USR }       *******
     .GAP } ===> * RGN *--->.XCM                   PREPARATION
     .SAP }       *******     |
                     |        |                       STAGE
                     V        |
                   .REQ       |
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~|~~~~~~~~~~~~~~~~~~~~~~~~~~~~
                              V                     A
                           *******                  N   S
                           * SPT *                  A   T
                           *******                  L   A
                              |                     Y   G
                              V                     S   E
                            .XDT                    I
                              |                     S
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~|~~~~~~~~~~~~~~~~~~~~~~~~~~~~
                              V
                           *******
               .GAP ===> * MXX * <=== .REQ
                           *******
                              |                       P
                              V                       R
                            .IPF                      O
                             / \                      C
                            /   \                     E
                           /     \                    S
                   *******        ********            S
     .STD } ===>   * PXX *        * XRFA * <=== { .RCF  I
     .REQ }        *******        ********      { .REQ  N
                      |              |                G
                      V              V
                    .VAL           .RES               S
                       \           /                  T
                        \         /                   A
                         *********                    G
                         * INVAL *                    E
                         *********
                              |          *********
                              V          * INVAL  *
                            .VAL <-------* CVAL   *
                             / \         *********
~~~~~~~~~~~~~~~~~~~~~~~~~~~~/~~*~~\~~~~~~~~~~~~~~~~~~~~~~~~
   R               ------/     *     \------            R   P
   E       ********/           *           \*******     A   R
   P       * RGN *             *            * RAG *     W   E
   O       *******             *            *******         P
   R          |                *               |        F   A
   T          |                *               |        I   R
              V                *               V        L   A
   S        .LST               *             .RAW       E   T
   T          |                *               |            I
   A          V                *               V            O
   G        Print              *           Further          N
   E                           *           processing
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

Figure 5. XRFS data processing flow chart.

the general analytical processing file (.GAP).

b) X-ray command file (.XCM)

This contains such information as the count times for the various elements (both peak and background) and the last tray number. This information is to re-program the spectrometer microprocessor and to define the analysis sequence at run-time.

Analytical stage

The program SPT uses the information held in the XCM-file to control the analysis. The raw X-ray data is written to a file with the extension .XDT. This is created by the spectrometer and is stored on the computer disc. For each sample the XDT-file contains an address (corresponding to the tray number and the position in the tray) and for each element, the number of counts and the duration for both the peak and background(s).

Processing stage

The processing stage can be started at any time after the batch run is complete. It is split into a number of separate sub-stages depending on whether major or trace element data are required.

All the raw X-ray data, major and trace elements, are treated by the program MXX. This uses the files .XDT, .GAP and .REQ to generate an Intermediate Processing File (.IPF). Data on the monitor sample, which is measured periodically, is extracted from the XDT-file. The program tests this data for instrumental drift over the duration of the run and for significant drift or intensity variations at both the peak and background positions. If there is no significant drift or intensity variation, the monitor measurements are averaged. This ensures that any bias arising from the use of a monitor in ratio measurements is then constant for the run. This process is described more fully by Harvey and Atkin (1981). Any outlying monitor data are identified using the procedure described by Harvey (1974).

Correction for mass absorption is achieved by the use of the Compton intensity ratio. The corrected count ratio, K_c, for any individual determination is given by:

$$K_c = \frac{p - b}{m} \cdot \frac{C_m}{C_u}$$

(Harvey and Atkin, 1981)

where p is peak count ratio of the element of interest for the "unknown" or standard,

b is the background count ratio for the "unknown" or standard,

m is the peak count ratio on the monitor sample,

C_m is the Compton peak intensity for the monitor,

and C_u is the Compton peak intensity for the "unknown" or standard.

It is noted that the Compton peak ratio (C_m/C_u) used in the correction for mass absorption, although generally constant, changes when major element absorption edges are crossed (eg. after Fe and Ti). Other corrections which may be applied to the data include those for enhancement (by which the presence of some element may increase the count ratio), spectral overlaps (eg. Ti kα overlaps the V kβ peak) and the effects of grain size. These are discussed in more detail by Harvey and Atkin (1983).

The program MXX also makes an initial estimate of the elemental composition of all the samples. This is done by the use of a pre-existing set of calibration coefficients. These together with the corrected count ratios are stored in the IPF-file for later use.

a) Trace element data.

The trace element compositions are calculated by the program PXX. This uses a reference standards file (.STD) and the REQ-file together with the IPF-file. It works on one element at a time and compares the initial estimates for the reference standards present in the batch with the "accepted" values held in the STD-file. A simple linear calibration is calculated based on these "accepted" values. This has the form:

$$Y = \alpha_0 + \alpha_1 X$$

where Y is the estimated value,

X is the "accepted" value,

α_0 is the intercept,

and α_1 is the gradient of the slope.

The software is designed so that values for individual standards may be removed or altered in order to give a better calibration.

By using the same reference standards for each run a check may be kept on the stability of the calibrations. When this has been completed for all the elements the unknowns are processed.

The element values for the unknowns, reference standards and monitors are written to a VAL-file.

b) Major element data.

The count ratio data held in the IPF-file and the REQ-file are also used by the program XRFA (Appendix A). This program (option "P") is used to calculate the major element compositions of each sample. These compositions are then temporarily stored in a file having the extension .RES which has an identical structure to the VAL-files previously referred to. The calculation is based on regression coefficients previously calculated by a multiple linear regression technique. The coefficients are stored in a file NAS.RCF which is listed later (Table 2).

Multiple regression attempts to take into account the fact that every element affects every other element to some extent. That is, the concentration of the element j, (C_j), is a function of the count ratio of itself and all the other (significant) elements present:

$$C_j = f(Z_1, Z_2, \ldots, Z_m)$$

where Z is the count ratio of an element in a system of m elements.

A simple model has the form:

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_m X_m + \varepsilon$$

or

$$Y = \alpha_0 + \Sigma_{j=1}^{j=m} \alpha_j X_j + \varepsilon \qquad (3.i)$$

where Y is dependent variable (major element composition),

α_0 is the constant term,

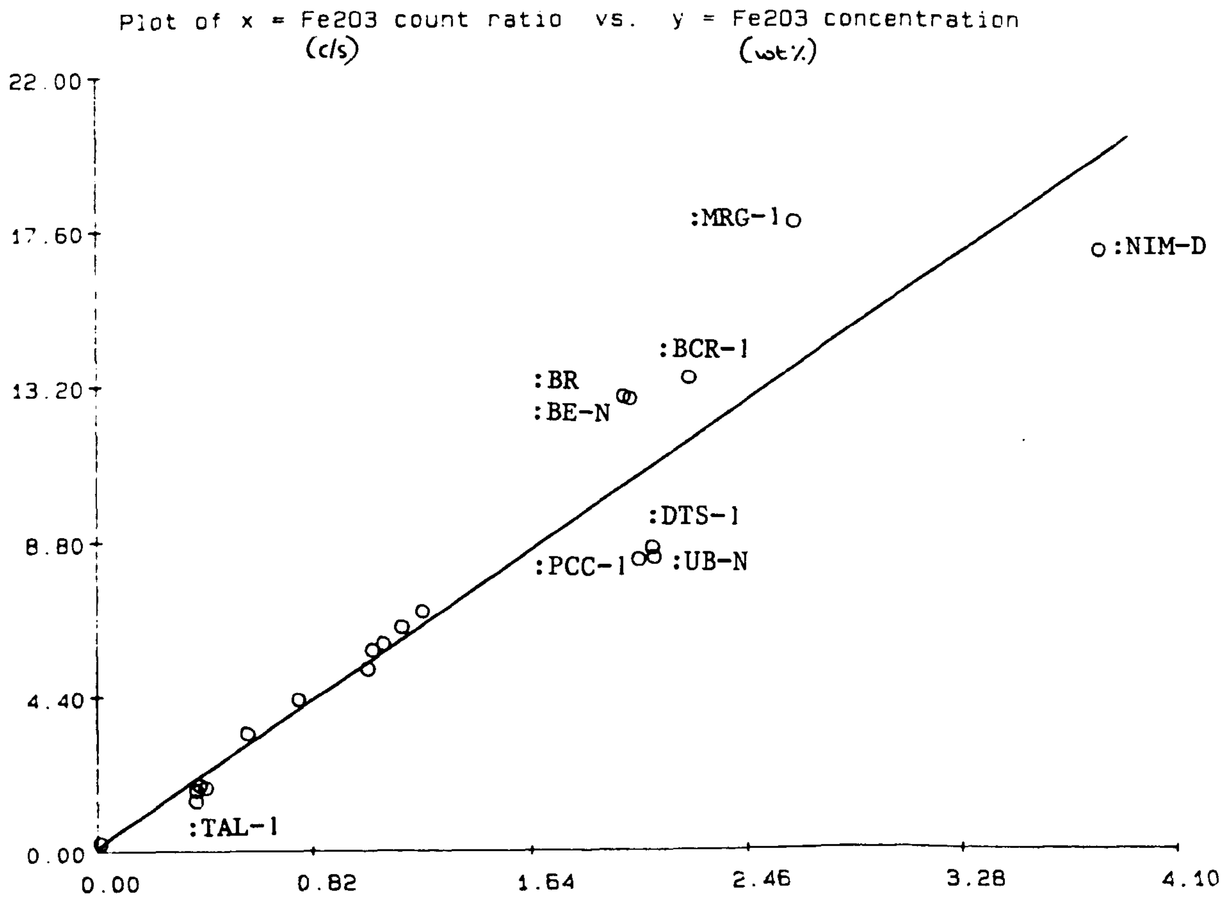
α_j are the coefficients,

X_j are the independent variables (count ratios of the major elements),

and ε is the random error.

This approach to the processing of major element data was taken in an attempt to correct for the matrix effects present when analysing pressed powder pellets. Using a conventional simple linear calibration technique reasonable results for major elements may be obtained if a limited range of rock types are being analysed and there are a number of good reference standards available. However, if a wide range of rock types are to be studied within the same batch, the calibration lines for several elements resulting from the reference standards tend to be poor with a moderately large standard error. Figure 6 shows the calibration lines for Fe_2O_3 and MgO, which both show a relatively poor fit. It was noted by Leake et al (1969) that for many elements, different rock types gave significantly different calibrations. Although in many instances specific reasons were not provided, it was suggested that many calibrations appeared dependent upon the mass absorption coefficients and upon mineralogical variations between different rock groups. It was observed that the largest scatter was most often seen in the basic rocks which show the greatest mineralogical variation. Other suggested reasons included spectral overlaps, sloping backgrounds and higher order reflections of other elements.

Finally the RES- and VAL-files containing the major and



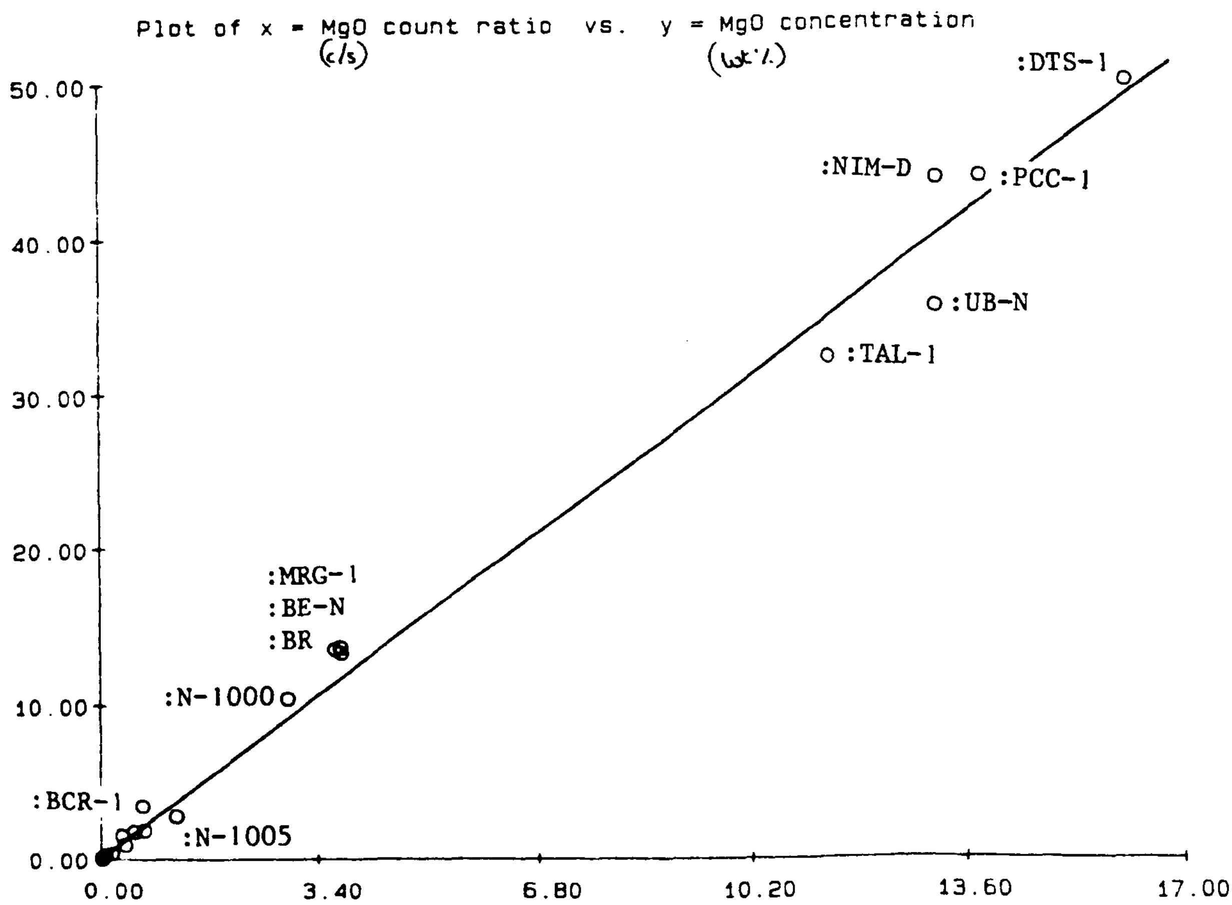


Figure 6. XRF calibration lines for Fe_2O_3 and MgO.

trace element data respectively are combined using option 1 of the program INVAL (Appendix A). The resulting file carries the extension .VAL. The second option of INVAL and the program CVAL may be used at this stage. The former was designed to combine two REQ- and VAL-files (eg. Rh- and Cr-tube data). The latter will alter all values of a particular element using the equation:

$$Y = \alpha_0 + \alpha_1 X$$

where Y is the true value,
X is the original value,
α_1 is the gradient,
and α_0 is the intercept.
An example of its use was in the correction of V values (V kα measured) which were affected by an overlap with the Ti kβ line.

Report stage

The report stage (RGN) uses the VAL-file together with the GAP- and REQ-files to produce a neat copy of the analyses ready for printing. This may include comments such as detection limits, range of calibration and major element totals.

Raw data file preparation

The VAL-file may also be converted by the program RAG into the self-formatting raw data file. This type of file is referred to frequently throughout this work as a RAW-file and carries the extension .RAW. A full description of this file which was developed at the Geology Department is described in

This RAW-file is then sub-divided into smaller RAW-files holding data for particular traverse lines for further processing. Only these small RAW-files together with the last generation VAL- and REQ-files are retained on the computer disc.

Derivation of the regression coefficients

The regression coefficients used by the program XRFA (option "P") are calculated in two stages. Early in the project 24 standards were analysed in duplicate for the 10 major elements. These are listed in Table 1 and were selected to cover the wide range of rock types found on the Lizard Complex. Processing of the data was taken to the MXX stage (Fig.5) with an IPF-file produced for the data.

Option "S" of the program XRFA creates a file xxx.RAW which consists of the "accepted" major element compositions of the various standards analysed followed by the corresponding count ratios. The former are extracted from the reference standards file (.STD) by the subroutine GETSTD, with the count ratios being taken from the IPF-file. This subroutine, together with all other subsequent subroutines referred to in this work may be found in Appendix A.

The regression coefficients were calculated by the program MLR (Option "A") which may be found in Appendix A. In this program, which was based originally on that of Davis (1973), the selected dependent and independent variables are

Ultrabasic
~~~~~~~~~~

:DTS-1 ..... Dunite (USGS)
:PCC-1 ..... Peridotite (USGS)
:UB-N ..... Serpentinite (ARNT)
:NIM-D ..... Dunite (SARM)
:UM-1 ...... (CANMET)
:UM-2 ...... (CANMET)
:UM-4 ...... (CANMET)

Basic
~~~~~

:W-1 .... Basalt (USGS)
:BHVO-1 .... Basalt (USGS)
:BR .... Basalt (ARNT)
:BE-N ...... Basalt (ARNT)
:N-1000 .... Gabbro (Nottm.Univ.)
:MRG-1 ..... Gabbro (CANMET)
:NIM-N ..... Norite (SARM)
:T-1 .... Tonalite (TANZ)

Intermediate
~~~~~~~~~~~~

:GSP-1 ..... Granodiorite (USGS)
:AGV-1 ..... Andesite (USGS)

Acid
~~~~

:NIM-G ..... Granite (SARM)
:ANG-G ..... Anorthosite (ANRT)
:RGM-1 ..... Rhyolite (USGS)

Others
~~~~~~

:TAL-1 ..... Talc (Nottm.Univ.)
:BCS-375 ... Soda feldspar (BCS)
:FK-180 .... Siliceous limestone (Bristol Univ.)
:NBS-1B .... Argillaceous limestone (NBS)

USGS ..... United States Geological Survey
ANRT ..... Association Nationale de la Recherche Technique
SARM ..... National Institute for Metallurgy (S.Africa)
CANMET ... Canadian centre for Mineral and Energy Technology
TANZ ..... Ministry of industries, mineral resources and power (Tanzania)
BCS ...... British Chemical Society
NBS ...... National Bureau of Standards

Table 1. Standards used in calculating the multiple linear regression coefficients.
~~~~~~

held in a one-dimensional array.

The usual way of calculating the least squares solution and hence the regression coefficients from equation 3.i is :

$$[\ A\ ].[\ \hat{\alpha}\ ] = [\ b\ ]$$

where [A] is the uncorrected sum of squares and cross-products matrix of the independent variables,
[$\hat{\alpha}$] is the vector of the coefficient estimates,
and [b] is the vector of uncorrected sums and cross-products of the dependent variable.
However, this approach may lead to some very large values in [A], particularly on the main diagonal which contains the sum of squares term. This may in turn lead to serious truncation of the data and hence affect accuracy (Longley, 1967).

In order to avoid this problem a number of modifications have been included in the algorithm to increase the accuracy of the computed regression.

The data are standardized by the subroutine OSTAND. The definitional equation for standard deviation is used so as to minimize problems of truncation of data:

$$\sigma = \sqrt{[\ \Sigma\ (\ x_i\ -\ \mu\ )^2\ ]}$$

where σ is the standard deviation,
x_i is the i^{th} value of the population X,
and μ is the mean of the population X.
By standardizing the data the magnitude of the variables is greatly reduced. The resulting standardized values for the individual variables which are calculated by:

$$Z_i = \frac{x_i - \mu}{\sigma}$$

have zero means and are measured in units of standard deviation.

Also, as a result of standardization, the coefficient α_o (Equation 3.i) becomes equal to zero.

By converting the standardized data to correlations round-off errors are further minimized, as all the entries in the matrix lie in the range +1.0 to -1.0. This is done by the subroutine OCORRL. Also, as the correlation matrix is symmetric about its leading diagonal, only half of the matrix need be stored in memory. The correlation coefficients are calculated by:

$$r_{jk} = \frac{SP_{jk}}{\surd[\ SS_j * SS_k\ ]}$$

$$= \frac{\Sigma X_j X_k - (\Sigma X_j * \Sigma X_k)/n}{\surd[\ (\Sigma X_j^2 - (\Sigma X_j)^2/n) * (\Sigma X_k^2 - (\Sigma X_k)^2/n)]}$$

where r_{jk} is the correlation coefficient between the j^{th} and k^{th} variable,

SP_{jk} is the sum of products,

and SS_{jk} is the sum of squares.

As the data have been previously standardized, the size of the squared terms in the sum of products and sum of squares are no longer so large as to cause problems with truncation of data.

The matrix equation for the least squares solution for the regression now has the form:

$$[\ r_{xx}\ ]\ .\ [\ A\ ] = [\ r_{xy}\ ]$$

where $[\ r_{xx}\ ]$ is the m X m matrix of correlations between the independent variables,

$[\ r_{xy}\ ]$ is the column vector of the correlations between the dependent and independent variables,

and $[\ A\ ]$ is the column vector of the standardized partial regression coefficients.

This may be solved by:

$$[\ A\ ] = [\ r_{xx}\ ]^{-1} \cdot [\ r_{xy}\ ]$$

The inversion of the matrix $[\ r_{xx}\ ]$ is performed by the subroutine MATINV. The resulting standardized partial regression coefficients must be <u>unstandardized</u> in order that they can be used in a predictive equation with raw data. This is done by the transformation:

$$\hat{\alpha}_j = A_j \cdot \frac{s_y}{s_j}$$

where s_j is the standard deviation of the j_{th} independent variable, X_j,

s_y is the standard deviation of the dependent variable Y,

and $\hat{\alpha}_j$ is the partial regression coefficient for the j_{th} variable.

The constant term, $\hat{\alpha}_o$, is found by:

$$\hat{\alpha}_o = \bar{Y} - \hat{\alpha}_1\bar{X}_1 - \hat{\alpha}_2\bar{X}_2 - \ldots - \hat{\alpha}_m\bar{X}_m$$

By using these partial regression coefficients, the estimated values for the dependent variables can be calculated together with the deviations. Summary statistics are also calculated including the various sums of squares (total, residual and deviations), F-test value, t-test value, correlation coefficient and the percentage of goodness of fit (100 X R^2).

Individual samples and elements may be removed (and re-inserted) from the regression calculation to improve the regression. Results may either be sent to the screen or to file. When satisfied with the regression obtained, the regression coefficients may be written to the file xxx.RCF.

Table 2 lists the regression coefficients for each of the independent variables in the equation:

$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_m X_m$

where Y is dependent variable (major element composition),

α_0 is the constant term,

α_m are the coefficients,

and X_m are the independent variables (count ratios of the major elements).

It additionally lists the % goodness of fit of the regression and the maximum and minimum values outside of which the regression may become unstable.

Whilst this multiple linear regression approach to the major element data has been successful over the last two and a half years when compared to the straight line calibration technique (Table 3), it can also be seen that the regression has deteriorated for most elements over time. In retrospect, to avoid this deterioration, it is felt that the regression coefficients should be recalculated for each run. It is also suggested that a stepwise technique (eg. Draper and Smith, 1966; Mather, 1976) should have been used at the start of the project. This would have allowed the best combination of elements for individual regressions to be selected. This would, in turn, have removed the necessity to analyze all the major elements in later analytical runs if only a few elements

Dependant variable	% Goodness of fit	Min/Max values	Intercept	Independant variables SI02	AL203	TI02	FE203	MGO	CAO	NA20	K20	MNO	P205
Si02	99.95	37.60/73.47	17.3918	34.1589	4.3098	-0.7203	-0.2130	0.0627	-0.9039	-1.4436	1.4724	0.6220	-0.5272
AL203	99.85	0.24/29.80	5.1482	-3.0190	12.6528	0.0442	0.2704	-0.1353	-0.2666	0.5668	0.1539	-1.0599	-0.1064
TI02	99.95	0.01/3.69	-0.0211	0.0050	-0.0137	0.6870	-0.0255	0.0013	0.0268	-0.0157	0.0118	0.0322	0.0097
FE203	99.67	1.88/17.83	-7.4453	3.8706	1.6682	0.3667	6.4890	0.1444	1.2466	-0.4898	-0.0655	-1.7716	0.2294
MGO	99.99	0.06/49.83	7.5539	-3.2176	-4.8850	-0.9219	0.5010	2.5155	0.6679	0.1155	0.6576	1.9006	-0.1136
CAO	99.99	0.15/14.77	-1.5031	1.0585	2.2785	0.1568	-0.1211	0.0335	4.0777	-1.1520	-0.4992	0.3536	0.3131
NA20	99.90	0.01/4.39	1.6883	-1.0557	-0.4458	0.0339	-0.0733	-0.0498	-0.1040	3.6133	0.1932	-0.0847	-0.3305
K20	99.98	0.00/5.53	0.8490	-0.2848	-0.4950	0.0062	-0.1153	-0.0378	-0.0357	0.2091	2.1189	0.0965	-0.1048
MNO	99.53	0.02/0.20	0.1123	-0.0292	-0.0470	-0.0009	-0.0042	-0.0077	0.0089	0.0032	-0.0087	0.0956	0.0027
P205	99.57	0.00/1.05	0.7578	-0.4946	0.0045	0.0328	-0.0684	-0.0225	-0.0993	0.0194	0.0044	0.0391	0.2020

Table 2. Regression coefficients used in determining major element compositions.

Major element	Straight line calibration Aug.1985	Multiple linear regression Nov.1982	Aug.1985
SiO_2	2.280	1.912	2.167
Al_2O_3	0.843	0.681	0.765
TiO_2	0.049	0.027	0.042
Fe_2O_3	1.916	0.838	0.847
MgO	1.929	1.409	1.510
CaO	0.259	0.100	0.214
Na_2O	0.261	0.289	0.280
K_2O	0.126	0.100	0.102
MnO	0.027	0.008	0.005
P_2O_5	0.041	0.028	0.040

Table 3. Standard errors of major element data obtained from straight line calibration and multiple linear regression techniques.

$$SE = \sqrt{\frac{(\Sigma \mathrm{Dev}\, n^2)}{n-2}}$$

were required.

3.4 Sampling and analytical errors

The sampling exercise was spread over a two year period with samples being analysed in batches over that time. The results of the geochemical mapping are therefore dependant on a consistent sampling strategy, an understanding of the errors which may be present as a result of sampling a natural medium and of running a series of analytical batches over time.

Analysis of variance is the most widely used method of posteriori inspection of survey data. It involves separating the total variance of a collection of measurements into its various sources or components. These individual sources of variability may then be compared by an F-test. The theory of error in geochemical data is reviewed by Miesch (1967). Detailed descriptions of the variety of models for analysis of variance that may be used are provided by Griffiths (1967).

Fixed analysis of variance model.

In this instance a fixed analysis of variance model is applied to four groups to identify any variation between analytical batches. These groups consist of monitor samples which are analysed periodically by the XRFS. Each group contains data obtained over a period of approximately three months.

By comparing the variations within groups of data with the variation between groups, a check may be made on the variation over a long period of time. This comparison is made by an F-test. If the between groups variation is significantly greater than the within groups variation, the null hypothesis that the four groups have equal means is rejected.

The general equation for the calculation of variance is:

$$\hat{\sigma}^2 = \frac{SS}{(ndf)}$$

where $\hat{\sigma}^2$ is the estimated variance,

SS is the corrected sum of squares,

and (ndf) is the number of degrees of freedom associated with the data.

For a two group situation the corrected sum of squares may be written as:

$$SS = \sum_{i=1}^{i=n} \sum_{j=1}^{j=m} (X_{ij} - \bar{X})^2$$

where X_{ij} is the j^{th} sample of the i^{th} group,

and $\bar{X}$ is the grand mean of all samples.

This may be expanded as:

$$SS = \sum_{i=1}^{i=n} \sum_{j=1}^{j=m} [(X_{ij} - \bar{X}_j) - (\bar{X}_j - \bar{X})]^2$$

where $\bar{X}_j$ is the mean value of the j^{th} group.

This may be further expanded to give a within groups sum of squares (SSW) and a between groups sum of squares (SSB) respectively:

$$SS = \sum_{i=1}^{i=n} \sum_{j=1}^{j=m} (X_{ij} - \bar{X}_j)^2 + \sum_{i=1}^{i=n} \sum_{j=1}^{j=m} (\bar{X}_j - \bar{X})^2 + 0$$

From these corrected sums of squares the two sources may be used to calculate the values of the mean squares (ie. the sample based estimates of the two sources of variation):

$$MSB = \frac{SSB}{(n-1)} \quad \text{and} \quad MSW = \frac{SSW}{(N-1)}$$

where MSB is the variation between groups,

n is the number of groups,

MSW is the variation within the groups,

and N is the total number of samples (m*n).

The F-statistic is calculated by:

$$F = \frac{MSW}{MSB}$$

This value is compared against the critical value of F for (N-1) and (n-1) degrees of freedom at the selected level of significance. If the calculated value exceeds the critical value (Dunstan et al, 1979) the hypothesis that the groups have equal means is rejected.

Table 4 shows the summarized results of the fixed analysis of variance model applied to the monitor samples by the program ERR1 (Appendix A). This shows that the monitor values for several elements have, over a two and a half year period remained constant. Many of the elements however, particularly Al_2O_3, TiO_2, MgO, CaO, P_2O_5, have extremely high F-values. If this test were to be rigorously applied the majority of the elements should be discarded. It is, however, considered that the analysis of variance technique is too sensitive to small changes over a long period of time and that, although many of the results give an indication of variance within the data, they should be rejected. The reasoning behind this may be best explained by taking two examples which show the greatest F-values:

Files read;
SYO:NASM1.RAW
SYO:NASM2.RAW
SYO:NASM3.RAW
SYO:NASM4.RAW

Elmt	SSB (3 d.f)	SSW (194 d.f)	MSB /	MSW	F-calc		Mean / %CV (Wt%)
SIO2	15.700	24.136	5.23350	0.12441	42.0661		52.66/ 0.85
AL2O3	5.607	1.778	1.86893	0.00917	203.9033		13.54/ 1.43
TIO2	0.082	0.025	0.02743	0.00013	212.0630		0.66/ 3.53
FE2O3	0.023	0.774	0.00770	0.00399	1.9322	**	5.25/ 1.21
MGO	2.706	0.420	0.90189	0.00217	416.3422		3.32/ 3.78
CAO	0.215	0.069	0.07160	0.00036	201.1282		4.72/ 0.80
NA2O	0.100	0.462	0.03349	0.00238	14.0704		3.28/ 1.63
K2O	0.028	0.062	0.00942	0.00032	29.4911		2.01/ 1.06
MNO	0.000	0.001	0.00004	0.00000	8.5062		0.10/ 2.37
P2O5	0.010	0.004	0.00324	0.00002	143.9349		0.24/ 3.52
BA	12595.941	57477.801	4198.64697	296.27731	14.1713		973ppm/ 1.93
CO	157.713	1722.715	52.57104	8.87998	5.9202		43ppm/ 7.20
CR	814.342	2046.731	271.44739	10.55016	25.7292		81ppm/ 4.72
CU	1462.572	1171.305	487.52405	6.03765	80.7473		62ppm/ 5.87
GA	626.711	893.505	208.90369	4.60569	45.3577		54ppm/ 5.16
NI	36.382	1299.530	12.12720	6.69861	1.8104	**	63ppm/ 4.14
PB	129.424	1882.060	43.14132	9.70134	4.4469	**	49ppm/ 6.53
RB	17.541	3086.617	5.84684	15.91040	0.3675	**	88ppm/ 4.48
SC	40.923	694.591	13.64099	3.58036	3.8099	**	11ppm/17.02
SR	3949.531	104403.555	1316.51038	538.16266	2.4463	**	805ppm/ 2.91
V	473.773	2372.625	157.92448	12.23002	12.9129		103ppm/ 3.67
Y	93.663	2068.309	31.22095	10.66139	2.9284	**	73ppm/ 4.52
ZN	76.840	1954.650	25.61349	10.07552	2.5422	**	92ppm/ 3.48
ZR	121.886	7239.806	40.62858	37.31859	1.0887	**	180ppm/ 3.38

** ..... F-calc < F-crit

F (0.5,3,194) = 4.452

Table 4. Analysis of variance table (Fixed model) for monitor samples.

a) MgO, $F_{(0.5,3,144)} = 416.34$. This value appears to be excessively large and therefore at first consideration the hypothesis that the means of the batches were equal should be rejected and the element should not be used. If, however, the coefficient of variation, %CV, is studied (Table 4) it will be seen that it is 3.78% for 3.35% MgO. This may be rewritten as 3.78 $\pm$ 0.13% at one standard deviation. As the samples collected during the project ranged between 0.00% and greater than 30%, it is suggested that this deviation will not significantly effect the results of mapping based on the multi-element geochemistry of individual samples.

b) TiO_2, $F_{(0.5,3,144)} = 212.06$. By taking a similar approach to above, this shows a %CV of 3.53% at 0.66% TiO_2. This is equivalent to 0.66 $\pm$ 0.02% TiO_2 which again is considered to be insignificant as the TiO_2 values in the district have a range of approximately 7%. Additionally all major element data are normally only quoted to 0.01%.

<u>Analytical precision</u>

The absolute value or accuracy is considered to be relatively unimportant to a geochemical survey of this type. The term accuracy in this work implies a close agreement between an estimate or group of estimates and the true value.

Precision, which is independent of accuracy, describes the reproducibility, or variation of data around the average value for the data. It is this relative repeatability that is generally taken to be the most important consideration. The concepts of accuracy and precision are described in some detail by Griffiths (1967).

Although it would be preferable to have accurate data, inaccurate data will have little effect on the overall interpretation so long as it is consistently inaccurate. This is only true, however, if the data is not going to be compared with other data from a different source.

A method of describing the precision of data is the use of the coefficient of variation (referred to earlier). This is a measure of the relative variability of a group of data. It takes into account the two main characteristics of the frequency distribution, the central tendency and dispersion (ie. the mean and standard deviation). It is calculated by:

$$\%CV = \frac{\text{Mean}}{\text{Std.devn.}} * 100$$

The precision of the method of X-ray fluorescence analysis for 6 elements over the last two and a half years is summarized in Figure 7. The other elements analyzed show a similar behaviour. These graphs show the relationship between the mean values of a series of replicate measurements of 14 samples which were analysed periodically during the project (standard and monitor samples).

From these it can be seen that as the mean value increases, the coefficient of variation tends to zero. Conversely, the coefficient of variation tends to infinity for lower concentrations.

All the points are plotted within the ornamented region with the bounding line representing the worst expected and measured coefficient of variation for a given mean

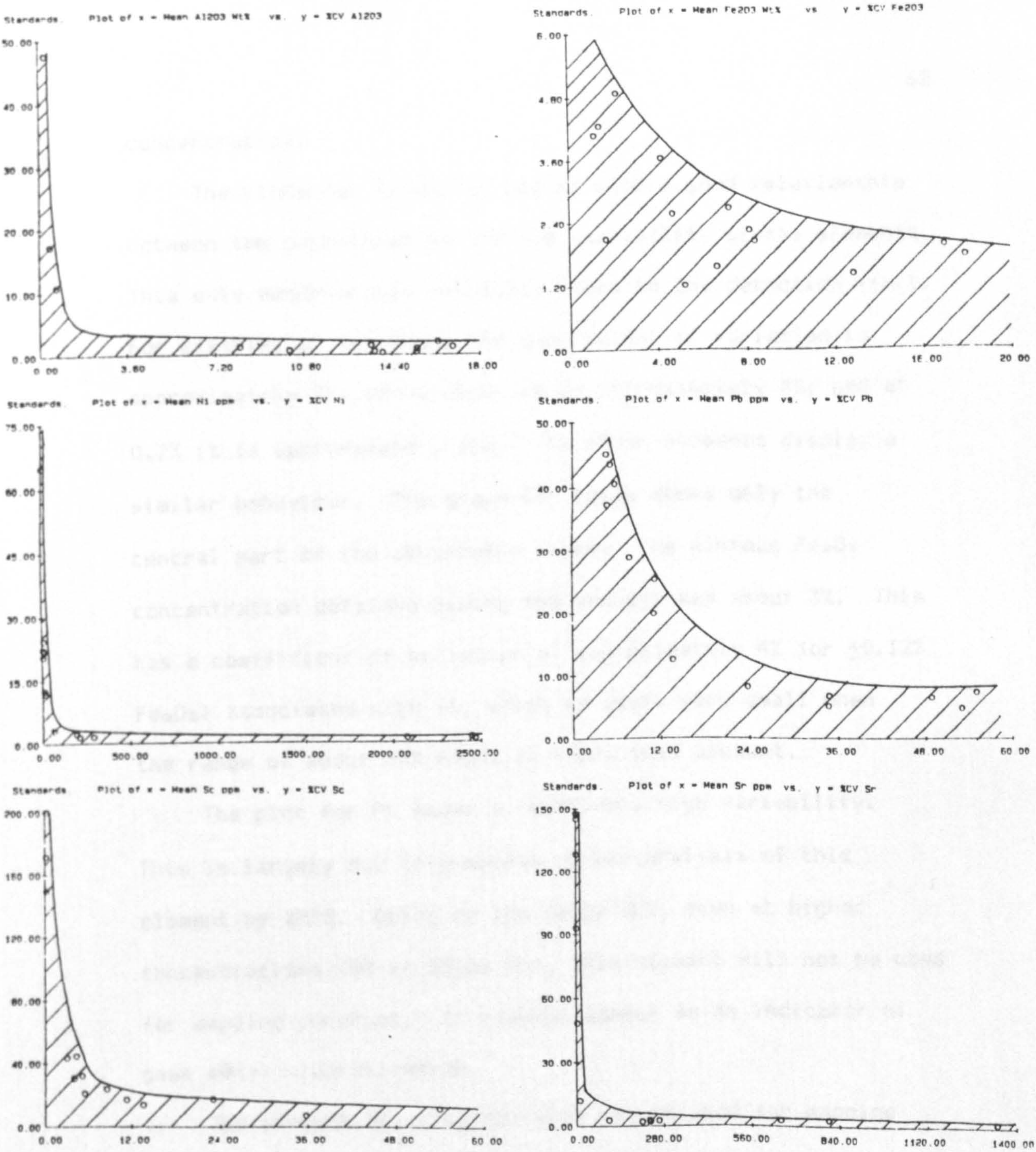


Figure 7. Plots of % coefficient variation against arithmetic mean for a variety of elements.

concentration.

The plots for Al_2O_3, Ni and Sr show a good relationship between the concentration and the variability of the elements. This only deteriorates seriously close to the detection limit. For example, at 16% Al_2O_3 the coefficient of variation is approximately 2%; at 3% Al_2O_3 it is approximately 4%; and at 0.7% it is approximately 10%. The other elements display a similar behaviour. The graph for Fe_2O_3 shows only the central part of the asymptotic curve. The minimum Fe_2O_3 concentration obtained during the project was about 3%. This has a coefficient of variation of approximately 4% (or $\pm$0.12% Fe_2O_3) associated with it, which is again very small when the range of about 20% Fe_2O_3 is taken into account.

The plot for Pb shows a relatively high variability. This is largely due to problems in the analysis of this element by XRFS. Owing to its large %CV, even at higher concentrations (8% at 55ppm Pb), this element will not be used for mapping purposes. It remains useful as an indicator of base metal mineralization.

The element Sc, like Pb, will not be used for mapping purposes. It also displays a high %CV across the range encountered during sampling the soils of the Complex. Initially this element was analysed using a Cr-tube anode which gave acceptable results. The measurement of this element using a different tube to all of the other elements (except Cs, which was analysed in the early part of the project) was extremely time-consuming. It was for that reason and the fact that the analysis of Cs was discontinued (Chapter 6.2.2) that it was decided to use the Rh-tube anode. As can be seen from the graph for Sc in Figure 7 this element does not give data with a high degree of precision when standard count times are used.

It should be noted that the poor precision exhibited by the latter two elements, Pb and Sc, is not confirmed by the fixed analysis of variance technique. This is due to the fact that the variation in the data existed both within and between the analytical batches.

Random analysis of variance model

If a sampling programme takes place in stages it is possible to separate the various sources of variation that may arise during each stage. The aim of the random model is to separate these components of variation and to compare them by the use of an F-test.

In order to assess the various sources of variation, four lithological units were sampled; gabbro (near Dean Quarry), Upper Landewednack hornblende schist (near Porthkerris), harzburgite (southwest of Coverack) and the cumulate zone (just north of Traboe Cross on Goonhilly Downs). In each area 16 samples were collected on a 4 X 4 metre grid. Later, during preparation, from each group 4 sub-samples were taken from 4 samples. Finally during analysis, which was carried out as a single run, one sample was analyzed 10 times. Figure 8 shows the detail of the various stages for one lithological unit.

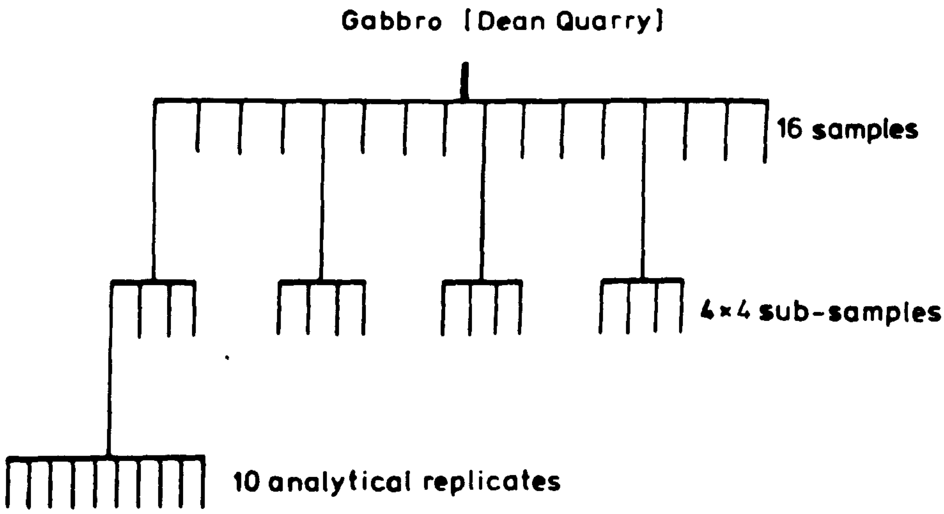


Figure 8. Multi-stage procedure used by random ANOVA model for one lithological unit.

The model describing a sample population has the form:

$X_i = \mu + V_i$ (Miesch, 1967)

where X_i is the concentration of some constituent of the i^{th} specimen,

μ is the arithmetic mean for all specimens in the population,

and V_i is the deviation from the mean.

The term V_i is a function of the various components or sources of variability within the population:

$V_i = f\ (\alpha + \beta + \gamma + \varepsilon)$

where α is the variability at the sampling site,

β is the variability due to sample preparation,

γ is the variability due to analysis,

and ε is the random error term which cannot be assigned to any particular source.

The γ term is generally considered to be a function of any machine instability, the sample matrix and the operator. It includes the random error term ε.

The β term describes those errors that arise as a result of contamination during preparation (eg. sieving and grinding) and from inhomogeneity in the powders. It also includes variation due to analysis.

The α term describes the uniformity of the various lithologies. It also includes the variation arising from sample preparation and analysis.

A comparison between the various components of variation may be made by the use of an F-test (as in the previous section). The calculations are performed by the program ERR2

(Appendix A). The method of calculation of the various mean squares is by the two-pass definitional equation for variance described in Chapter 3.3.

On the basis of the F-test values shown on Table 5 several comments may be made. Generally for the comparison between sample sites and both analytical replicates and sub-sample means (ie. a/c and a/b) the hypothesis that the two groups are equal is rejected. For most elements, the mean square for the sample site (MSa) is significantly greater than both the mean squares of the analytical replicates (MSc) and the sub-sample means (MSb). The most notable exceptions are those of Pb and Sc which were described and rejected earlier.

The comparison between variation due to sub-sampling and that arising from the analytical replicates shows an interesting relationship. The major elements, with the notable exception of Na, mostly show that the variation due to sub-sampling is significantly greater than that arising from analytical error. In contrast, the trace elements, with the exception of Cr, generally show that the two groups of data have equal means. This implies that the errors arising during analysis of the trace elements are significantly large compared with those due to sample preparation.

The reason for this difference between the major and trace elements may be accounted for by studying the count ratios of the various elements obtained by XRFS. These show that the peak counts ratios for most of the major elements are between two and three orders of magnitude greater than those

Elmt ****	Group *****	MSa (15 d.f)	MSb (12 d.f)	MSc (9 d.f)	########## F-calc ########### a/c	 a/b	 b/c
SIO2	1	2.11?40	0.23087	0.01959	107.889	9.155	11.785
	2	0.45669	0.95384	0.01120	40.783	0.479**	85.179
	3	3.43164	0.22270	0.00641	535.410	4.740	115.[illegible]
	4	4.96872	0.45271	0.00668	744.034	10.976	67.790
AL2O3	1	1.37380	0.10418	0.00207	663.902	13.186	50.348
	2	0.22930	0.28852	0.00087	263.374	0.795**	331.393
	3	2.34674	0.01839	0.00221	1061.527	127.605	8.319
	4	0.79787	0.02981	0.00129	620.558	26.764	23.186
TIO2	1	0.04332	0.00023	0.00007	656.766	187.420	3.504
	2	0.02900	0.00425	0.00005	557.122	6.828	81.592
	3	0.01134	0.00015	0.00004	264.145	77.541	3.407
	4	0.00681	0.00048	0.00008	82.034	14.066	5.832
FE2O3	1	0.60451	0.01488	0.00293	206.097	40.623	5.073
	2	0.12806	0.04017	0.00084	152.847	3.188	47.947
	3	2.06530	0.03340	0.00281	734.734	61.842	11.881
	4	1.89703	0.01188	0.00245	773.940	159.724	4.845
MGO	1	0.81527	0.02284	0.00521	156.361	35.687	4.381
	2	0.08978	0.00975	0.00125	71.654	9.209	7.781
	3	7.11329	0.00576	0.00347	2049.051	1235.232	1.659**
	4	1.50735	0.01018	0.00472	319.649	148.031	2.159**
CAO	1	0.40748	0.00722	0.00059	693.564	56.409	12.295
	2	0.05870	0.01525	0.00040	145.634	3.848	37.845
	3	0.19857	0.00512	0.00015	1347.665	38.790	34.743
	4	0.02427	0.00488	0.00014	173.524	4.970	34.911
NA2O	1	0.01701	0.00125	0.00113	15.000	13.578	1.105**
	2	0.00519	0.00357	0.00181	2.861*	1.456**	1.965**
	3	0.00999	0.00099	0.00050	20.078	10.057	1.996**
	4	0.00588	0.00097	0.00043	13.679	6.085	2.248**
K2O	1	0.48630	0.00026	0.00003	17089.668	1879.415	9.093
	2	0.00132	0.00050	0.00003	39.448	2.661	14.822
	3	0.02373	0.00012	0.00004	588.552	195.457	3.011*
	4	0.02679	0.00014	0.00003	858.496	185.297	4.633
MNO	1	0.00035	0.00001	0.00001	51.955	33.954	1.530**
	2	0.00006	0.00002	0.00000	52.486	3.154	16.641
	3	0.00250	0.00001	0.00000	837.138	173.809	4.816
	4	0.00249	0.00001	0.00000	1039.322	187.959	5.530
P2O5	1	0.00149	0.00003	0.00001	111.395	49.578	2.247*
	2	0.00026	0.00014	0.00001	23.739	1.954**	12.149
	3	0.00045	0.00016	0.00000	206.248	2.785	74.053
	4	0.00080	0.00009	0.00001	116.138	8.424	13.787
BA	1	833.38501	139.82239	106.34362	7.837	5.960	1.315**
	2	85.91117	78.47421	97.23316	0.884**	1.095**	0.807**
	3	1019.06049	72.15089	34.95495	29.154	14.124	2.064**
	4	718.59442	36.73268	75.56219	9.510	19.563	0.486**
CO	1	14.96872	10.87899	14.75740	1.014**	1.376**	0.737**
	2	16.31567	5.43811	7.36229	2.216**	3.000	0.739**
	3	288.06543	5.05936	10.92835	26.359	56.937	0.463**
	4	401.45496	5.33684	6.81614	58.898	75.223	0.783**
CR	1	829.12280	44.49226	6.65403	124.605	18.635	6.687
	2	153.57353	34.99477	4.28144	35.870	4.388	8.174
	3	121443.67969	1191.36926	215.63562	563.189	101.936	5.525
	4	66604.14062	692.53278	88.38339	753.582	96.175	7.836
CU	1	39.05981	3.09238	1.41166	26.961	12.308	2.191**
	2	22.00256	2.55469	2.58705	8.505	8.613	0.987**
	3	26.24993	3.43702	1.55410	16.891	7.637	2.212**
	4	10.36884	3.60639	2.59398	3.997	2.875	1.390**
GA	1	2.20265	1.55558	1.19026	1.851**	1.416**	1.307**
	2	0.95199	0.26671	0.26055	3.654	3.569	1.024**
	3	2.79307	0.76047	0.43063	6.486	3.673	1.766**
	4	0.77815	1.37530	0.34343	2.266**	0.566**	4.005
NI	1	63.91162	2.43854	1.62900	39.234	26.209	1.497**
	2	19.85579	6.61051	1.16156	17.094	3.004	5.691
	3	177392.98437	293.96704	245.27512	723.241	603.445	1.199**
	4	77322.88281	175.77205	141.11391	547.947	439.904	1.246**
PB	1	6.42602	3.90467	6.66135	0.965**	1.646**	0.586**
	2	13.99355	7.33664	2.89119	4.840	1.907**	2.538*
	3	5.08439	4.02286	3.73052	1.363**	1.264**	1.078**
	4	5.77999	4.46292	2.78885	2.073**	1.295**	1.600**
RB	1	130.13651	1.15748	1.29630	100.391	112.431	0.893**
	2	1.51839	1.37659	1.45043	1.047**	1.103**	0.949**
	3	25.09371	1.09706	0.92741	27.058	22.873	1.183**
	4	17.85618	0.49243	1.52532	11.707	36.262	0.323**
SC	1	11.91208	10.83022	10.26237	1.161**	1.100**	1.055**
	2	8.98355	5.09039	11.08244	0.811**	1.765**	0.459**
	3	15.13707	3.74337	5.73960	2.637*	4.044	0.652**
	4	12.39166	3.23960	4.44871	2.785*	3.825	0.728**
SR	1	275.87222	1.96790	1.82613	151.069	140.186	1.078**
	2	55.20628	1.85548	4.16500	13.255	29.753	0.445**
	3	96.92989	2.07958	0.82415	117.612	46.610	2.523*
	4	7.50858	1.09466	5.16093	1.455**	6.859	0.212**
V	1	441.62088	17.41067	9.45545	46.705	25.365	1.841**
	2	66.39066	13.64149	6.95254	9.549	4.867	1.962**
	3	202.50005	3.71061	10.13342	19.983	54.573	0.366**
	4	22.68528	5.98470	5.10411	4.445	3.791	1.173**
Y	1	6.08933	0.85287	0.93198	6.534	7.140	0.915**
	2	1.20775	0.63553	0.59860	2.018**	1.900**	1.062**
	3	11.44056	0.58387	0.51612	22.166	19.594	1.131**
	4	0.61709	0.79851	0.31796	1.941**	0.773**	2.511*
ZN	1	1818.28784	6.54853	2.41921	751.605	277.664	2.707*
	2	50.86968	7.28741	3.73507	13.619	6.980	1.951**
	3	19.23845	2.97141	3.89980	4.933	6.475	0.762**
	4	104.86827	5.41753	4.65225	22.541	19.357	1.164**
ZR	1	391.95789	14.37785	13.05126	30.032	27.261	1.102**
	2	50.85051	14.58918	2.66483	19.082	3.485	5.475
	3	1167.89441	25.30630	14.80387	78.891	46.150	1.709**
	4	609.69434	9.61970	22.56905	27.015	63.380	0.426**

* ..... F-crit > F-calc @ 5% level of significance
** ..... F-crit > F-calc @ 10% level of significance

ie. the hypothesis that the 2 groups have equal means is accepted.

Source of variation (No.of samples/file)	Groups ****** 1 Gabbro	2 U.Land.	3 Harzburgite	4 Cumulate zone
a) Within sampling sites (16)	NAS50.RAW	NAS51.RAW	NAS52.RAW	NAS53.RAW
b) Within sub-sampling means (4)	{NAS50A.RAW {NAS50B.RAW {NAS50C.RAW {NAS50D.RAW	NAS51A.RAW NAS51B.RAW NAS51C.RAW NAS51D.RAW	NAS52A.RAW NAS52B.RAW NAS52C.RAW NAS52D.RAW	NAS53A.RAW NAS53B.RAW NAS53C.RAW NAS53D.RAW
c) Within analytical replicates (10)	NAS50Z.RAW	NAS51Z.RAW	NAS52Z.RAW	NAS53Z.RAW

Table 5. Analysis of variance table (Random model).

of the trace elements. This is due largely to the significantly higher concentrations of the major elements (generally between 0.1 and 70%). The element Na shows very low peak count ratios due to the effects of absorption at the high wavelength (low atomic number) end of the X-ray spectrum. It is noted that the low count ratios could be increased if longer count times were employed. The application of increased count times are described by Galson et al (1983) and in more general terms by Harvey and Atkin (1983).

The above concept also accounts for the reason why the major elements generally give higher levels of precision than the trace elements. If fusion beads were used, assuming count times remained constant, the levels of precision would be decreased (as the sample is diluted considerably). The resulting data would, however, be more accurate (due to removal of the matrix effects).

The trace elements have very high mean squares for the analytical replicates (MSc) in comparison with the major elements. This is again a function of the counting statistics. Due to the elements being present in low concentrations (relative to the major elements) and the relatively short count times, the variances associated with the analytical measurements are several orders of magnitude higher than those of the major elements. The anomaly in Cr may be due to discrete grains of chromite which may give rise to a nugget effect during sample preparation.

The mean squares (or variances) of the various sampling sites shown in Table 5 provide an indication of the relative variability of the different lithological units. This variability appears to be greatest in the ultrabasic units, although it should be remembered that these groups show concentrations of the greatest magnitude. The very high variation in the Zn for the gabbro is due to the effects of minor mineralization in the area and does not reflect the 'normal' background values. The variability of the various units is used later as an aid to the identification of some of the lithological units.

CHAPTER 4

NATURE AND GEOCHEMISTRY OF SOILS OF THE AREA

4.1 Introduction

As an introduction to the soils of the area the various processes which operate in the transition from rock to soil are reviewed. A description is also provided of the various products which are released or formed during the weathering process.

4.1.1 Weathering processes

Weathering is the alteration of rocks and minerals at or near to the Earth's surface. It is the mechanism by which the various components of the parent material can achieve equilibrium with the environment. There are three main forms of weathering; physical, chemical and biological activity.

The processes of physical weathering include all of those which cause rock disintegration. They are usually the dominant mechanism in extreme climatic environments and do not cause substantial changes to the geochemistry or the mineralogy of the rock. Under normal conditions chemical weathering is the dominant factor in governing the nature of the weathering products. Biological activity is generally restricted to the soil profile and may under certain conditions play an extremely important role in rock decomposition and soil formation.

The chemical agents of weathering may have a very great effect on the composition, properties and texture of rocks and their constituent minerals. The processes which may take place rarely work separately and include hydrolysis, hydration, solution, cation exchange reactions and oxidation/reduction.

Hydrolysis. This is the most important process in the destruction of the common silicates and aluminosilicates. It is the replacement of cations in the mineral structure by H^+ ions from solutions. Cations that are released by this reaction may either be removed in solution, or held as a part of the crystal lattice of clay minerals, or held as exchange ions adsorbed to the surface of colloidal particles. These retained ions are then available for subsequent reaction and exchange with the constituents of other passing solutions. Owing to the variation in mineral structures, the products of hydrolysis may be different. The basic cations (Na, K, Ca and Mg) are always the first to be replaced by H^+ ions. The stage which most affects the orthosilicates (eg. olivine) and the chain silicates (eg. pyroxenes and amphiboles) is the removal of iron. These Fe ions link together the individual tetrahedra or tetrahedral chains and therefore the result of their removal is a high degree of decomposition. The removal of the basic ions from the framework silicates (eg.feldspars) does not have the same marked affect. Subsequent removal of aluminium from the tetrahedra, however, causes severe weakening of the crystal lattice. This in turn leads to the complete disintegration of the mineral. Some of the factors that affect the rate of hydrolysis include surface area, pH, availability of solutions and temperature.

Hydration. This is the absorption of water by the crystal lattice of a mineral. It is generally not important on its own in the early stages of weathering. It may be of greater importance to the weathering process in hydration prior to hydrolysis. It may also affect secondary minerals formed by hydrolysis.

Together both hydrolysis and hydration are extremely important in the decomposition of many of the rock-forming silicates, and also in ionization and colloid formation. They may in turn allow other reactions to take place.

Solution. Most minerals are soluble to a lesser degree in mild acids such as carbonic acid which may result from rainwater mixing with dissolved oxygen and carbon dioxide in the atmosphere. Percolation through the soil may add organic compounds and further carbon dioxide.

Cation exchange reactions. This is the ability of a material to adsorb cations and is an extremely important mechanism in the development of soils. It depends largely on the amounts and types of clay and organic matter present. It arises as a result of:

i) Unsatisfied bonds at the edge of crystals;

ii) An increased number of charges due to isomorphous replacement. This is the substitution of one cation for another (eg. Al^{3+} for Si^{4+}) which produces an inbalance in the charges within the structure.

It can enable large amounts of certain elements to be adsorbed (Chapter 4.1.2). Particle size, pH, surface area, amount of soil moisture and degree of crystallinity may all affect the ability of clay minerals and humus material to adsorb these elements. Not all elements are adsorbed to the same extent by these materials. As a general rule (Kelly, 1948) lower valency cations are less strongly adsorbed than higher valenry cations:

$Na^{+}<Ca^{2+}<Al^{3+}<Th^{4+}$;

and under equal conditions and a constant valency, the cation with the lower atomic number and smaller ionic radius will be less strongly adsorbed:

$Li^{+}<Na^{+}<K^{+}<Rb^{+}<Cs^{+}$

$Mg^{2+}<Ca^{2+}<Sr^{+}<Ba^{2+}$.

Jenny (1968) has suggested, however, that it is the manganese and iron oxides that are the controlling factors in the fixation of many of the common metals (eg. Zn, Cu, Ni, Co) in the near surface weathering zone.

Oxidation/Reduction. Iron is the principle element affected by this process. It commonly exists in the Fe^{2+} form in many rock-forming minerals. Upon reaching the oxygenated hydrosphere it is oxidized to Fe^{3+}. The equilibrium of the crystalline lattice breaks down and the mineral therefore becomes more vulnerable to further weathering.

4.1.2 Products of weathering

The weathered prooucts of rocks may take three forms: residual primary minerals, secondary minerals that are stable in the weathering environment, and soluble material that may be removed from the weathering environment.

The most common igneous and metamorphic minerals are unstable in the weathering environment and eventually alter to a more stable form. The most resistant minerals take the greatest length of time to decompose. This results in the fact that the common rock-forming minerals most often found in a residual soil are quartz and muscovite. Some of the accessory minerals which may be significant in soils because of their resistance to chemical weathering include magnetite, ilmenite, rutile, zircon, tourmaline and sphene.

As previously recognized most primary minerals are unstable in near surface conditions and eventually form stable secondary minerals. The most important of these are the clay minerals and the hydrous oxides and hydroxides of iron, aluminium and manganese. These may either be formed _in situ_ or by reaction with solutions passing through the weathering zone. Generally all of these secondary products are very fine grained or colloidal in nature.

The clay minerals are relatively stable hydrous phyllosilicates formed by the decomposition of other aluminosilicates. This layered sheet structure appears to have a greater stability than the other crystallographic groups under near surface conditions. They may be divided into 6 groups (Millot, 1970):

a) Kaolinite or kandite group.

This is the simplest of the clay groups and includes kaolinite, halloysite, dickite, chamosite and the various serpentine minerals (hydrous magnesian silicates, eg. chrysotile, antigorite and lizardite). With the exception of the serpentine minerals, they have an approximate composition $Al_4[Si_4O_{10}](OH)_8$, although Fe^{2+} and Mg ions may partially substitute for Al ions. Kaolinites tend to form in freely drained, acid environments. These conditions may in turn lead to a thorough leaching of the bases. It is the most common of the clay minerals and develops most readily in relatively humid climates where rainfall exceeds evaporation and where leaching is intense. They have a rigid structure and display no isomorphous replacement. The latter means that sites where cation exchange may occur are limited to the broken edges of crystals. The result of this is that this group has a low cation exchange capacity (Table 6). For all the clays, the nature of the parent material may be an important factor in determining the type of clay mineral formed; for example, in the case of kaolinite, granitic rocks are kaolinized more readily than mafic rocks.

b) Mica group.

This group includes the micas, talc, illite and glauconite. They consist of non-expanding minerals having a complex chemical composition of K together with Mg, Fe, alumina and silica. They tend to form most readily in non-acid, K-rich conditions where rainfall is moderate and intermittent. In temperate conditions, as leaching becomes stronger they tend to be become more abundant near the surface.

Mineral	Exchange capacity (meq/100g)*
Kaolinite	3-15
Illite	10-40
Montmorillonite	80-150
Chlorite	10-40
Vermiculite	100-150

* .... Milligram equivalents per 100g of dry solid.

Table 6. Cation exchange capacities of some common clay minerals.

c) Montmorillonite or smectite group.

This group, which includes montmorillonite, beidellite, nontronite and saponite, has a theoretical composition $Al_4[Si_8O_{20}](OH)_4.nH_2O$ with Mg and Fe partly replacing Al. It is characterized by an ionic lattice capable of expansion and contraction which is ~~are~~ controlled by its variable water content. They have a high cation exchange capacity (Table 6) due to the relatively large amount of isomorphous replacement of Si by Al that gives rise to a large number of potential exchange sites. The development of this group is favoured by neutral to alkaline conditions and by the partial leaching of bases. It has a close structural relationship with the micas and chlorite groups, both of which it may alter to. It may also convert to kaolinite if drainage conditions change and leaching becomes effective.

d) Chlorite group.

This is distinguished from the mica group by being relatively rich in Fe^{2+}. It has a mixed layer type of structure with an alternating two layer (kandite) and three layer (smectite) arrangement of ions. It has been recognized as being able to weather to vermiculite in well-drained soils (Butler, 1953) and to chlorite-smectite and then smectite under poorly-drained conditions (Hargitt and Livesey, 1975). In a temperate climate members of the chlorite group-tend to show an opposite behaviour to those of the mica group by increasing towards the base of the profile.

e) Vermiculite group.

Structurally this group resembles the micas although it is more Al- and Mg-rich and may contain variable amounts of water between its structural layers (as in the montmorillonite group). It is chemically very similar to the montmorillonite group and displays many of its properties (eg. a high cation exchange capacity). Like the chlorite group, in temperate conditions, it generally increases towards the base of the soil profile.

f) Mixed-layer clay minerals.

These are quite common and are clay minerals in which more than one clay mineral species are interlayered in a single crystal. This is possible as many clay minerals are structurally similar and because some expand readily in water or upon weathering. The mixing may be regular, the most common examples being illite-vermiculite, illite-montmorillonite, illite-chlorite, montmorillonite-vermiculite, montmorillonite-chlorite and vermiculite-chlorite, or it may be wholly random. They are considered by Millot (1970) to be predominantly concentrated in the upper horizons of the soil.

Fuller discussion concerning the structures and properties of the clay minerals may be found in Grim (1968) and Brindley and Brown (1980).

The hydrous oxides and hydroxides of iron, manganese and aluminium that may develop in the zone of weathering are important in connection with the chemical dispersion of the many trace elements which are adsorbed or co-precipitated by them. The adsorptive capacity of some of these compounds may be very great and hence may play an important role in retaining many trace elements in the near surface zone of weathering. Humus also plays an important role in the retension of trace elements. This is considered to be due to adsorption and to the formation of insoluble humates.

The final form that the weathering products may take is that of soluble material. These are released by the decomposition of the primary minerals and tend to reflect the composition of the parent rock. They are held in solution until such time as they are either used in the formation of more stable secondary minerals or removed from the system. Siliceous rocks tend to yield alkalis, alkaline earths and colloidal silica (as a result of the hydrolysis of the primary silicates). The proportion of these is dependant upon the nature of the parent material. Calcium and magnesium predominate in mafic rocks, whereas in granites and felsic schists potassium and sodium predominate. As a general rule, calcium is more liable to be removed than Mg, which may be strongly adsorbed by the clays or incorporated in montmorillonites or chlorites. Potassium may be retained by illite whereas sodium tends to remain in solution. Iron and manganese are relatively insoluble and tend to remain in the near surface zone of weathering except under reducing conditions.

4.2 Soil formation

Soils may be best thought of as a natural body consisting of layers or horizons of mineral and/or organic constituents of variable thickness, which differ from the parent material in their morphological, physical, chemical and mineralogical properties and their biological characteristics (Joffe, 1949). Prior to studying the soils of the Lizard Complex in more detail a brief description of the soil profile and the factors which effect its formation are given.

4.2.1 Soil profile

The basic unit of study is the soil profile which may be divided into three classes; major groups, groups and subgroups. These are based on the similarities in the character or the arrangement of the horizons that can be identified or inferred in the field (Avery, 1980). The individual soil horizons differ in composition, colour, texture and/or structure, with the boundaries between them often being very sharp. They are conventionally distinguished by letter notation from the surface downwards as O, A , E, B, C and R (Hodgson, 1976):

O horizon. An organic-rich horizon accumulated under wet conditions.

A horizon. A mixture of organic debris and mineral matter found at, or very close to, the surface. It develops primarily as a result of decomposition of humus material and leaching (eluviation) of mineral matter. The weak acids formed by the decomposing humus result in soluble salts which, together with some of the colloidal and mineral matter, are then moved downwards in solution or suspension by circulatory waters.

E horizon. A light coloured horizon of maximum eluviation of clay, iron oxides and/or organic matter which in consequence is a very poor sampling medium. Chiefly a mixture of sand and silt.

B horizon. A zone of maximum accumulation (illuviation) of silicate clay minerals, or of iron and organic matter. Part of the leached material from upper horizons may be deposited here although the most soluble elements (eg. alkalis and alkaline earths) may be carried further downwards. It is relatively easily identified by its reddish-brown or yellowish-brown colour and clayey texture, also by its lack of original rock structure. Owing to the presence of clay minerals and iron and manganese oxides which have a large capacity to adsorb metals, it is this zone which is generally sampled in geochemical soil surveys.

C horizon. A zone of unconsolidated or weakly consolidated mineral horizons which are only partly decomposed and so retains its original rock structure. In the case of residual soils, this horizon grades downwards into unaltered parent rock. Organic matter is generally very low and illuviation at a minimum.

R horizon. Consolidated bedrock.

The soil horizons described above are commonly more complex and may be subdivided still further to denote such features as gleying, accumulation of translocated clays or cementation. Transistional horizons (eg. AB, BC) may also be recognized. The constituent horizons of the soil profile do not remain uniform throughout their lateral extent but may develop to differing degrees and, over a distance, grade into other horizons.

4.2.2 Factors affecting soil formation

It is recognized by workers in the field of the soil sciences (Fitzpatrick, 1971; Birkeland, 1974; Townsend, 1974) that a number of factors determine the nature of the soil that develops at any particular locality. These include four interdependant factors, parent material, climate, biological activity and topography, and time.

a) Parent material

In soils other than those of a transported origin the chemical and mineralogical composition of the parent material are largely responsible for the course of soil formation, and the resulting chemical and physical composition of the soil including the secondary weathering products. It also influences the nature of the vegetation capable of growing in the area. This is particularly the case over the ultrabasic and loess of the Lizard Complex where a highly distinct flora can be observed (Coombe and Frost, 1956). The physical nature of the parent material will also affect the soil-forming process; for example, a porous, permeable parent rock will assist leaching and the rate of movement of fluids thereby increasing the rate of soil development. The diverse nature of the parent material also accounts for the range in pH of the soil solutions found in this relatively small area. Those soil horizons derived from basic/ultrabasic units tend to be slightly alkaline to neutral, whilst those which are coarse and silty under heathland tend to be moderately acidic. In this area parent material is a major influencing factor and it shall be returned to later (Chapter 4.3.6).

b) Climate

Climate controls the relative effectiveness of the weathering process. Temperature influences the rate of the chemical reactions (principally hydrolysis of the primary minerals) in the soil, it also controls the development of vegetation and the rate of decomposition of organic matter (and therefore pH). The movement of moisture through the soil, which may be derived directly by precipitation or supplied by surface run-off or as groundwater, determines the differentiation of the horizons.

With the relatively high rainfall experienced by the study area (886mm pA), water movement is dominantly downwards with any soluble salts, colloidal material and small mineral particles tending to be removed from the surface layers and transported into the underlying layers. Eluviation of this kind tends to lead to heavy clay subsoils with loamy or sandy topsoils.

A saturated subsoil may lead to a reducing environment which causes gleying of the soil. This creates a mottled bluish-grey colouration, with the soil becoming admixed with varying amounts of amorphous organic matter, ferrous iron complexes and salts. Gleyed soils are commonly found over large areas of the Complex associated with both surface water and groundwater. A saturated subsoil such as this may result from a number of factors; a high watertable, high precipitation or very slow water movement through the soil profile. The latter is important over much of the ultrabasic body where the serpentinite weathers to produce an impermeable clay layer just below surface. During the drier months, rainfall may be balanced by evaporation and therefore effective leaching is unable to take place. This causes the mobile products of weathering to tend to remain within the soil. During the driest months, if evaporation exceeds rainfall, water may be drawn through the pore spaces to the surface where it evaporates and deposits its dissolved salts. It is partly for these reasons that sampling was largely carried out during the early spring and late autumn when climatic conditions are broadly similar.

c) Biological activity

This is largely a function of vegetation although organisms influencing the development of the soil range from microscopic bacteria to large mammals. Microorganisms play an important role in decomposing plant debris and in determining the fate of organic matter in the soil. Climatic conditions are an important factor in determining the amount and kind of vegetation, its decay products and the types of microorganisms present.

d) Topography

Topographic relief influences soil formation through its relationships with groundwater levels, drainage and erosion. Gradient of slopes and elevation are two of the topographic factors which influence run-off and drainage conditions, and therefore indirectly soil formation. In areas of flat or gently sloping relief there is a tendency for thicker soils to develop with a high percentage of clays and other resistant minerals. Conversely, as slopes become more steep, erosion increases and the units are thinner.

In sampling in the Lizard area, steep slopes were avoided wherever possible because of the possibility of mass movement on them. The affects of solifluction during periglacial periods, however, could not be avoided as considerable movement can occur on slopes as low as 2°. Taking into account the overall topography of the area and the sample spacing used, it is considered that only the areas lying in a 1 km arc southwest to southeast of the Crousa gravels may cause problems (Mr.S.J.Staines, pers.comm.).

e) Time

Soil formation is a very slow process and over the long period of time in which the soil profile is forming, there may be periodic changes in climate, vegetation and relief which may in turn cause differences in soil development.

4.3 Soils of the Lizard Complex

Several workers have described all or some of the soils of the area. Coombe and Frost (1956) described a number of the soils developed on the serpentinite and loess. More recently Staines (in press) studied the whole Lizard Peninsula including the Meneage zone in compiling a soil map and memoir of the District.

The different soils developed reflect the complexity of the parent material, both lithological and exotic (described earlier in Chapter 2.3), the topography and the climate. Figure 9 shows the Major Soil Groups of the area, the distribution of which broadly outlines the known geology. The contrast in soil types is particularly noticeable between the hornblende schists and the ultrabasic, the Kennack gneiss and the ultrabasic, and the Crousa gravels and the gabbro.

The soils of the area are believed to have formed in the mid-Tertiary during a warm, humid climatic period (Bristow, 1977; Staines, in press). The clay mineralogy also suggests that the soils developed in a sub-tropical climate (Butler, 1953). This may account for the depth of some of the soils encountered during the BGS power auger programme, where the average depth was 4.3 metres with many profiles being in excess of 10 metres. Large differences were also observed between the different rock types and the depth of weathering (Fig.10). The slightly lower average depth of the schist compared to the gabbro being a function of the relatively higher proportion of resistant minerals in the schists.

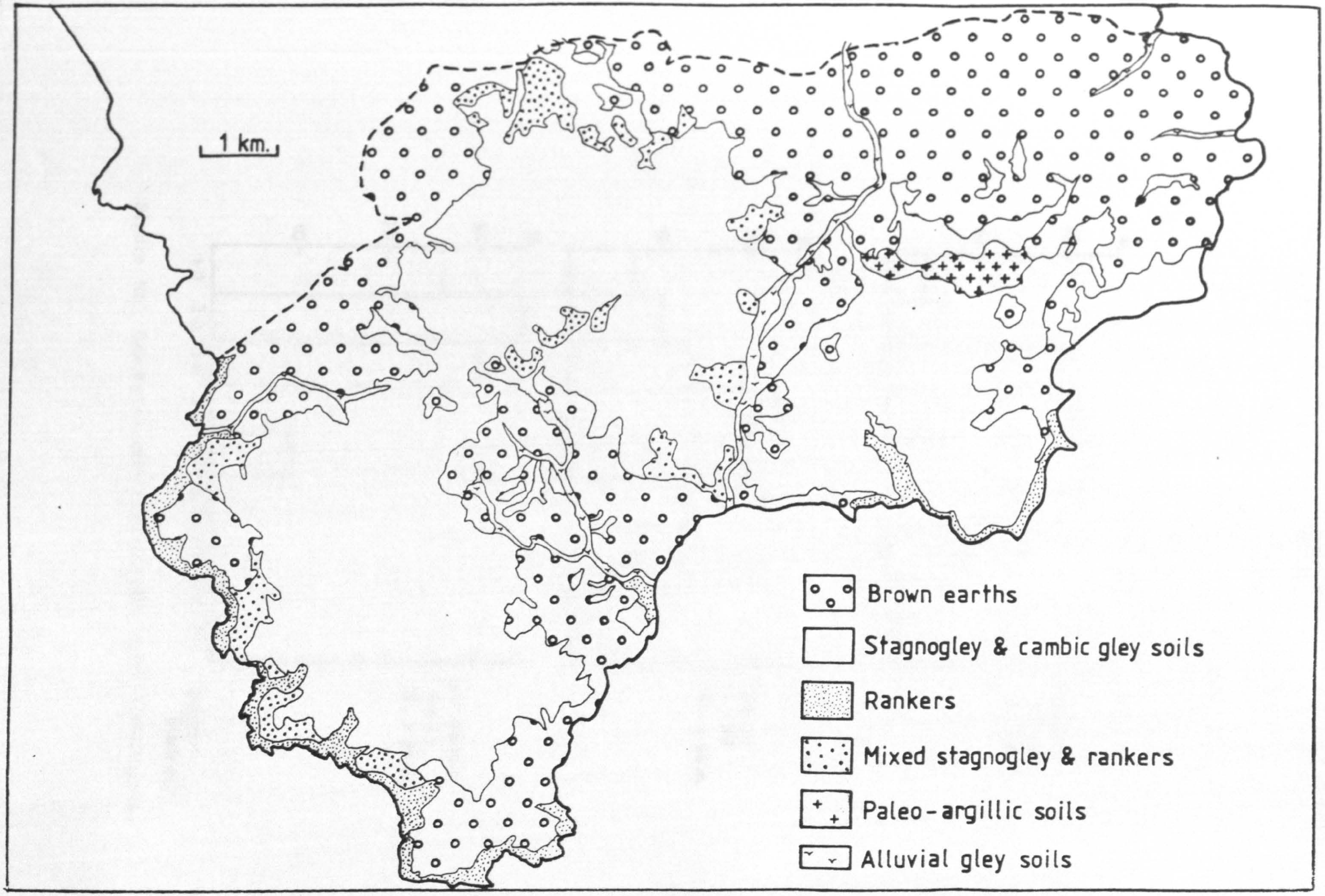


Figure 9. Major soil groups of the Lizard Complex. After Staines (in press).

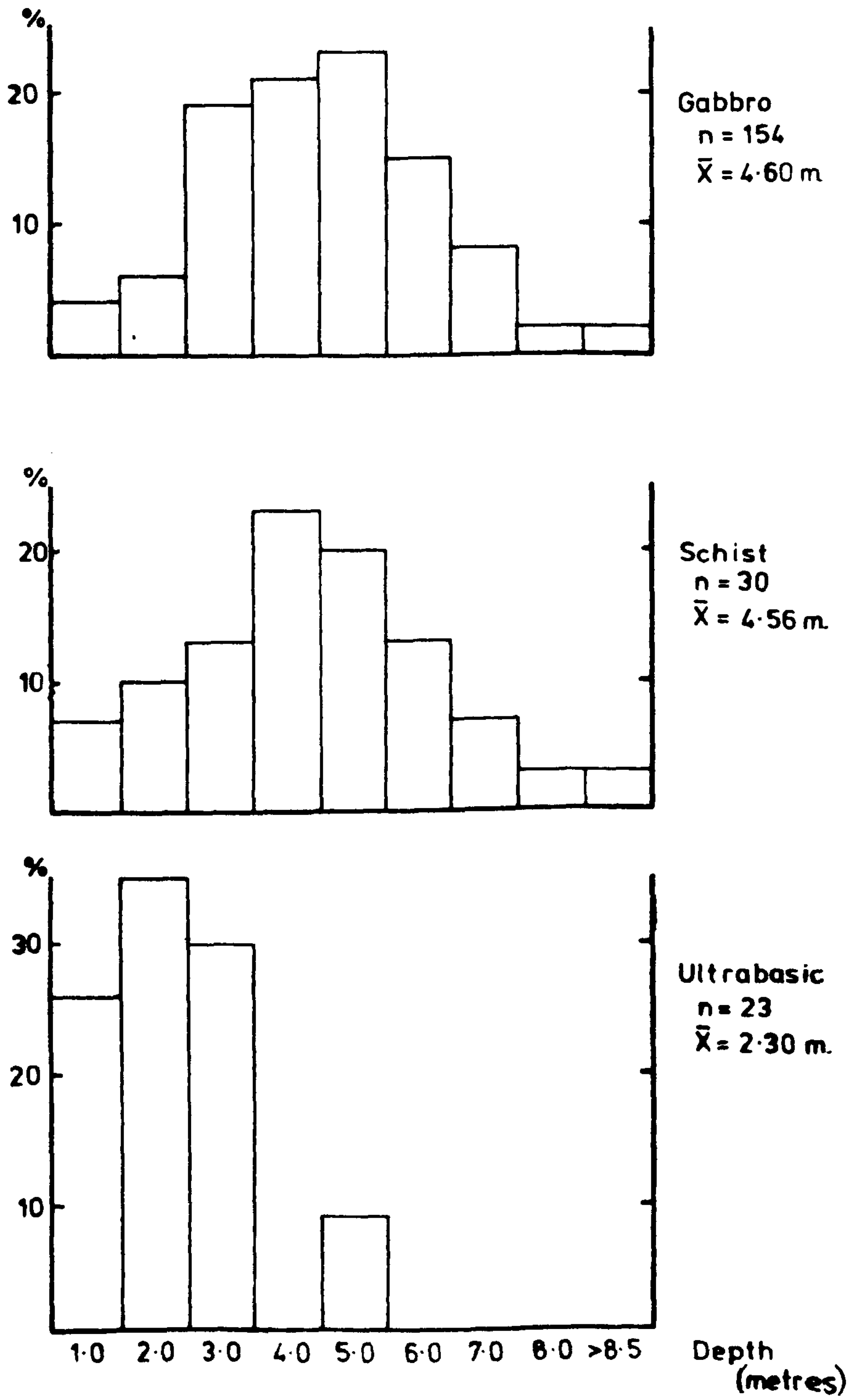


Figure 10. Depths of soil profiles for three lithologies.

Below is a brief description of the various Soil Groups belonging to the Major Soil Groups shown in Figure 9. These may be further subdivided into Soil Subgroups and Soil Series. The Soil Series are generally named after the locality where they were first described or where it is extensive and are based on particle size distribution and lithology. It should be noted at this early stage that although over individual geological units a variety of soils may develop, no difference is seen in the geochemistry.

Lithomorphic soils (Major Soil Group)

These occupy a relatively small area of the Complex and are generally very shallow (<40cm). They have a distinct humose or peaty topsoil and the B horizon may be either absent or only very weakly developed.

a) Rankers (Soil Group).

i) Brown rankers - Dominant Soil Subgroup. Normally brown in colour and show no sign of gleying.

ii) Stagnogleyic rankers - Show gleyic features such as bluish-grey colouration or mottling. Mottling occurs under fluctuating moisture conditions when the profile may be part oxidizing and part reducing.

Brown earths

These have an argillic B horizon and are normally brownish or reddish in colour reflecting the relatively well drained and oxidized state of the soil profile.

a) Brown earths. These are the most widespread of the district and generally have a weathered B horizon of uniform brown colour above 40cm but may include gleying below.

i) Typical brown earths - Dominant Soil Subgroup. Show no gleyic features above 80cm and comprise of loamy, friable and well aerated profiles with no impedence to drainage.

ii) Stagnogleyic brown earths - Slowly permeable subsoil with gleyic features due to intermittent waterlogging.

iii) Gleyic brown earths - Similarly gleyed. Waterlogging may be associated with a high watertable.

The latter two Subgroups may have profiles showing a wide variation in the degree of mottling.

b) Argillic brown earths. These are brown soils having accumulations of translocated clays resulting in argillic horizons.

i) Stagnogleyic brown earths - Show gleyic features as a result of intermittent waterlogging.

c) Paleo-argillic brown earths. These are brown soils with a paleo-argillic B horizon which are mainly developed in Wolstonian or older drift and associated with pre-Devensian ground surfaces.

i) Stagnogleyic paleo-argillic brown earths.

<u>Surface water gley soils</u>

This Major Soil Group has gleyed sub-surface horizons primarily attributable to seasonal saturation caused by slowly permeable horizons. They are found over the ultrabasic, on the sloping ground off the Crousa gravels and around the southern contact of the gabbro and the ultrabasic.

a) Stagnogley soils. These have a distinct topsoil and are gleyed to within 40cm of the surface. They lack a pervious C horizon and have only a slowly permeable B and/or BC horizon.

   i) Typical stagnogley soils - Dominant Soil Subgroup.

   ii) Pelo-stagnogley soils - Have an argillic layer greater than 30cm thick.

   iii) Cambic stagnogley soils - Lack both pelo-features and an argillic B horizon.

   iv) Paleo-stagnogley soils - Have a paleo-argillic B horizon.

<u>Groundwater gley soils</u>

These have gleyed sub-surface horizons that are permeable or overlie permeable sub-strata. Gleying is due to the presence of a high, fluctuating watertable. They are generally confined to depressions particularly over the ultrabasic.

a) Cambic gley soils. Dominant Soil Group. These are loamy or clayey non-alluvial soils gleyed to within 40cm of the surface. They have distinct, non-humose topsoils and permeable subsoils.

   i) Typical cambic gley soils - B and C horizons generally permeable, loamy and show a bluish-grey colouration due to the effect of high watertable.

b) Humic gley soils. These are similar to above but have a humose or peaty topsoil.

   i) Typical humic gley soils - No argillic B horizon.

· Others

a) Peat soils. These form only under very wet conditions and occupy a few small patches.

b) Miscellaneous alluvial gley soils. These are developed on recent alluvium in small valleys. They are associated with high watertables and include both peaty and loamy soils.

4.3.1 Soils of the ultrabasic and the loess

Although these units have totally different compositions they are intimately mixed over the Lizard Complex and for this reason are treated together. A smaller, less significant loessial component may be found mixed with some of the soils derived from the other units described in Chapter 2.3, where it has been more thoroughly mixed and diluted in the deeper soils that have developed.

Figure 11 shows some of the soils which may be developed over the serpentinite and loess. The nature of the soils over the ultrabasic where there is little or no loess present tends to be closely related to landform. On sloping land it tends to weather to produce a loamy, permeable material which is generally very shallow (<30cm) and associated with rock outcrop. Examples of these are the brown rankers (Kynance series), stagnogleyic rankers (Holestraw series) and the typical brown earths (Black Head series). The Holestraw series also occupies a few shallow depressions inland. On the less steep slopes and flat land, heavier and more impermeable stagnogleyic brown earths (Coverack series) occur.

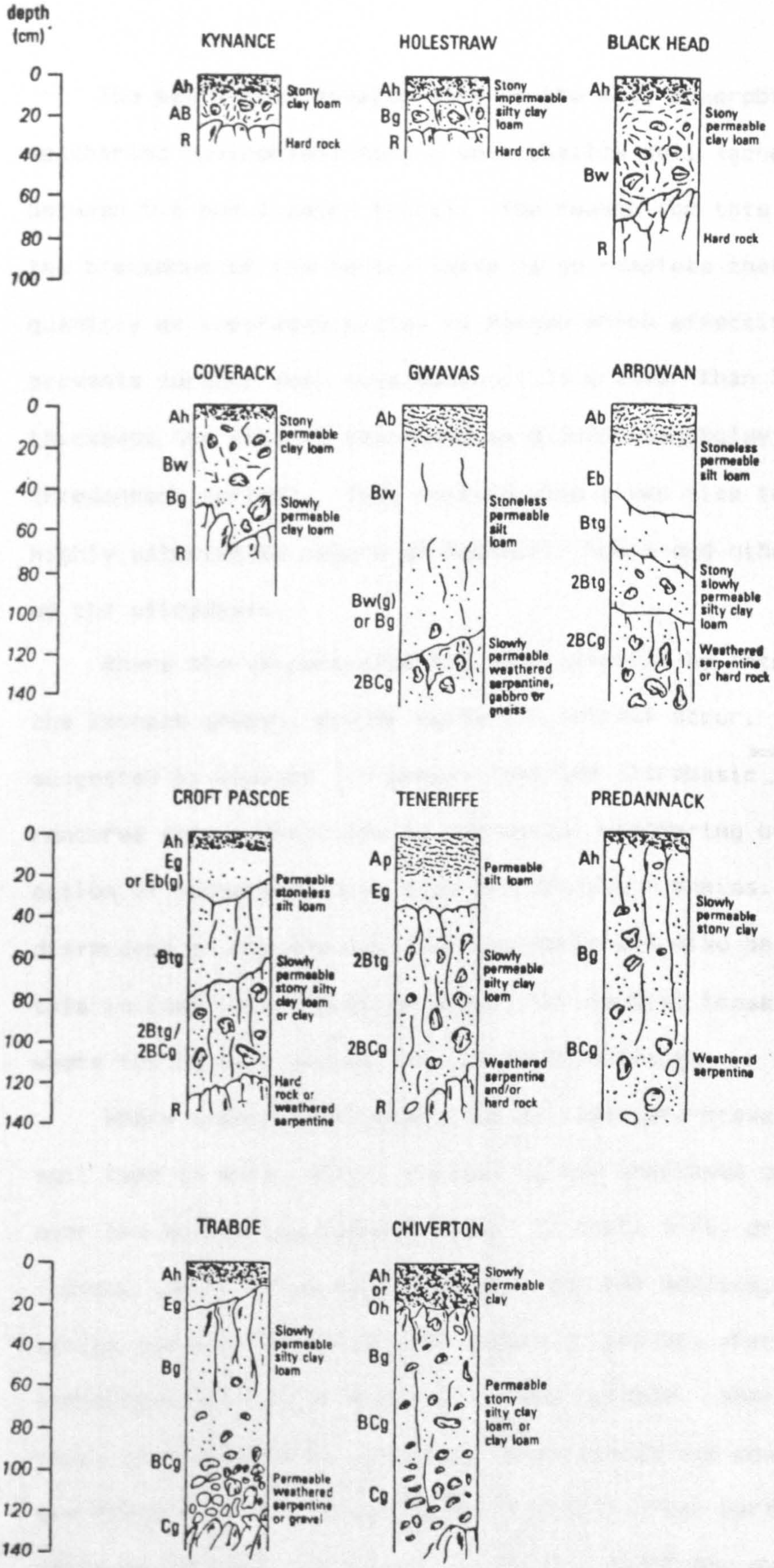


Figure 11. Some soils developed over the serpentinite and loess. After Staines (in press).

The soils that develop here in the wet, anaerobic weathering environment form a very shallow soil (generally between 0.5 and 1 metre thick). The reason for this is that the breakdown of the serpentinite is so complete that a large quantity of impermeable clay is formed which effectively prevents further soil development. If greater than 30cm in thickness the soil is described as a pelo-stagnogley soil (Predannack series). This feature also gives rise to the highly waterlogged nature of Goonhilly Downs and other areas of the ultrabasic.

Where the serpentinite has been affected by intrusions of the Kennack gneiss, deeper soils (>2 metres) occur. It is suggested by Staines (in press) that the ultrabasic rock is rendered more susceptible to sub-aerial weathering by the action of vapours emitted from the intrusive gneiss. A difference in the chemistry of the soils can also be seen and this is used later (Chapter 6.4.1) to identify those areas where the Kennack gneiss lies close to surface.

Where significant quantities of loess are present the soil type is more closely related to the thickness of loess over the weathering serpentinite. In thick silty drift (>80cm) gleyic brown earths (Gwavas series) develop. This series may also be found over gabbro or gravels where they are associated with interfluves or raised beaches. Where the loess is between 40cm and 80 cm in thickness and conditions are relatively dry, stagnogleyic argillic brown earths (Arrowan series) are found. If wetter conditions exist typical stagnogley soils (Croft Pascoe series) occur. Where only thin loess deposits are found typical stagnogley soils of the Teneriffe series develop.

The upper parts of the loess-rich profiles are dominated by silt as shown by Figure 12 for the Gwavas and Croft Pascoe series. The particle size distribution of some other soils are shown for comparison; Tresize series (schist) and St.Ruan series (gneiss).

In depressions and along streamlines where loess is absent or thoroughly mixed with the weathered serpentinite, typical cambic gley soils (Traboe series) are found. Under wetter conditions typical humic gley soils (Chiverton series) develop.

4.3.2 Soils of the gabbro and the Crousa gravels

As in the previous case these two units are grouped together because of their proximity to each other. On the lower slopes off the main body of the Crousa gravels the results of the power auger programme, which are described later, suggest that there has been some intermixing of the soils developed from the two units.

Staines (in press) recognizes two major soil patterns developed over the gabbro (Fig.13) related to landform. The first is associated with the rolling country around St.Keverne, where typical brown earths of the Trusham series are dominant. Some argillic variants occur around St.Keverne and are thought to be remnants of a former soil produced

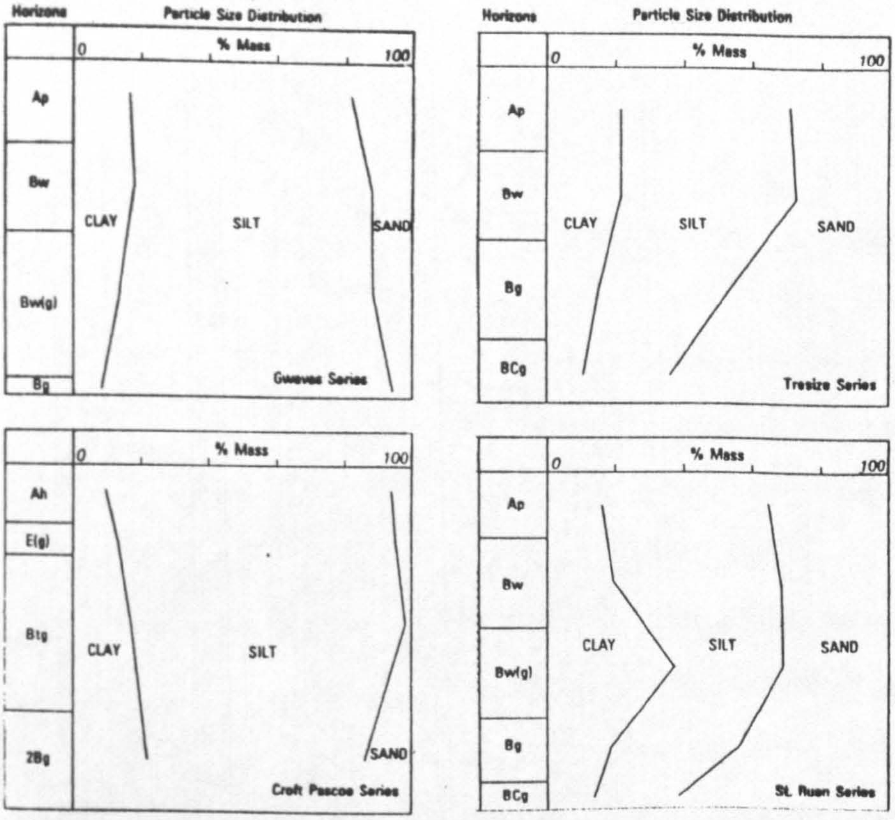


Figure 12. Particle size distributions of some loessial soils.

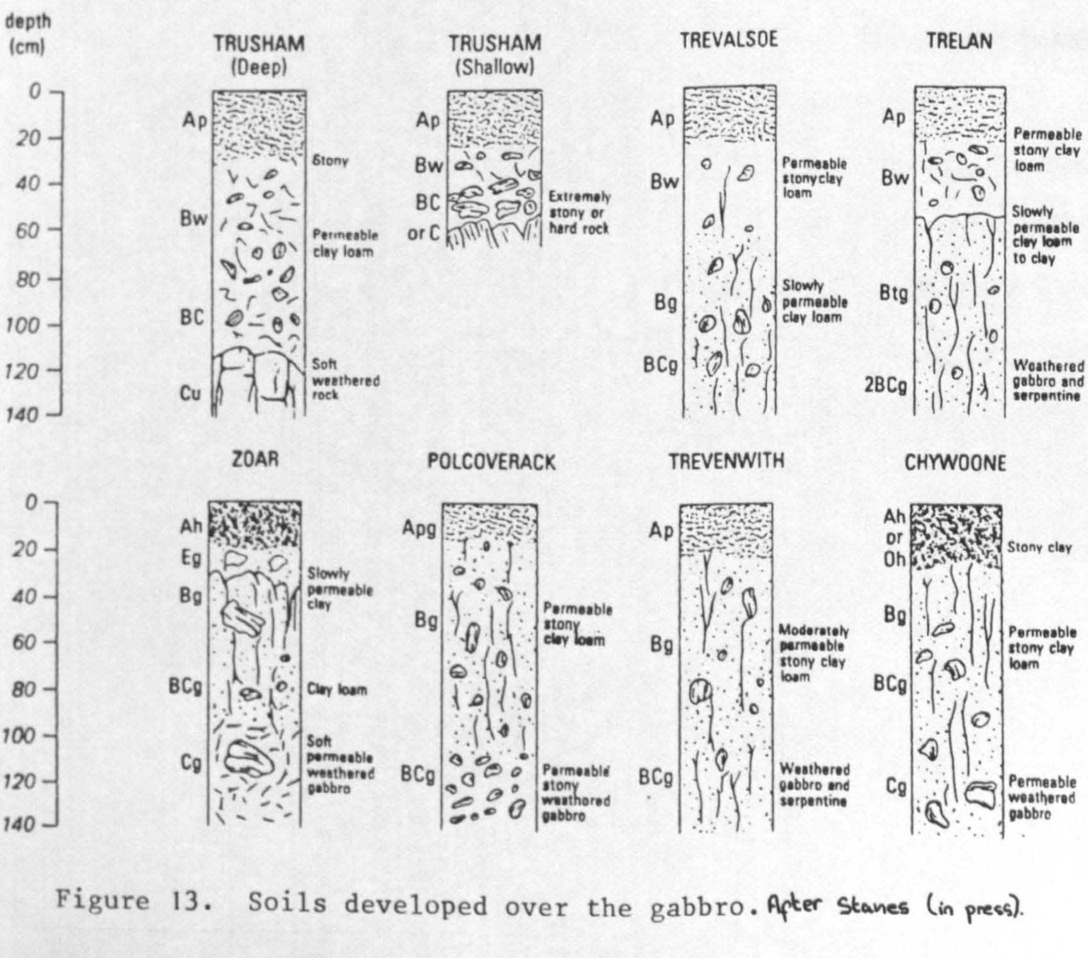


Figure 13. Soils developed over the gabbro. After Stanes (in press).

during interglacial or pre-Pleistocene times. In valleys and depressions loamy and permeable typical cambic gley soils and stagnogleyic brown earths (Polcoverack and Trevalsoe series respectively) form. Small areas of wetter typical humic gley soils (Chywoone series) and peat soils are associated with springs. The second soil pattern is found on the relatively featureless topography to the south which have cambic stagnogleyic soils (Zoar series), cambic gley soils (Trevenwith and Polcoverack series) and stagnogleyic argillic brown earths (Trelan series). The latter together with the Trevenwith series are noted by Staines (op cit) as being derived from a mixture of gabbroic and ultrabasic material. Soils of the Chywoone series occupy shallow depressions and valley heads.

The Crousa gravels overlying the gabbro around Crousa Common support two main soils, both of which have impermeable subsoils. Stagnogleyic paleo-argillic brown earths (Berkhamsted series) occur directly over the gravels, whilst wetter paleo-argillic stagnogley soils of the Oak series are to be found on the lower slopes. These grade downslope into soils (Zoar/Polcoverack map unit) which although derived from the gabbro have a large silty component and numerous quartz grains (Re. Chapter 4.4).

4.3.3 Soils of the schists

The soils developed over these units (Fig.14) are less intensely weathered than those found over the gabbro and the

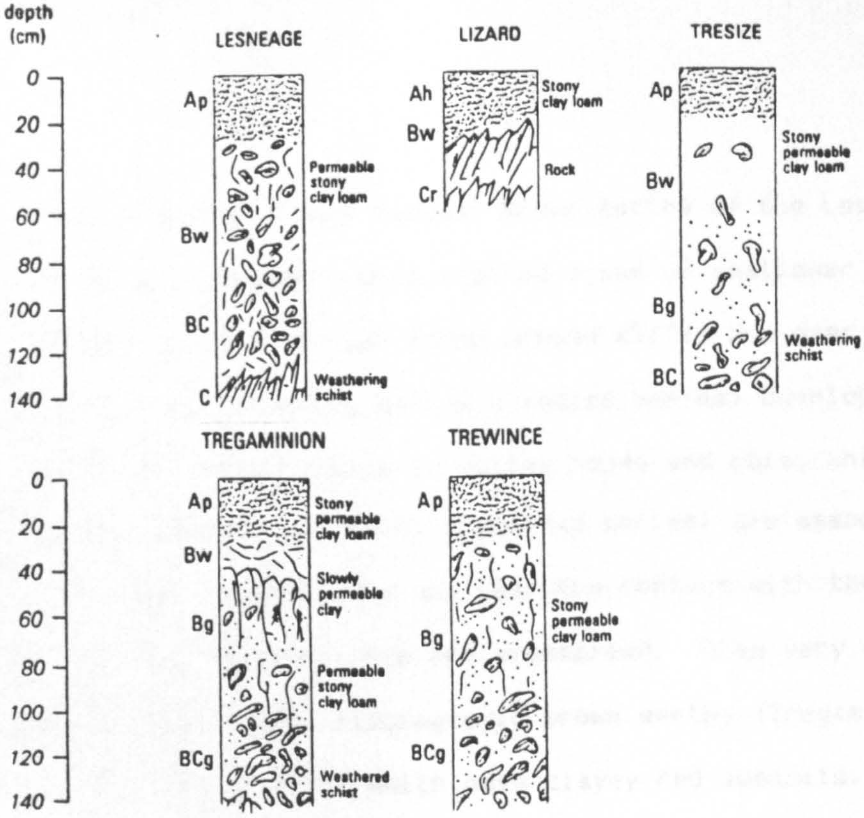


Figure 14. Soils developed over the schists.

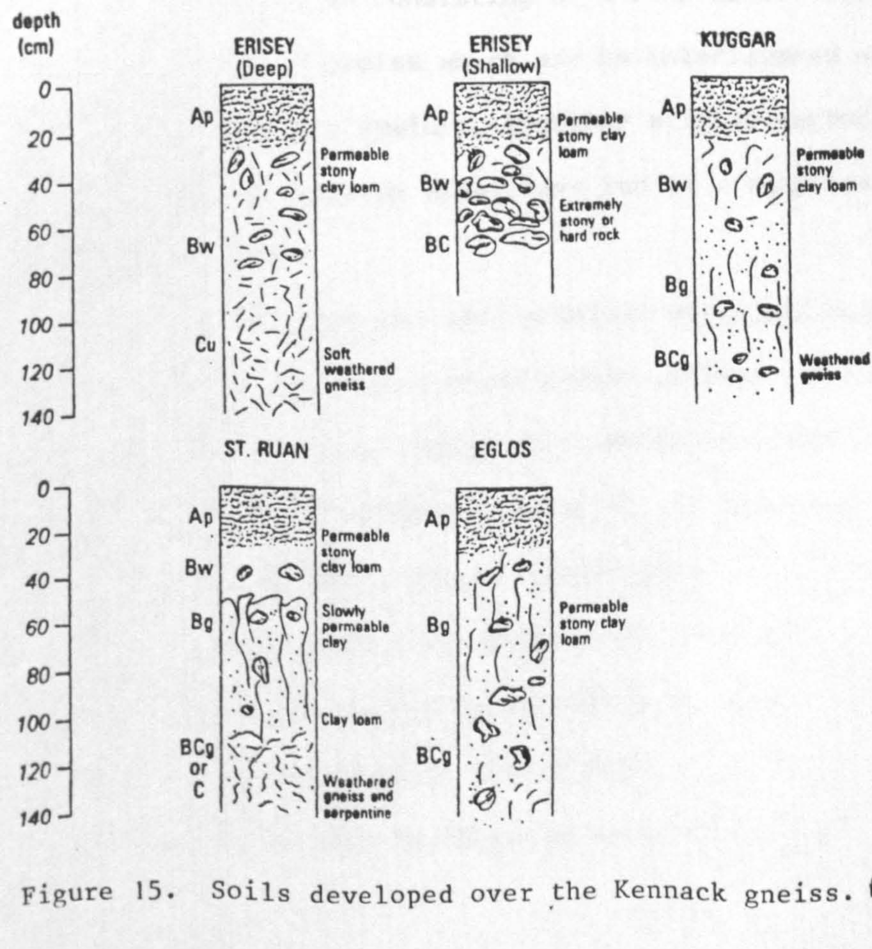


Figure 15. Soils developed over the Kennack gneiss. After Staines (in press).

Kennack gneiss. Deep typical brown earths of the Lesneague series are dominant, with limited areas of shallower brown rankers (Lizard series) found around cliffs and over convex ground. Gleyic brown earths (Tresize series) develop in areas of deeply rotted schist in valley heads and cols, whilst typical cambic gley soils (Trewince series) are associated with lower valley sides and near the contact with the ultrabasic where springs are widespread. Also very close to this contact loamy stagnogleyic brown earths (Tregaminion series) may be found which have clayey red subsoils.

4.3.4 Soils of the Kennack gneiss

As observed earlier in Chapter 2.3.6 the Kennack gneiss is now recognized as consisting of a complicated mixture of acid and/or basic gneiss which may be interlayered with serpentinite. This feature, together with differences in relief over the outcrop area, have led to a complicated pattern of soils.

Figure 15 shows the soil profiles which may develop. Loamy typical and gleyic brown earths (Erisey and Kuggar series respectively) develop over weathered gneiss where there is no significant ultrabasic material. In waterlogged depressions, however, typical cambic gley soils (Eglos series) develop. Where there is a significant ultrabasic component loamy stagnogleyic brown earths (St.Ruan series) occur. A feature of these soils is that although they are often deeply weathered, they tend to retain a perfect geological structure.

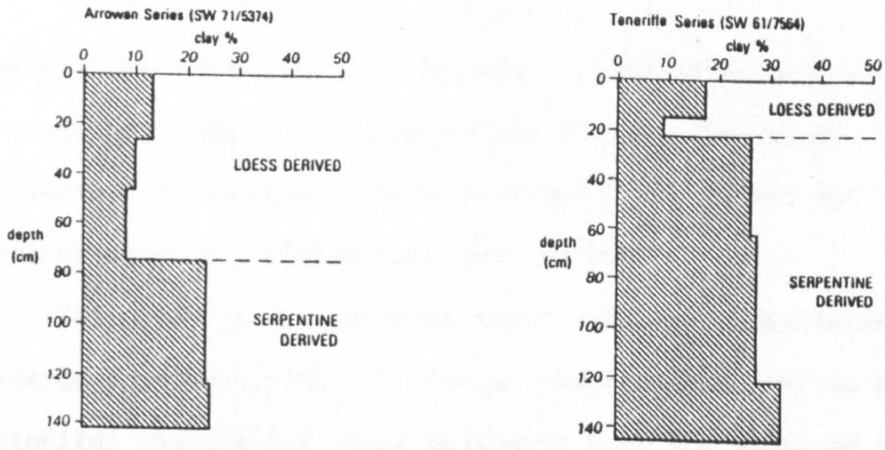


Figure 16. Clay contents of two loessial soils. After Staines (in press).

Parent material (no.of horizons)	Mean CEC (meq/100g)*	Mean clay ($2 \mu m$ %)	CEC/clay
Serpentinite (14)	67	35	1.9
Loess (5)	9	15	0.6
Gabbro (7)	15	20	0.8
Granite-gneiss (4)	16	13	1.2
Schist (4)	16	15	1.1
Granite/ Serpentinite (4)	42	22	1.9
Gabbro/ Serpentinite (4)	30	27	1.1
Crousa gravels (1)	7	42	0.2

* .... Milligram equivalents per 100g of dry solid.

Table 7. Cation exchange capacities for some selected subsoil horizons. After Staines (in press).

largely smectites and vermiculites. Those soils with a significant loessial component show a mixed mineralogy (chlorite, mixed layer chlorite-vermiculite, illite and kaolinite) with a correspondingly low CEC.

The clays in the gabbroic soils tend to be dominated by fine-grained kaolinite with lesser quantities of illite and chlorite; whereas the clays developed from the soils of the schists consist of chlorite (from the hornblende) and kaolinite with illite (from the plagioclase).

The Crousa gravels have a very low CEC which is consistent with kaolinite or micas being the main clay minerals. This low CEC together with the low base saturation of these soils is a common feature of clays in long weathered horizons. The presence of kaolinite would lend further support to the earlier suggestion that the soils may have developed under the intense weathering conditions of a sub-tropical climate.

The gneiss is dominated by illite (from the potash feldspars) and kaolinite (from the plagioclase), with some vermiculite.

The majority of the soil profiles examined by Staines showed a general increase in clay content down the profile to the BC horizon; the silty soils developed over loess-rich material (Gwavas and Arrowan series) being the notable exceptions (Figs. 12 and 16). The clay content of the gneissic soils relate largely to the amount of serpentinitic material present.

4.3.6 Influence of the parent material

As mentioned earlier in Chapter 4.2.2, the parent material may play an extremely important role in determining the nature of the soil developed in an area. The products of weathering will be largely controlled by the initial mineralogy; a pure sandstone for example will weather very slowly to form a poor sandy soil. In the Lizard Complex there is a wide variety of parent material ranging from ultrabasic to granitic rocks, with additional metasediments and superficial deposits. Each of these has a different mineralogy and will therefore form differing proportions of the secondary minerals produced by the weathering process.

The various minerals which make up any rock do not weather at a constant rate. Goldich (1938) summarized the relative resistance to weathering of the common rock-forming minerals (Fig.17). The Goldich series, which is the reverse of Bowen's reaction series, indicates that the minerals which crystallized at the highest temperatures and under the most anhydrous conditions are most readily weathered. Fieldes and Swindale (1954) described the weathering of the primary rock-forming minerals showing how the primary minerals change to successive secondary minerals through the weathering process. The relative stabilities of the common rock-forming minerals may be explained by a number of factors. Some are related to the mineral itself (eg.crystallographic structure, grain size) whilst others are related to the weathering environment (principally climate, topography and drainage

```
Olivine                                          |
                                                 |
                  Calcic plagioclase             |
                                                 |
Augite                                           |
                                                 |
                  Calcic-alkali plagioclase      |
                                                 |
Hornblende        Alkali-calcic plagioclase      |
                                                 |
                  Alkali plagioclase             |
                                                 |
          Biotite                                |
                                                 |
          Potassium feldspar                     |
                                                 |
          Muscovite                              |
                                                \|/
          Quartz                                 V
                                            Increasing
                                            stability
```

Figure 17. Relative stabilities of the common rock-forming silicates under chemical weathering. After Goldich (1938).

Parent	Mineralogy
Lherzolitic peridotite	Olivine, diopside, enstatite + chromite
Harzburgitic peridotite	Olivine, enstatite + chromite
Gabbro	Plagioclase, augite, diopside + hornblende, olivine, ilmenite
Upper Landewednack	Hornblende, plagioclase
Lower Landewednack	Hornblende, plagioclase + epidote, grossular garnet
Mica schist granulite	Plagioclase, hornblende, quartz + epidote, biotite, muscovite
Kennack gneiss	Plagioclase, orthoclase, quartz + biotite, hornblende Plagioclase, hornblende + biotite

Table 8. Mineralogy of the main lithologies of the Lizard Complex.

conditions).

Minerals other than quartz which are highly stable in the weathering environment include zircon, tourmaline, magnetite, ilmenite and chromite. All of these are present in some of the rocks of the Complex and would be expected to be retained in the soil profile.

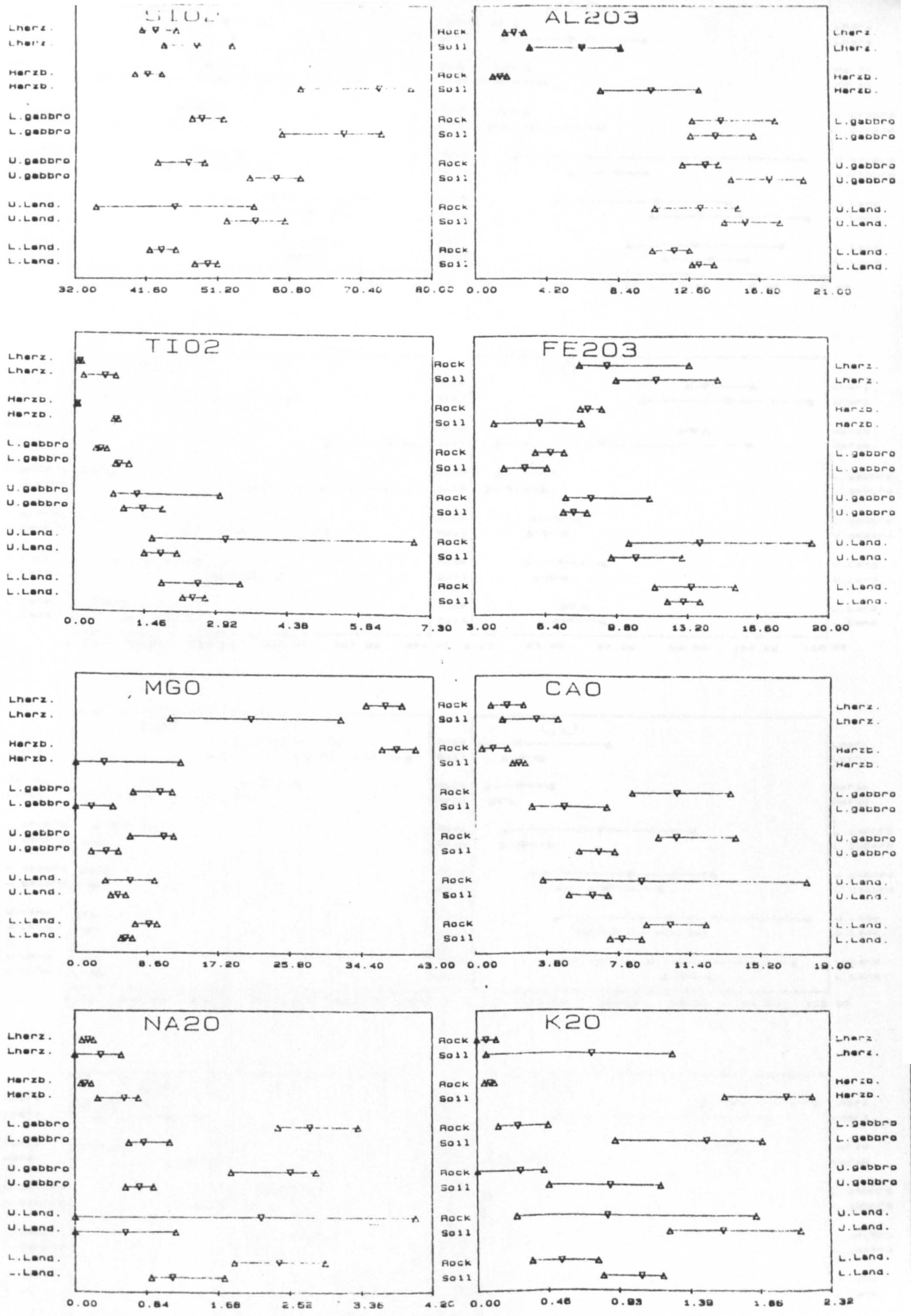
Table 8 shows the mineralogy of the principle rock groups as described in Chapter 2.3. Those lithologies with a high content of the less stable minerals will weather more rapidly than those rocks comprised largely of more resistant minerals As each of the various mineral constituents of a rock are decomposed those elements which are held in the lattice are released. These must then be either retained in the soil profile or removed. In attempting to map on the basis of the residual soil geochemistry, the proportions of the various elements in the primary minerals which may be released into the soil is extremely important. Table 9 gives some indication of the typical compositions of some of the common rock-forming minerals.

Figure 18, produced by the program DEG (Appendix A), shows the changes in composition which occur when various lithologies sampled during the orientation survey weather to a soil.

Examination of the principle elements present in the soil shows marked increases for all groups in SiO_2, Al_2O_3 and K_2O in the change from rock to soil whereas MgO displays a marked depletion.

Mineral	x%	0.x%	0.0x%	0.00x%
Olivine	Si Fe Mg	Ca Mn Ni	Al Co K Na P Ti	Cu Cr Sc V Zn
Clinopyroxene	Si Ca Fe Mg	Al K Na Mn Ti	Cr Ni Sr V	Ba Co Cu P Rb Zn
Orthopyroxene	Si Fe Mg	Al Ca K Mn Ti	Cr Na Ni K Sr V	Ba Co Cu P Rb Zn
Amphibole	Si Al Ca Fe Mg	Cl F K Na Mn Rb Ti	Cr Ni Sr V Zn	Ba Co Cu Ga P Pb
Plagioclase	Si Al Ca Na	K	Ba Fe Mg Mn Rb Sr Ti	Cu Ga Ni P Pb V Zn
Orthoclase	Si Al K Na	Ca	Ba Fe Mg Rb Sr Ti	Ga Pb
Biotite	Si Al Fe Mg K Ti	Ca F Li Mn Na Rb	Ba Co Ga Sr Zr	Cr V
Muscovite	Si Al K Fe	Ca F Fe Mg Na Ti	Ba Ca Li Mg Mn Rb Ti	Cr Ga V
Quartz	Si			

Table 9. General levels of some elements typically found in the common minerals.



Lherz. Lherzolite
Harzb. Harzburgite
L.gabbro Lower gabbro
U.gabbro Upper gabbro
U.Land. U.Landewednack schist
L.Land. L.Landewednack schist

Figure 18. Composition changes occurring during weathering from rock to soil of the various lithologies of the Lizard Complex.
Δ.... min/max ∇... mean. Oxide data in wt%, else ppm.

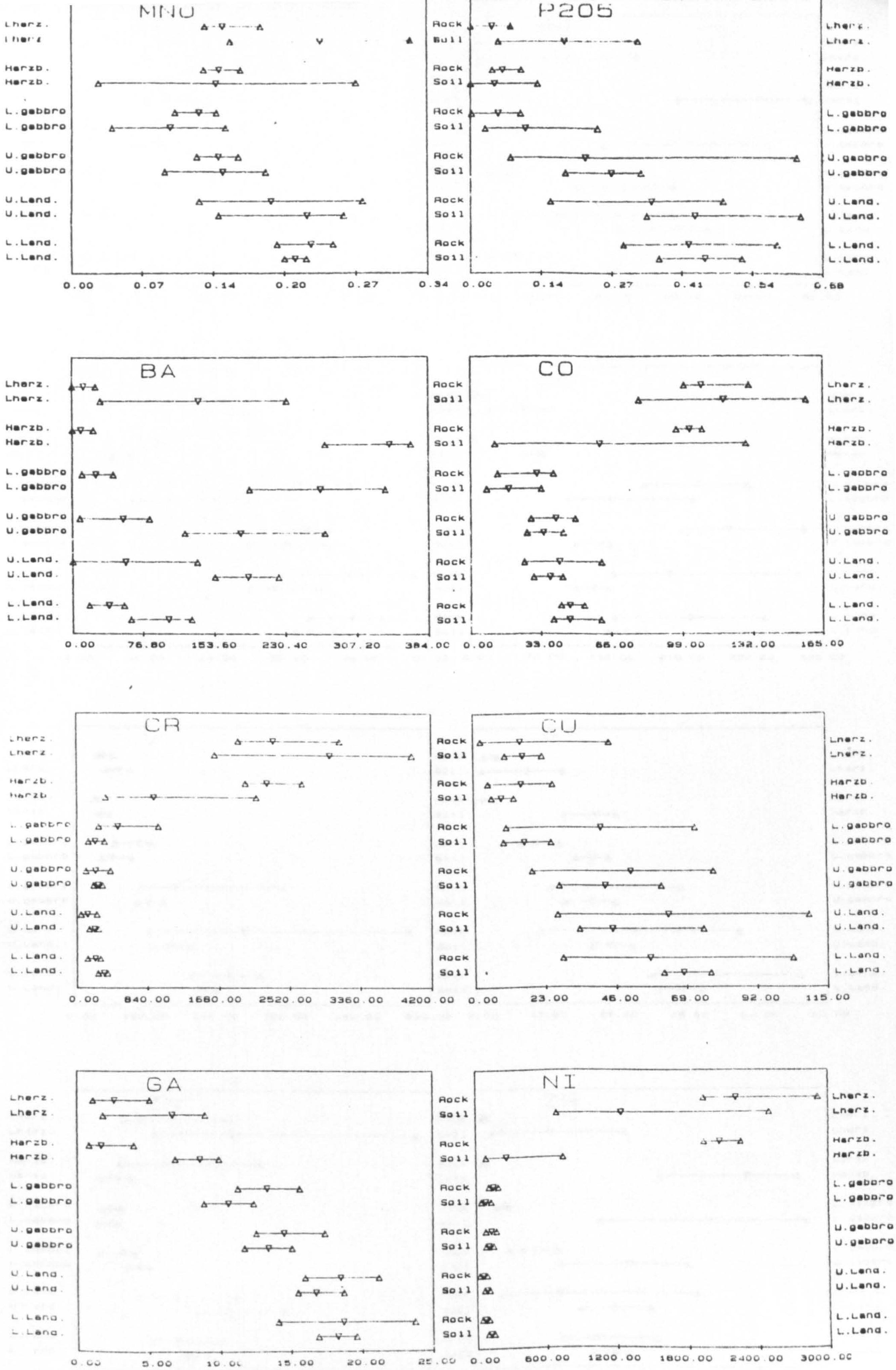


Figure 18 continued.

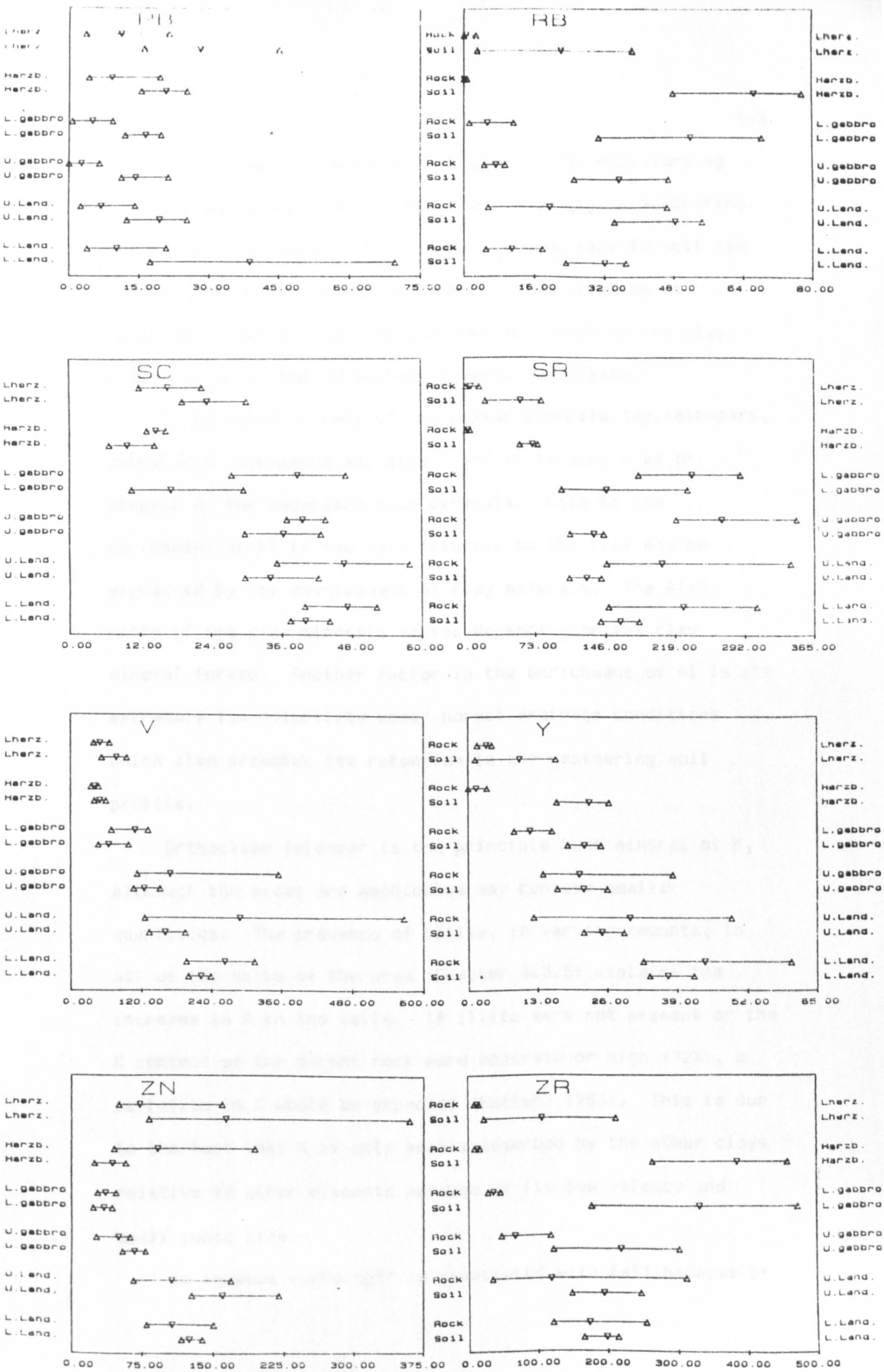


Figure 18 continued.

Si is a major constituent of most of the rock-forming minerals and of many of the secondary products of weathering. Its overall increase on the transition from rock to soil can be explained either by the presence of quartz which is retained by the soil profile, by the formation of the clay minerals, or by the formation of amorphous silica.

Al is found in many of the common minerals (eg.feldspars, amphiboles, pyroxenes and micas) and it is also a major element in the secondary clay minerals. Like Si the enrichment of Al in the soil relative to the rock may be explained by the development of clay minerals. The Al:Si ratio of the clay minerals varies depending on the clay mineral formed. Another factor in the enrichment of Al is i' extremely low solubility under normal drainage conditions which also promotes its retention in the weathering soil profile.

Orthoclase feldspar is the principle host mineral of K, although the micas and amphiboles may contain smaller quantities. The presence of illite, in varying amounts, in all of the soils of the area (Chapter 4.3.5) explains the increase in K in the soils. If illite were not present or the K content of the parent rock were moderate or high (>2%), a depletion in K would be expected (Butler, 1953). This is due to the fact that K is only weakly adsorbed by the other clays relative to other elements because of its low valency and small ionic size.

In igneous rocks Mg^{2+} is associated with Fe^{2+} because of its similar ionic radii. The Fe-Mg silicates that may form are able to host a variety of other trace elements (eg. Mn, Co, Ni, Zn, Sc). It may be an important constituent of olivine, pyroxenes, amphiboles and micas. The depletion of Mg in the soils may be explained by the fact that the only clay minerals commonly found developed in the rocks of the area (other than the ultrabasic) having a moderate to high Mg content are vermiculite and chlorite. The consequence of this is that there is no suitable host for the mobilized Mg ions. The MgO content of the ultrabasic rocks is so extreme that it must be nearly impossible for the limited variety of potential secondary products to take up all of the mobilized Mg ions which result from the breakdown of the orthosilicates and chain silicates.

Fe, like Mg, is concentrated in the early formed minerals of the differentiation sequence such as olivine, pyroxenes and amphiboles. In contrast, feldspars and quartz generally contain only trace quantities. The graph for Fe_2O_3 (Fig.18) shows that for most of the lithologies there is an overall depletion in the soil relative to the original rock (a notable exception is the lherzolite). The relatively low Fe content of most of the clay minerals may account for some of this, although the drainage conditions are probably of greater importance. In a reducing gley environment any Fe oxides present take the Fe^{2+} form. As this is insoluble it would be expected to remain in the soil profile. As all the samples from the orientation survey were collected from within 70cm of the surface and from relatively well-drained sampling sites, the Fe present would have been in its oxidized and soluble state. Ferric oxides that are formed by weathering are generally very finely grained and, as a result, are easily removed from the soil profile.

Na_2O and CaO also show a general depletion in soil geochemistry relative to the original rock for all lithologies except the ultrabasic. Plagioclase feldspar is the principle host mineral for both these elements, although they may also be found in many clinopyroxenes and amphiboles. Na is only weakly adsorbed by the clay minerals and is highly soluble. Therefore most Na (other than in the soils over the ultrabasic) is probably primary in the form of detrital plagioclase. An additional factor for the low levels of both the elements is that their contents in the clays is generally very low. The reason for the increase in the ultrababsic rocks is unknown, although it is possible that it is connected with the low levels of many of the other elements with which Na and Ca would normally have to compete with for adsorption by the clay minerals. The increase in Na for the lherzolite taken from the western coast may also be a function of the sea spray affecting the area (Re. Chapter 6.2.1).

The graph for TiO_2 (Fig.18) shows an enrichment in the soils over the ultrabasic rocks and the southernmost gabbro, and a marked depletion for the Upper Landewednack series. The former have the lowest overall Ti values in the rocks (probably held largely in the pyroxenes) which, upon weathering, is available in sufficiently low concentrations to be entirely incorporated by the clays and by any Fe- and Mn-oxides, therefore giving rise to the relative enrichment in the soils. The high Ti values in the rocks of the Upper Landewednack is primarily due to the presence of hornblende and accessory ilmenite. The Ti released from the hornblende is unable to be taken up to any great extent by the chlorite and so is largely removed from the system. A notable feature of the TiO_2 graph is the larger range of concentrations in the rocks from the northern portion of the gabbro and the Upper Landewednack compared with their soils. This is probably due largely to the presence of discrete grains of ilmenite in the rocks.

The behaviour of MnO is broadly similar to that of Fe_2O_3 and is most likely to be a function of the conditions prevailing in the soil profile. The Mn content is highest in those rocks containing the largest proportion of Fe-Mg minerals. These rocks upon weathering release Mn^{2+} ions into the soil profile which are then oxidized to Mn^{4+}. This reaction is catalyzed by adsorption onto ferric oxides and clay minerals. Although its oxides have a very low solubility, its solubility increases in the reducing environment. The wide scatter of Mn concentrations in the soils of some of the lithologies is due to the local accumulation of Mn oxides and to the different degrees of decomposition of the Mn host minerals.

The feldspars and micas are important carriers of Ba, Pb and Rb (substituting for K). The graphs for these elements all show very marked increases in soil geochemistry. This can be accounted for by the fact that these minerals are fairly resistant to weathering (except biotite), and therefore will tend to be retained as detrital fragments in the soil. Any mobilized Ba or Pb is readily adsorbed by the clay minerals and will also tend to form insoluble compounds which will also be retained by the soil profile. The relative increase in Rb (which is also found in some amphiboles) is probably due to isomorphous replacement of K in the lattice of the clay minerals (particularly illite).

Zr (Fig.18) shows a similar increase in the transformation from rock to soil. The most important and abundant source of Zr in many of the rocks is zircon [$Zr(SiO_4)$]. Brooks (1969) noted that the presence of one grain of zircon amongst 10^4 equal size grains of other minerals would raise the concentration of that material by 50ppm. It is also found in varying, but significant, amounts in clinopyroxenes, amphiboles, micas and garnets. Zircon itself is extremely stable chemically, and any Zr released during the weathering of other minerals will tend to be either incorporated into certain clay minerals (eg.montmorillonite) or hydrolysed to form colloidal particles of oxides, hydroxides or phosphates. These colloidal particles may then be either trapped in the profile or washed away.

P_2O_5 shows a similar, though less marked, increase in the soil profile to Zr. This is due to the fact that P ions are readily adsorbed by the clays, and are also capable of forming complex compounds in their own right. It may also be a function of the application of fertilizers on the farming land. High P values in rocks are generally associated with the presence of apatite (eg.Dean Quarry gabbro). If apatite is not present it may be attributed to P^{5+} substituting for Si^{4+} in the silicate minerals (Wedepohl, 1969-78).

Co and Sc mimic the patterns shown by those of Fe and Mn with an increase in the lherzolite and a general decrease in the other groups. They are primarily associated with the Fe-Mg minerals. In the soil both may be held in residual grains of accessory minerals such as magnetite and ilmenite or by clay minerals (Co may be heavily adsorbed by montmorillonite and illite in particular). It is also noted by Short (1961) that the fate of these elements on weathering may also be controlled by the formation of Fe- and Mn-oxides.

Ga tends to be concentrated in the later products of differentiation (eg. some micas, feldspars and amphiboles) where it behaves in a similar manner to Al. Moderate levels may also be associated with magnetite. The feldspars are the principle host mineral for Sr where it substitutes for Ca and K. If released from the silicate lattice during weathering it is relatively mobile. This feature is used later in the mapping of the Kennack gneiss which have high concentrations of Sr. In the common rock-forming minerals V is largely associated with the pyroxenes and amphiboles. Very high levels may also be found in some magnetites. It is relatively mobile in most secondary environments (Andrews-Jones, 1968), although its eventual fate in the soil profile will be largely controlled by the presence of Fe- and Mn-oxides by which it is readily adsorbed. Finally Y is predominantly associated with the Fe-Mg minerals, although it is found in far greater concentrations in garnets and epidotes (particularly allanite). This feature may account for the high Y values in the rocks of the Lower Landewednack series. These four elements (together with Ti and Ca) generally show increases in the transition from rock to soil for those igneous rocks that are formed early in the differentiation process. A notable feature is that all are present in very low amounts in these units. The metasediments and higher differentiates, which have higher initial concentrations in the rocks, show a depletion as the weathering products are unable to retain these larger concentrations.

In the common silicates, Cr and Ni are concentrated in the Fe-Mg minerals (olivine, pyroxenes and amphiboles). Higher Cr values, particularly in the ultrabasic rocks, depend primarily on the presence of chromite itself. Any Cr released during weathering may be readily adsorbed by Mn-oxides. Ni, which is easily mobilized, may be co-precipitated with Fe- and Mn-oxides. The graphs for Cr and Ni (Fig.18) show a reverse behaviour to the previous group, although there is an increase in the Cr composition of the soil for the lherzolite. This may be accounted for by the greater proportion of free chromite ... the rock compared with the harzburgite.

The Cu values in most rocks are controlled largely by the presence of sulphides. This helps to explain the larger ranges present in the rocks compared to the soils as shown in in the graphs of Figure 18. Some of the Zn values may be similarly explained, although replacement to varying degrees of Fe and Mg in the silicate lattice accounts for most of this. The behaviour of Cu and Zn is highly variable and follows no readily observable trends.

Further references to the behaviour of the various elements studied are made in the subsequent section dealing with element mobility down the soil profile.

4.3.7 Trace elements in the soil profile

During the power auger programme referred to in Chapter 3.1, a number of samples from soil profiles were collected. The original aim of the exercise was to study the mobility down the profile of the various elements used in the mapping program. Many of the factors controlling the movement of the elements in the soil have been discussed in the previous sections.

In an idealized podzolic soil the trace metal contents of many elements are generally considered to be greatest in the near surface A_o horizon and towards the top of the B horizon. This is considered to be related to the increased levels of organic matter and of clay minerals respectively. Figure 19 shows the variations in a number of physical and chemical properties in a generalized soil profile. In

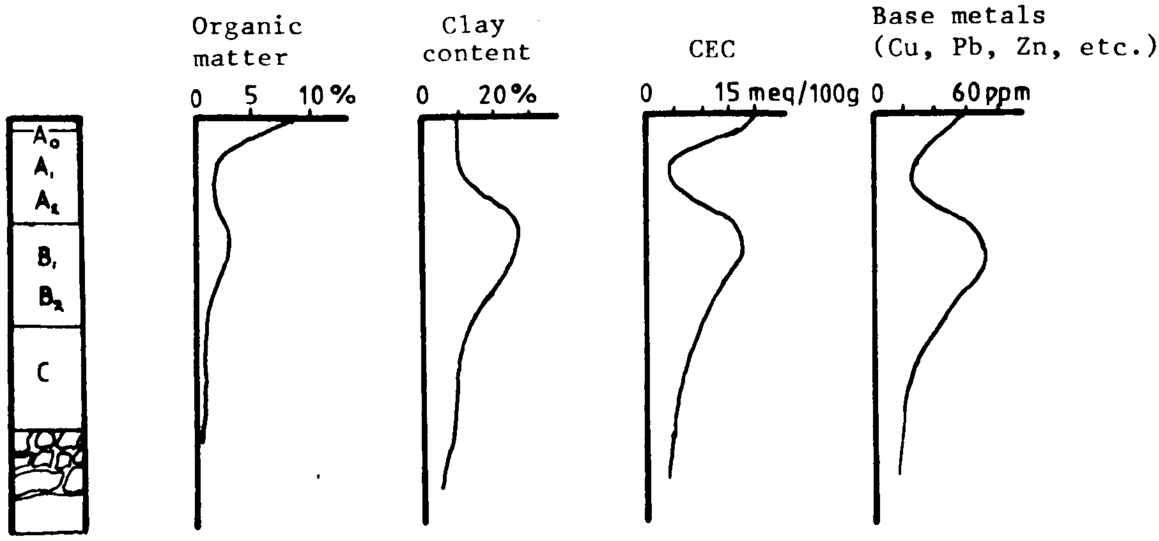


Figure 19. Variation in selected physical and chemical properties in a generalized soil profile.

addition to the importance of the clay minerals and organic matter, the scavenging effect (by adsorption or co-precipitation) on metals by hydrous oxides of iron and manganese may have a considerable influence on the trace metal contents in the soil profile. Although several adsorption sequences have been reported (as with the clay minerals), they contain a number of discrepancies when compared. These are most likely due to to local environmental conditions and the fact that, like the clay minerals, different Fe and Mn minerals have different adsorption characteristics.

There has been relatively little published work relating solely to this subject. Discussions relating to the distribution of several elements in various Russian soils are provided by Ermolenko (1972) and also by Vinogradov (1959). Most other specific works have dealt with laterites (eg.Mazzucchelli and James, 1966; Zeissink, 1969). In each instance they are concerned with varieties of soil which are not found in the district. Mitchell (1972) provides a generalized summary on trace elements in the soil and describes some of the factors controlling the mobilization of them. The relative mobilities of many elements in the secondary environment were empirically estimated by Andrews-Jones (1968). This classification was based upon Eh and pH and is summarized in Table 10. It was noted, however, that many other factors also play an important role.

In studying the data it has become apparent that whilst a few generalizations may be made, it is not possible to do so

Relative mobilities	ENVIRONMENTAL CONDITIONS			
	Oxidizing	Acid	Neutral to alkaline	Reducing
Very high			V	
High	V Ca Na Mg Sr Zn	V Ca Na Mg Sr Zn Cu Co Ni	Ca Na Mg Sr	Ca Na Mg Sr
Medium	Cu Co Ni			
Low	Si F K Pb Rb Ba	Si F K Pb Rb Ba Fe Mn	Si F K Pb Rb Ba Fe Mn	Si F K Fe Mn
Very low to immobile	Fe Mn Al Ti Cr Zr REE	Al Ti Cr Zr REE	Al Ti Cr Zr REE Cu Co Ni	Al Ti Cr Zr REE V Zn Cu Co Ni Pb Rb Ba

Table 10. Relative mobilities of selected elements in the secondary environment. After Andrews-Jones (1968).

in any more detail. The likely reason for this is the number of variables involved in the formation of the soil profile. The model for this is one in which the processes of removal, addition and transfer of elements, together with mineral transformations, are active (Simonson, 1978). The relative influences of these processes, operating on rocks of different elemental concentrations, are responsible for the variability of soils and their trace element contents within the profile.

To highlight the concept of enrichment and depletion in the soil profile, Figure 20 shows the graphs of several elements for three profiles taken from the areas around Trelan and Polkanoggo.

The pattern for the more mobile elements tend to be similar with a significant depletion towards the top of the soil profile (eg. MgO and CaO, Fig.20). Conversely those elements which are relatively immobile tend to show an enrichment towards the top of the profile. Examples of this are also shown in Figure 20 and include Al_2O_3, P_2O_5 and Ba. These are most probably retained in the formation of the clay minerals. Another example would be the element Cr assuming it were present as discrete grains of chromite (as in the ultrabasic) which have a very low solubility and are therefore retained by the soil profile.

The above enrichments and depletions concern only absolute values of the various elements in the profile. An approach which may be taken to assess the relative losses and gains in the system is to use weathering indices. This

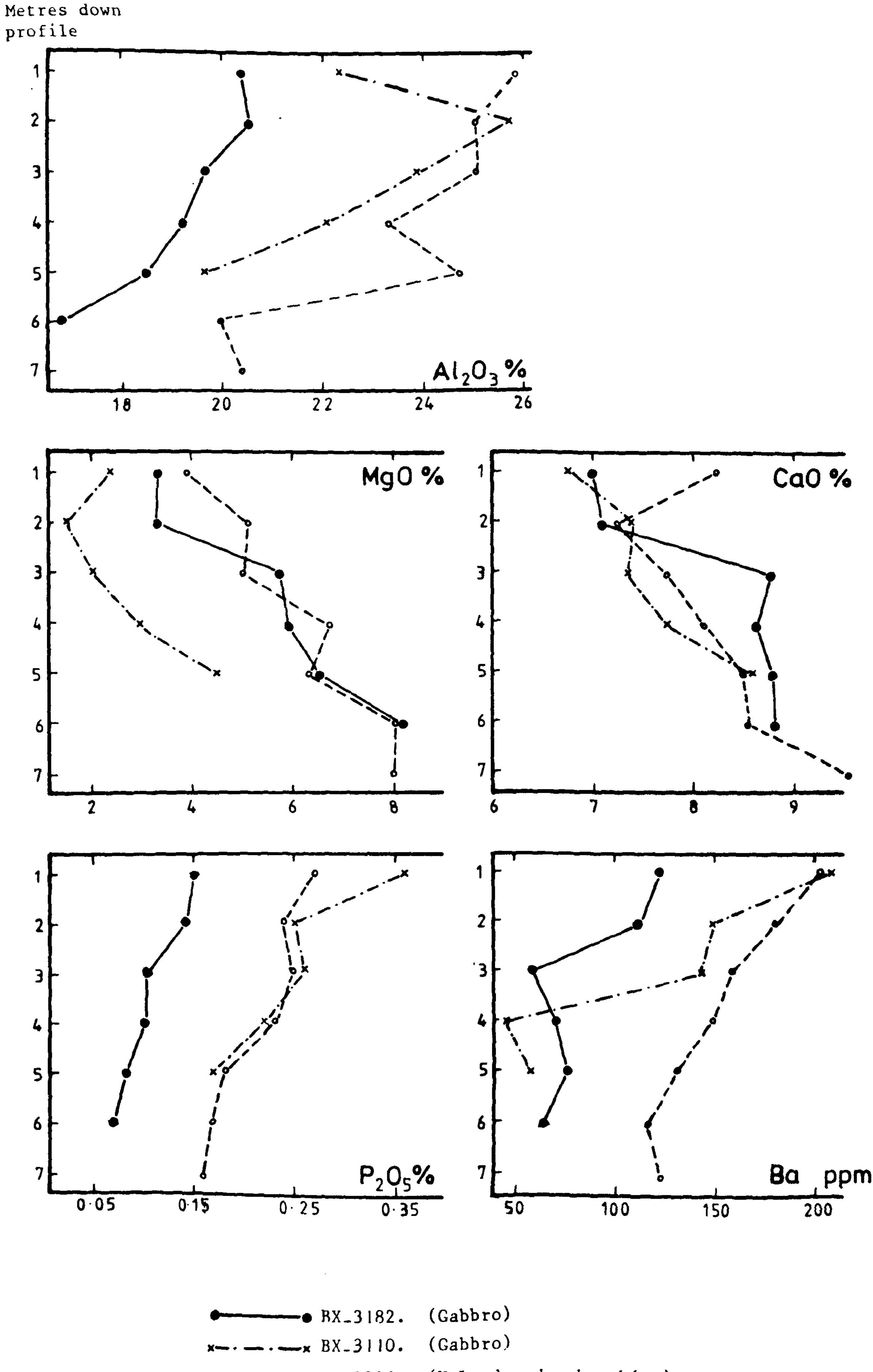


Figure 20. Typical geochemical profiles for selected elements.

technique assumes one particular constituent of the parent material remains constant, whilst the other elements are lost, altered or redistributed. An example of the use of this technique would be to assume that the Zr content remained constant and to use it as an index against which all the other constituents may be recalculated. This is done by:

$$X_i' = \frac{X_i}{Zr_i} \cdot \frac{Zr_b}{X_b}$$

where X_i is the concentration of the element X at i metres in the profile,

Zr_i is the Zr concentration at i metres in the profile,

X_b is the concentration of X at the base of the profile,

Zr_b is the Zr concentration at the base of the profile,

and X_i' is the recalculated value of X_i.

If $X_i' = 1.0$, there has been no loss or gain of the element X and the it remains present in the same proportions as it was at the base of the hole. If $X_i' > 1.0$, the element X has been enriched at that point in the profile. Conversely if $X_i' < 1.0$, there has been a depletion.

This approach assumes, however, that all the Zr is present as discrete grains of zircon. Any Zr that is held within the mineral lattice (eg. in alkali-rich pyroxenes and amphiboles) may be lost from the system during weathering. This would invalidate the primary assumption of the technique.

An alternative approach is to use an element such as Al_2O_3. It is generally considered that all Al released by the weathering process is immediately fixed by the system in the clay minerals. If this is correct then it may be used as an index. Figure 21 shows the same profiles as shown earlier (Fig.20) but with the elements recalculated against a~~n~~ constant Al_2O_3 ~~constant~~. These confirm the depletion of MgO and CaO and the enrichment of P_2O_5 and Ba in the profile. The graphs of P_2O_5 and Ba both show a strong enrichment to the top of the profile. This probably relates to the top of the B horizon where most of the clay minerals tend to be concentrated.

4.4 Power auger programme

This programme carried out by the British Geological Survey towards the end of 1983 allowed a test to be carried out on the validity of using the geochemistry of shallow soil samples to identify underlying lithologies. By collecting samples from both 1 metre and the base of the hole a comparison of their respective geochemistries could be made. As some of the original crystals and the overall structure remained visable in many of the basal samples, it is assumed that these samples did truly represent the rotted bedrock. Therefore if the shallow samples are related to their deeper counterparts, they should exhibit a similar (although not necessarily identical) geochemistry along a traverse line. In order to test this assumption the traverse line data for the shallow and basal samples were superimposed on a graph for comparison. This was originally done by the program GRA (Appendix A), although the graphs shown below were drawn using a plotting program written by Dr.P.K.Harvey for use with a

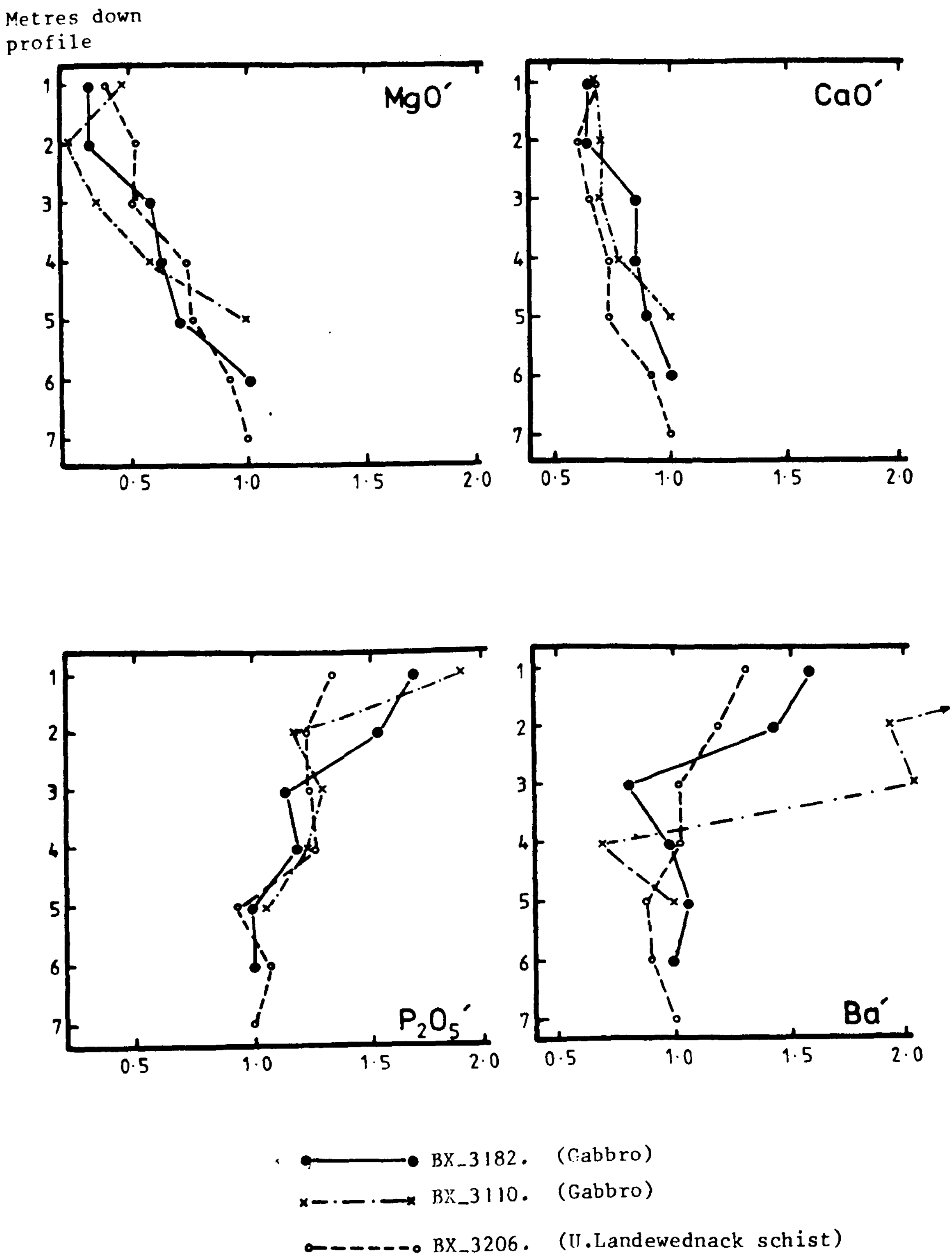


Figure 21. Typical geochemical profiles for selected elements calculated against ~~an Al2O3~~ constant Al_2O_3

Hewlett Packard graphics plotter.

Figures 22 and 23 show the responses of 12 different elements along two traverse lines. The data shown has been smoothed by a 3-point moving average program (MAV; Appendix A) prior to plotting. The two lines, NAS145/146 and NAS153/154, are located about 0.5km along strike from each other and may be found on Figure 4 (Chapter 3.1). Both traverse lines selected show the boundary near to Trelan between the ultrabasic and the gabbro to the north. The remaining 12 elements not shown give similar patterns. At the base of each set of graphs is an interpretation of the geology along the line.

Whilst the contact between the two units is relatively easily identified by many of the elements, the similarity in patterns between the shallow and basal samples should be noted. There are, however, a number of exceptions along small sections of the traverse lines.

a) Gravel and gabbro / Gabbro. Both lines show small areas in which the surface samples have been identified as a mixture of gravel and gabbro whilst the basal material is described as gabbroic. This is largely based on the geochemistry but also on the fact that the areas occupy small, poorly drained depressions in the field. It is suggested that both these small areas have a significant component of gravel-derived material mixed in with the near surface residual gabbroic soils. This intermixing, although apparent in many of the graphs, can most easily be seen if the graphs of MgO (Fig.23),

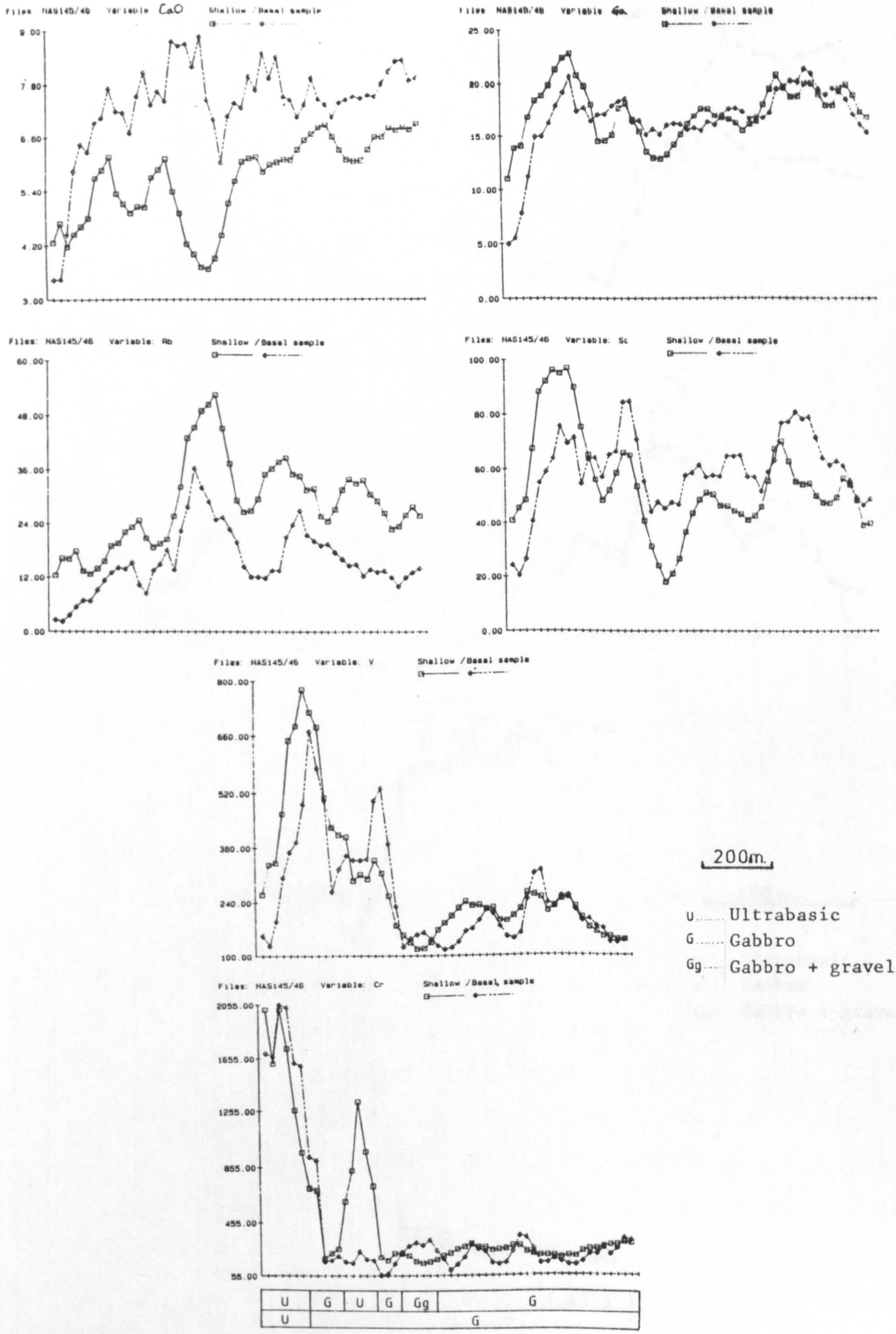


Figure 22. Traverse line plots for 6 elements over the basic-ultrabasic contact (NAS145/146).

oxide data in wt%, else ppm

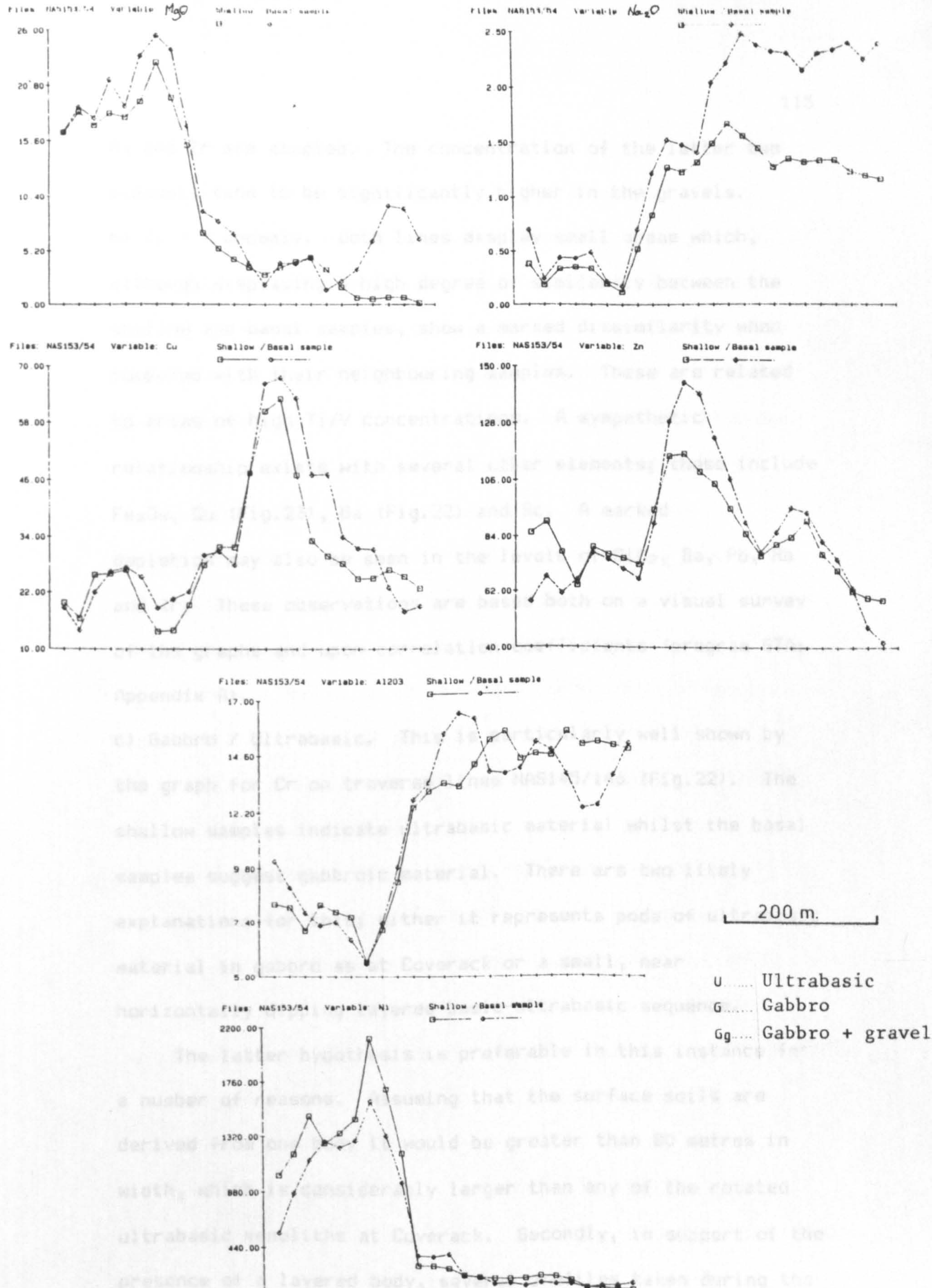


Figure 23. Traverse line plots for 6 elements over the basic-ultrabasic contact (NAS153/154).
Oxide data in wt%, else ppm.

Ba and Zr are studied. The concentration of the latter two elements tend to be significantly higher in the gravels.

b) Ti / V anomaly. Both lines display small areas which, although displaying a high degree of similarity between the shallow and basal samples, show a marked dissimilarity when compared with their neighbouring samples. These are related to areas of high Ti/V concentrations. A sympathetic relationship exists with several other elements; these include Fe_2O_3, Cu (Fig.23), Ga (Fig.22) and Sc. A marked depletion may also be seen in the levels of SiO_2, Ba, Pb, Rb and Zr. These observations are based both on a visual survey of the graphs and upon correlation coefficients (program STA; Appendix A).

c) Gabbro / Ultrabasic. This is particularly well shown by the graph for Cr on traverse lines NAS145/146 (Fig.22). The shallow samples indicate ultrabasic material whilst the basal samples suggest gabbroic material. There are two likely explanations for this; either it represents pods of ultrabasic material in gabbro as at Coverack or a small, near horizontally dipping layered basic-ultrabasic sequence.

The latter hypothesis is preferable in this instance for a number of reasons. Assuming that the surface soils are derived from one body it would be greater than 80 metres in width, which is considerably larger than any of the rotated ultrabasic xenoliths at Coverack. Secondly, in support of the presence of a layered body, several profiles taken during the power auger programme just east of Trelan showed distinct changes in soil colour as the chemical environment of the soil changed as different lithologies were intersected. The gabbroic material generally showed paler yellow-brown soils in the oxidizing environment which became greyish-green under reducing conditions. The ultrabasic-derived soils tended to be much darker, more commonly waterlogged, and often a very dark reddish-brown near to the base of the hole. Figure 24 shows the graphs for some of these profiled power auger holes.

In conclusion it is considered, on the basis of the results of this exercise on 9 such traverse lines, that the use of shallow soil samples as an aid to geological mapping is justified. However, two points should be recognized:

i) The gravels and loess may become intermixed to a varying degree with the residual soils. This may give rise to spurious interpretations if the influence of the superficial material is not recognized.

ii) Only the surface material will be identified and any underlying units where one lithology underlies another will probably not be identified. The only possible exception to this is that of the Kennack gneiss where it is concealed by the serpentinized peridotite (Re. Chapter 6.4.1).

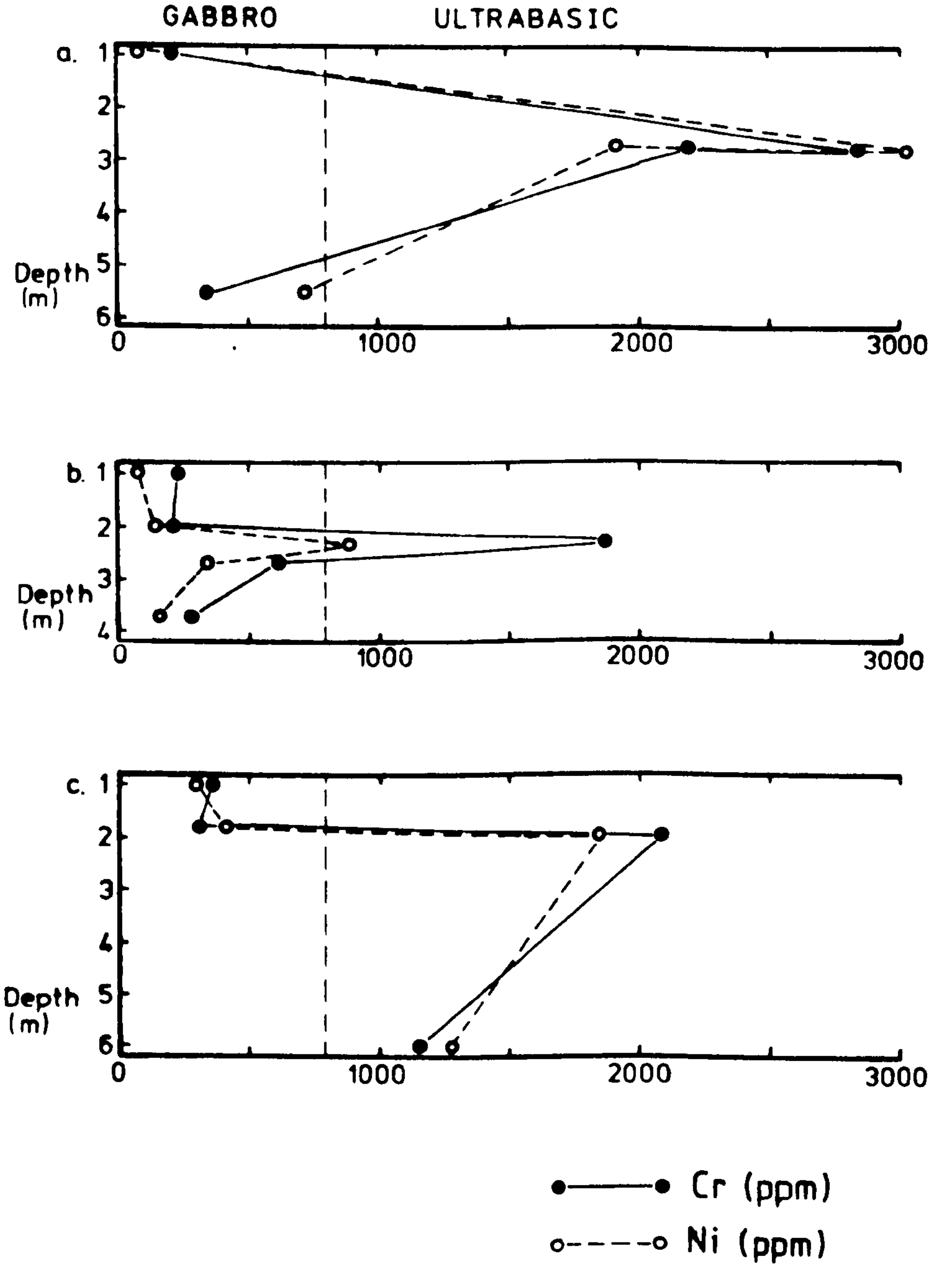


Figure 24. Selected profiles showing layering of basic and ultrabasic units.
a) BX_3002 (NAS143/144)
b) BX_3004 (NAS143/144)
c) BX_3047 (NAS147/148)

CHAPTER 5

PATTERN RECOGNITION

5.1 Introduction

Pattern recognition is a term given to a variety of multivariate statistical techniques used in data analysis to identify or classify a sample, or group of samples. They include such recognized techniques as cluster analysis and discriminant analysis. The related techniques of principal component analysis (PCA) and factor analysis are commonly applied to data as a pre-processing stage. It is a relatively new and effective approach to data interpretation in geology. For this reason, and also because of the confusion that has arisen over the use of some of the terms, it is worth describing some of the concepts and terminology involved at this early stage.

A pattern consists of a collection of measurements characterizing a sample which are considered as an entity for the purpose of subsequent analysis (Howarth, 1972).

Classification "allocates entities to initially undefined classes so that the individuals in a class are in some sense close to one another" (Cormack, 1971). It is internally based in as much as it does not depend on *a priori* knowledge about the relations between these entities or samples. The samples are free to enter any class that may emerge in the process of classification. The result is that the entities should be placed into approximately homogeneous groups. The classificatory system that arises can then be used to describe any class such that it in some way conveys information about the entities of that class (Jardine and Sibson, 1971). These entities may be individual variables, a number of variables making up a sample, or classes of samples. Therefore the classes of one classificatory system may be the entities of another.

Identification or assignment should be regarded as "the process of choosing which of a number of defined classes a new entity should be allotted to" (Cormack, 1971).

There are two aspects to the pattern recognition problem; the development of a decision rule whose function is to divide multidimensional measurement space into $\underline{x}$ decision regions each corresponding to one class, and the implementation of that rule (Young and Calvert, 1974). These two aspects may, as in the case of cluster analysis, occur simultaneously. This enables the technique to function without _a priori_ knowledge, although clearly the existence of a training set allows a user to evaluate the efficiency of the algorithm. The alternative is that it occurs sequentially and therefore can be based on _a priori_ knowledge as with discriminant analysis and identification.

The techniques used in pattern recognition are a collection of numerical algorithms for solving specific problems posed in a particular way. Their aim is to reduce a very large body of data into a relatively compact description. Successful application of a selected technique is dependant upon careful formulation of the decision rule by the user and an understanding of the assumptions and limitations involved. Without this a successful interpretation of the results may not be made. Careful consideration must be given in the preparation of the data, and in the selection and implementation of the methods to be used. Rapid "feasibilty studies" will tend to produce inconclusive results.

The numerical methods used in the pattern recognition process are generally based on relatively simple concepts. They owe their development to the existence of computers which have the ability to store and process large numbers of samples in a very exact manner and are able to work with ease in multidimensional space.

The techniques have their origins in many fields of study with significant amounts of literature in such diverse areas as:

a) Life sciences (including the related field of palaeontology) where it is frequently referred to as numerical taxonomy. Its general usage ranges from developing complete taxonomies to delineating the subspecies of a distinct but varied species (eg. Simpson, 1961; Sokal and Sneath, 1963).

b) Engineering sciences where it is used for the analysis of a variety of subjects including handwriting, speech, circuit design and electrocardiogram waveforms (eg. Fu, 1968; Meisel, 1972; Fukunaga, 1972; Young and Calvert, 1974).

c) Medical sciences (including psychiatry) where it used to discover more effective and economical means for making positive diagnoses in the treatment of patients (eg. Baron and Fraser, 1968; Tryon and Bailey, 1970).

d) Earth sciences (eg. Agterburg, 1974; Davis, 1973; Mather, 1976; Le Maitre, 1982). This includes work relating to image processing carried out on satellite photographs (eg. Landsat), although this also has a military application.

e) Behavioural and social sciences.

f) Information and policy sciences.

Unfortunately there has been only limited cross-fertilization of ideas between the various workers and fields, with individual users tending to use only one preferred technique rather than the most suitable technique for the task in hand. Also because of the diversity of applications there is a lack of a comprehensive and integrated approach to the problems of using the techniques with real data.

The remainder of this chapter will be concerned with some of the statistical techniques used in pattern recognition and a description of the identification procedure developed for use as a mapping tool on the Lizard Complex.

5.2 Cluster analysis

Cluster analysis can be defined as "the classification of individuals into groups based on the observations on each individual of the values of a number of variables" (Kendall, 1973). Ideally the methods should sort the individual data units or samples into groups such that the degree of "natural association" is high among members of the same group, whilst the clusters themselves are "relatively distinct" from each other. This is of course dependant on the particular problem under study and the technique selected.

Its advantage over most of the other techniques used in pattern recognition is that it does not need a priori knowledge. Although clearly some knowledge of the ~~the~~ category structure or the existence of a training set allows a user to study the efficiency of the selected algorithm.

A problem with clustering in general is that, if the data forms well structured clusters that are compact and well separated from each other, almost any clustering procedure will provide meaningful and unique clusters. If, however, the distribution of the data resembles a uniform distribution the resultant clusters may be different with differing clustering techniques, or even with the same techniques over several attempts.

The necessity for a technique such as cluster analysis when little or nothing is known about the category structure can be demonstrated by studying the relatively simple problem of sorting 25 samples into five groups. The number of possible ways of sorting $\underline{n}$ observations into $\underline{K}$ groups is a Stirling number of the second kind (Anderburg, 1973):

$$S_n^{(K)} = \frac{1}{K!} \cdot \sum_{k=1}^{k=K} (-1)^{K-k} \cdot \binom{K}{k} \cdot k^n$$

$$S_{25}^{(5)} = 2,436,684,974,110,751$$

If the number of groups is unknown the number of possibilities is a sum of the Stirling numbers:

$$\sum_{n=1}^{n=25} S_{25}^{(n)} > 4 \times 10^{18}$$

Even with the use of a computer it would take an excessive length of time to examine all the possibilities, and even then the ability to distinguish between good and bad category structures would rapidly diminish. It is generally the purpose of clustering algorithms to find an acceptable solution whilst considering only a small number of alternatives.

A particularly useful role it can play is to generate hypotheses about category structure. These groups may in turn contribute directly to the development of an identification scheme (Section 6.4.1). Thus, theoretically, cluster analysis can be used to develop inductive generalizations. Although a set of results should be applied only to the samples on which they were based they may, with appropriate modification, be extended to describe the properties of other samples and ultimately the parent population. It is this approach that is taken for some of the lithological units in the later identification of soil samples from the Lizard Complex.

As a note of caution, prior to describing the two different clustering approaches, it is recognized by Anderburg (1973) that during clustering two possibilities are often overlooked:

a) The data may contain no clusters. This is caused by the absence of discriminating variables and a uniform distribution of points in the measurement space.

b) The data may contain only one cluster. This is due to the absence of discriminating variables combined with a lack of meaningful mutual associations among the data units.

At this point it is useful to divide clustering into two fundamentally different approaches:

a) Hierarchical cluster analysis, where the relationships between the resulting category structures is described (Fig.25a).

b) Non-hierarchical cluster analysis where the data units are divided into groups producing a simple partitioning of the entire data set (Fig.25b).

It should be noted that the clusters obtained at some stage by a hierarchical method can be viewed in isolation as the output of a non-hierarchical method (Fig.25a, dotted line), and conversely that clusters resulting from a non-hierarchical technique may be fitted together into some hierarchical system (Fig.25b, dotted line).

In deciding which approach may be most suitable for a particular problem it is necessary to be aware of the overall purpose of the study for which the results are required. If comparing the relationships between different sets of data, hierarchical techniques may well be the most useful. If however, the object of the exercise is only to separate the various groups within a data set it may be preferable to use non-hierarchical techniques.

5.2.1 Hierarchical cluster analysis

The hierarchical methods operate on a similarity matrix which describes the strengths of all the pair-wise relationships among the entities of a given data set. This similarity matrix may be based on a variety of measurements. Most commonly used are some sort of measurement based on

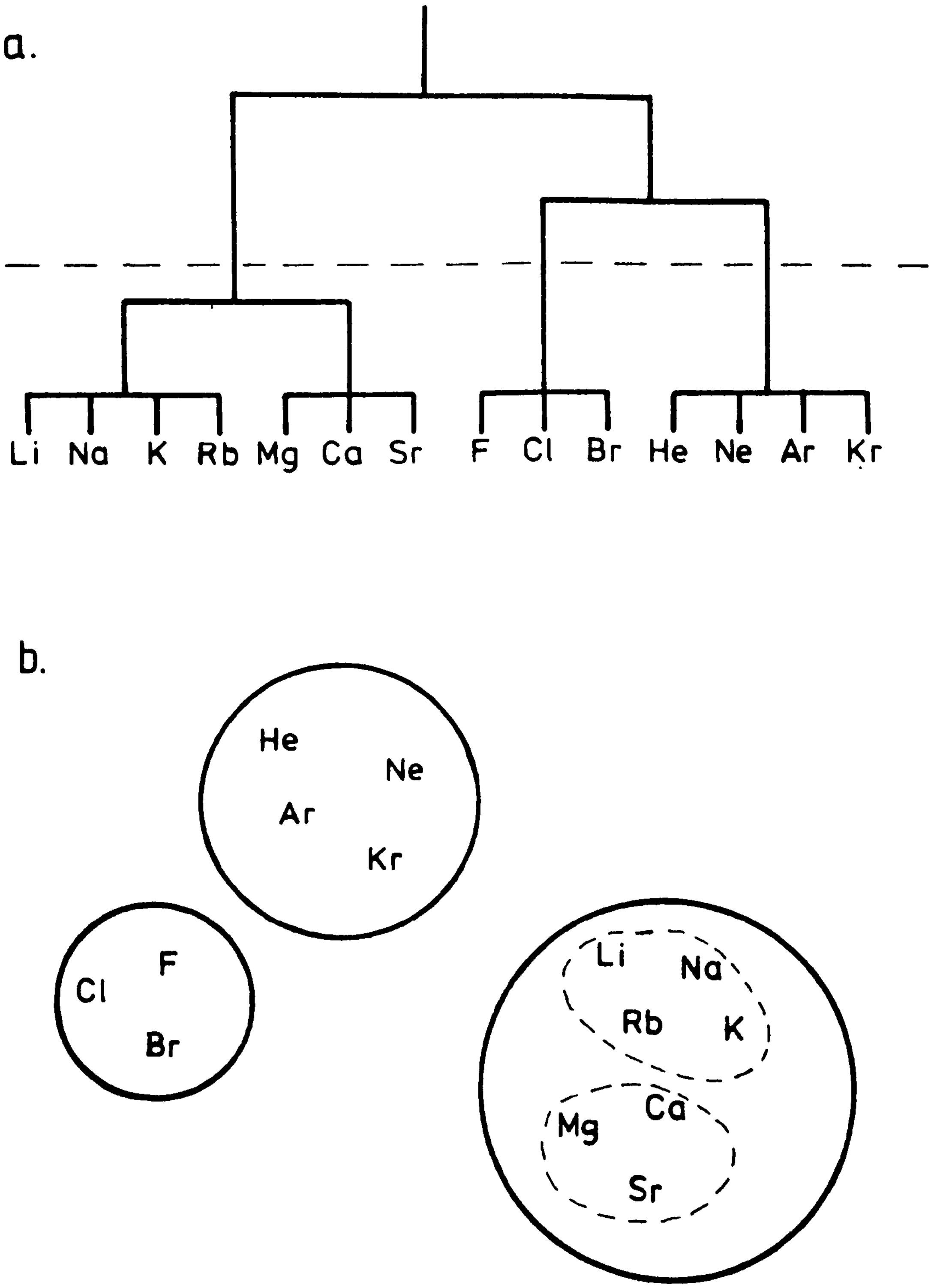


Figure 25. Examples of hierarchical and non-hierarchical cluster analysis.

distance, eg. the distance between the nearest (or furthest) element in each cluster or the distance between the centroids of each cluster, or measurements based on correlation. If standardized data are used measurements of distance and correlation coefficient may be directly transformed from one to another. In other words distance may be looked on as a measure of dissimilarity.

As a general observation, distance-based measures tend to cluster more successfully (based on cophenetic correlation) than correlation-based measures. They also appear to be less susceptible to changes in clustering method (Davis, 1973). Although the two measurements will tend to give similar results, distance-based measurements are not constrained between ± 1.0 and therefore may be expected to produce better results if a few of the data units are very dissimilar from one another.

The result of these procedures is generally shown as a tree diagram or dendrogram. This displays the relationships between the entities (Fig.25a). There are two alternative approaches to the construction of the dendrogram:

a) Agglomerative methods which build a tree from the branches (representing one entity) to the root (representing the entire data set). These methods group the entities into small clusters which are progressively merged into larger and larger clusters. A property of these techniques is that once a link is formed it can not be broken. This feature could prevent two distinct clusters, joined by a chain, from being cleanly separated. In Figure 26 the two groups would be linked at a very early stage because of the similarity of some of the objects in the chain. Marriott (1974) points out that although such a distribution of data is unlikely in 2-dimensional space, it is much more likely in higher dimensional space as the number of variables increase.

b) Divisive methods which operate in a converse manner.

Mather (1976) provides a summary and comparison of the various hierarchical clustering algorithms. Full descriptions of some of the most commonly used hierarchical techniques can be found in Jardine and Sibson, 1971; Anderburg, 1973; Davis, 1973; Hartigan, 1975.

A serious problem with hierarchical clustering algorithms is their need to store the similarity matrix in such a way that its values can be accessed in any sequence. This storage requirement seriously restricts the number of data units that can be clustered. The storage requirements for the similarity matrix alone (not including storage required for the program and the various ancillary arrays) increases at a rate of almost $\underline{n}^2/2$ where $\underline{n}$ is the number of data units. Table 11 shows the storage requirements for a similarity matrix with increasing $\underline{n}$.

Much computational effort is required in hierarchical clustering, the majority of which is in the search for the most similar pairs and in the subsequent updating of the similarity matrix. The number of comparisons required for this is approximately 2 X $\underline{n}^2$. Table 12 shows the actual

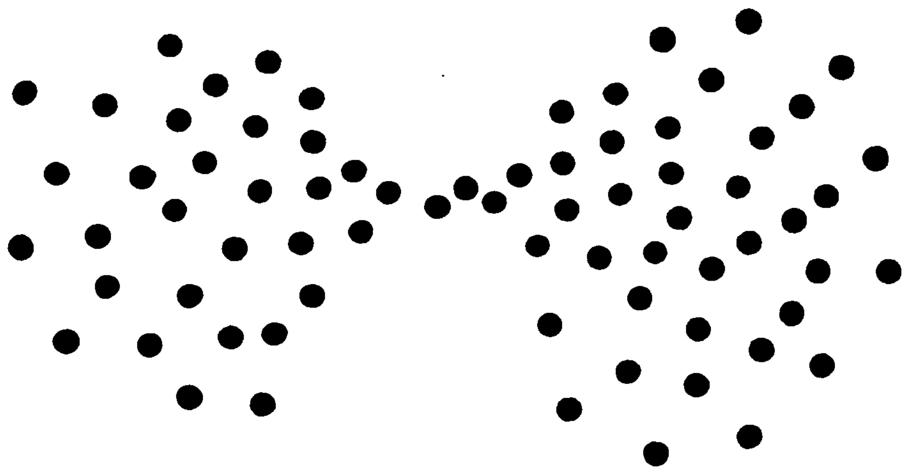


Figure 26. Poor separation of clusters by hierarchical methods.

No.of data units	Storage (actual)	Storage (kByte)
50	1,225	4.9
100	4,950	19.8
200	19,900	79.6
400	79,800	319.2
800	319,600	1,278.0

Table 11. Storage requirements for the similarity matrix used by a typical hierarchical clustering technique.

No.of data units	No.of comparisons ($2n^2-9n/2$)
50	4,775
100	19,500
200	79,000
400	318,200
800	1,276,400

Table 12. Number of comparisons required by a typical hierarchical clustering technique.

number of comparisons required. However this large number can be accomplished in a relatively short length of computer time.

Another serious problem with the hierarchical procedures is that their theoretical basis is incomplete. The statistical properties of the various techniques are poorly understood and there are few tests of significance (Switzer, 1970). As there are few tests of significance there is not the same need as with the other multivariate statistical techniques for a multivariate normal distribution. Multivariate normality does, however, become important if correlations are taken as the measure of similarity.

Most researchers using hierarchical clustering algorithms normally experiment with a variety of similarity measures and clustering techniques. They then choose a combination that appears to yield the most satisfactory results with their data. This, in turn, introduces an element of subjectivity into a process which is supposed to be objective.

5.2.2 Non-hierarchical cluster analysis

This technique partitions the entire data set of $\underline{n}$ objects into $\underline{K}$ discrete groups on the basis of the optimization of a stated mathematical criterion. The number of clusters formed, $\underline{K}$, may either have been previously specified or determined during the clustering operation. The technique is not used for the classification of variables.

The non-hierarchical procedure best adapted to the classification of large data sets around moving centres is the K-means algorithm. The basic concept of this method is to select some initial partition of the entities and then to modify the cluster membership in order to obtain an improved partition. This initial partition may either be one based upon groups or a set of seed points (or centroids) around which such groups may be formed. The data are processed serially, unlike the hierarchical methods which require the calculation and storage of the similarity matrix, and so they may be read from a temporary file (unformatted scratch files are used for this purpose). This in turn permits much larger problems to be studied as the data are no longer held within the program itself.

The term sample, as used in geology, is synonymous with the terms data unit, entity and object. It is not used in its statistical sense. The individual measurements characterizing a sample are termed variables. In this instance they are element concentrations as produced by XRFS (Chapter 3.3).

The clusters are separated by piecewise linear boundaries (Fig.27). These are the locus of points equidistant from two given points in a straight line perpendicular to the line joining the two points. In higher dimensional space the boundaries become segments of a hyperplane.

The algorithm presented below and listed in Appendix A (program KMN) is loosely based on that of MacQueen (1967); other workers to have been responsible for the development of the method include Forgy (1967), Jancey (1967) and Ball and

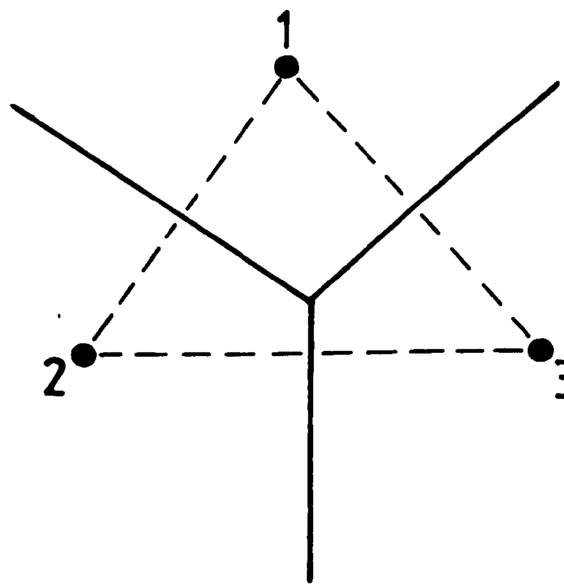


Figure 27. Piecewise linear boundaries used in partitioning clusters by the non-hierarchical techniques.

Hall (1967). By the extensive use of unformatted scratch files and Direct Access files it is possible to cluster an almost unlimited number of samples. The technique is used in Chapter 6.4.1 to recluster all the gabbroic material of the Complex. The procedure in its most basic form takes place in several stages.

A summary of the algorithm described below may be found in Appendix C together with a simple example.

Standardization

The object of standardization or equilization is to cause each variable to have a common numerical property. This removes the problem which arises when different units of measurement are used to express element concentrations (ie. Weight percent and Parts per million; major elements and trace elements respectively). It also accommodates variables which use the same scale of measurement but have different magnitudes. The process of standardization is achieved by dividing all the scores for a variable by an equalizing factor expressed in the same units. This converts all the variables to a single index of similarity.

The method of homogenizing variables used in this work is that of reducing to a standard form (ie. zero mean and unit standard deviation) by:

$$Z_{ij} = \frac{(x_{ij} - \bar{x}_i)}{\hat{\sigma}_i}$$

where Z_{ij} is the standardized value for the i^{th} variable of the j^{th} sample,

x_{ij} is the i^{th} variable of the j^{th} sample,

$\bar{x}_j^i$ is the overall mean of all values of the i^{th} variable and $\hat{\sigma}_i$ is the standard deviation associated with the i^{th} variable.

This removes the effect of magnitude of the various variables eg. 10% Fe_2O_3 may now be equivalent to 2000ppm Cr or 15ppm Ga. In a number of experiments which were carried out on standardized and unstandardized data for which there was *a priori* knowledge, it was found that standardized data tended to give improved partitions.

Whilst this is the most commonly used standardization process, other procedures may be used. These include the division of all the measurements for a variable by the mean or the range of that variable. Although standardization causes variables to become comparable, it weights variables equally. This is unlikely in a natural situation and is discussed below.

Distance measure

The measure of association among samples used for the K-means technique during the course of the project is the squared Euclidean distance. This is calculated from the standardized data by the function DIST (Appendix A):

$$D^2 = \Sigma_{k=1}^{k=m} (x_{ik} - x_{jk})^2$$

where D^2 is the squared Euclidean distance,

x_{ik} is the k^{th} variable of the i^{th} sample

and x_{jk} is the k^{th} variable of the j^{th} sample.

No account is given to correlations between variables by the use of the Euclidean distance measurement. Although a principal components transformation will remove the effects of the lack of orthogonality, this approach was not taken as it was found, by working in an a priori situation, that good results could be obtained without their use.

Cormack (1971) provides a brief review of many of the measurements of similarity which can be used in classification. Further details may be found in work by Anderburg (1973) and Hartigan (1975).

Standardization, described above, may be carried out simultaneously within the distance calculation. No other weighting was applied to the data of individual variables. This approach can be usefully taken if a few elements are recognized as being particularly important to an algorithm or if some measurements are considered to be more reliable than others. Neither of these are considered pertinent to the present study. All the analyses were carried out on the Nottingham XRF and those elements which showed a lack of precision were removed earlier (Chapter 3.4). Additionally the elements which consistantly have little influence on the identification of an unknown are removed in Chapter 6.2.2.

Selection of seed points

A set of $\underline{K}$ seed points are used as cluster nuclei around which a set of $\underline{n}$ data units may be grouped. The value of $\underline{K}$ is in most cases specified by the user prior to clustering. Dependant upon the option of KMN selected ("F" or "C"/"O") the initial centroids are selected by:

a) Select the first $\underline{K}$ samples within the data set to be the initial seed points (MacQueen, 1967). If the initial configuration does not influence the ultimate outcome, then this method is the cheapest computationally and the simplest. Figure 28 shows a two group situation in which the two initial seed points are of little importance. It also describes diagrammatically the operation of the technique from selection of the seed points, through the initial partition and iterative relocation, to the final partition. Appendix C shows in more detail the workings of a simple three group, two dimensional example. Whilst the use of an alternative method, such as that described below, would provide the same answer, it would increase the speed of the clustering operation.

If the groups are relatively indistinct and the initial selection of seed points is important then it may be preferable to read in a single file of seed points which are considered suitable. This may be done as the program KMN will read in any number of files so long as they contain no more than 50 variables. Seeding the data set in this manner gives an improved partition and generally decreases the time taken for convergence to occur.

b) The second option ("C" or "O") is to choose $\underline{K}$ seed points which are well separated from each other and therefore span the data set (Ball and Hall, 1967). Figure 29 shows diagrammatically how this is achieved in an example using three traverse lines collected during the orientation survey (NAS121, NAS137 and NAS136A; Lower Landewednack hornblende

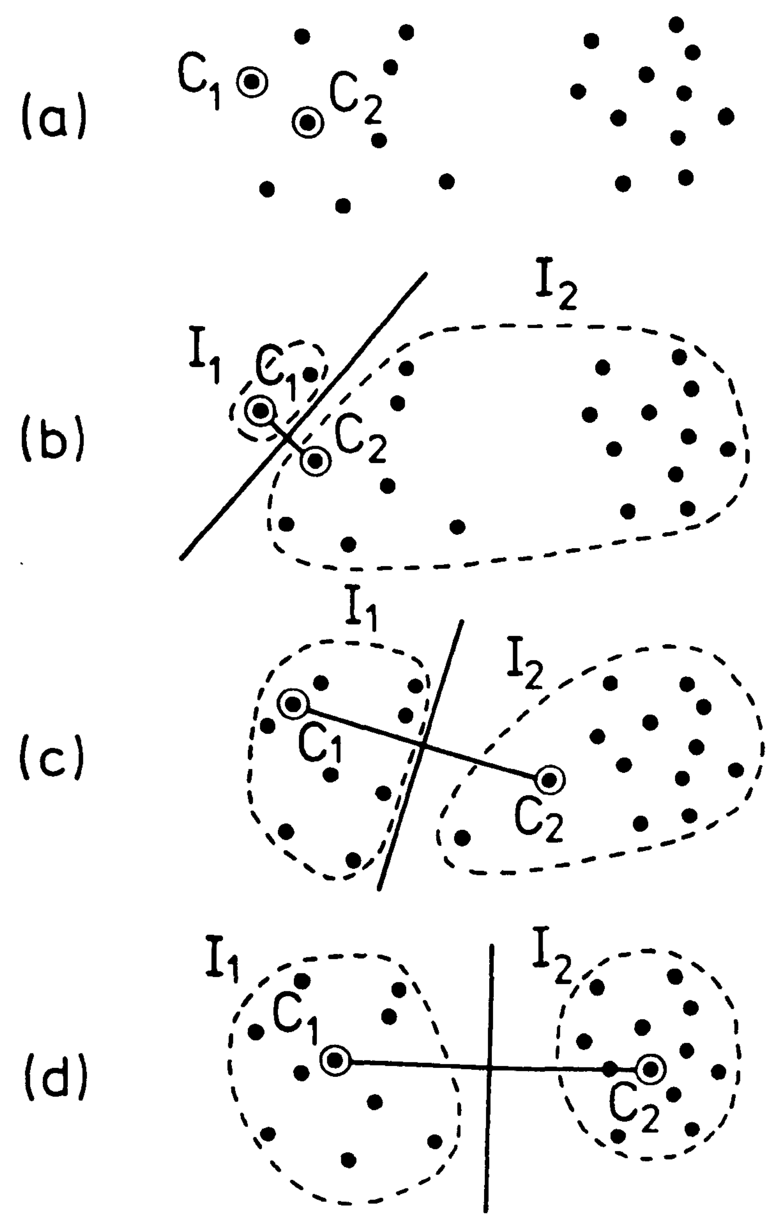
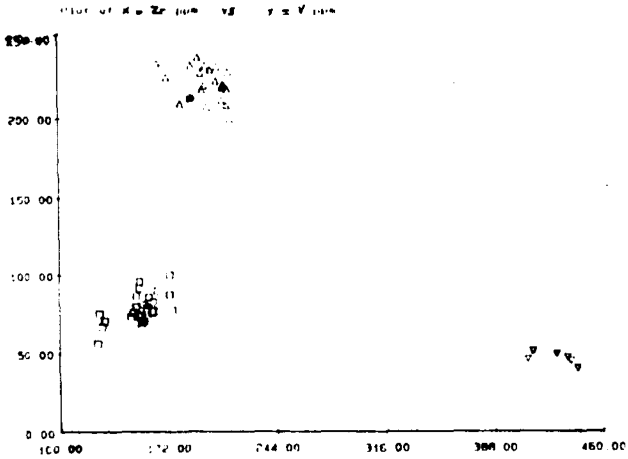
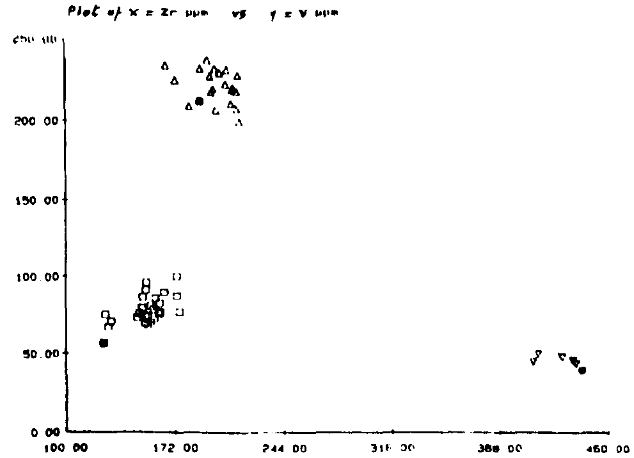


Figure 28. Theory of K-means clustering technique.
a) Random drawing of centroids C_1 and C_2.
b) Partition of groups I_1 and I_2 based on previous centroids.
c) New centroids based on groups created in b) and resultant new groups, I_1 and I_2.
d) Final centroids from groups created in c) and final partition of groups, I_1 and I_2.
Modified after Lebart et al (1984).

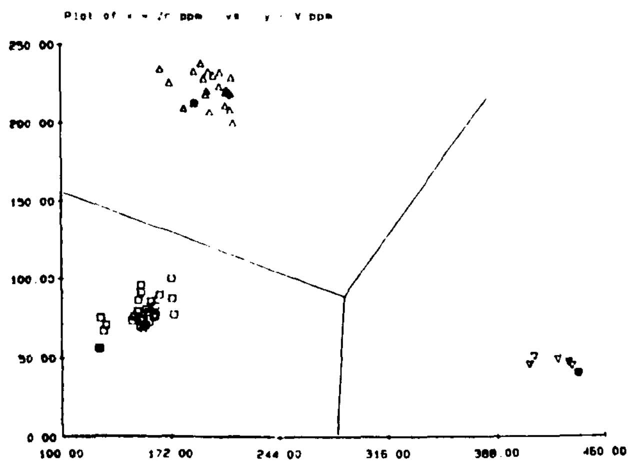


Select first seed point (centroid).

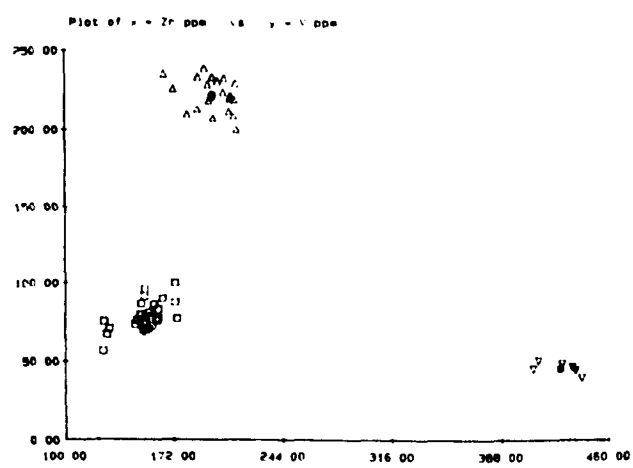


Select other two seed points.

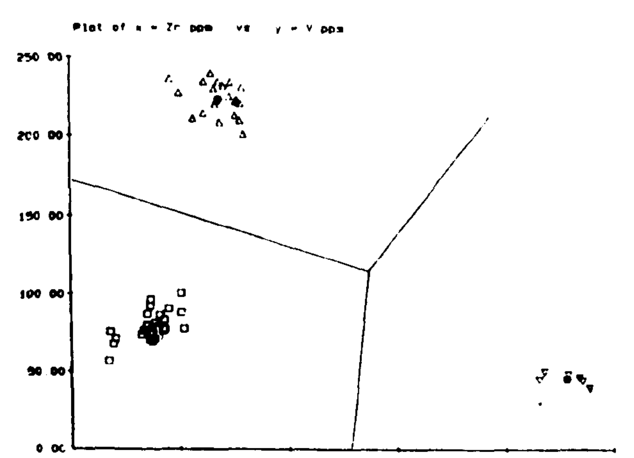
NB. Minimum acceptable distance between seed points; •———•



Create partition.



Calculate new centroids.



Final partition.

Figure 29. Selection of a well-spaced set of seed points.

schist, Kennack gneiss and loess respectively). The first seed point to be selected is the first sample held in the scratch file containing all the data. The remaining ($\underline{K}$-1) seed points are selected by examining the data in sequence and accepting any data unit which is at least some specified distance, $\underline{D}$, from all the previously selected seed points. If there are insufficient samples or it is considered that $\underline{D}$ was set too small (for example, if it considered to little of the data), then a new value of $\underline{D}$ could be selected. If the selected seed points were acceptable then they would be moved to the first $\underline{K}$ positions in the scratch file. The earlier option (a) would then be used and the first $\underline{K}$ samples selected as the initial seed points.

Initial partition

Given a set of $\underline{K}$ seed points, let each seed point initially be a cluster with one member, then sequentially allocate the ($\underline{K}$+1) to $\underline{n}$ data units to the cluster whose seed point is closest. This is achieved by sequentially calculating the distances between each data unit and all the cluster centroids. The sample is assigned to the cluster which has the closest centroid. The seed points or centroids remain constant for the assignment of the full data set. After the first iteration, the centroid is updated so that it is the true mean vector for all the data units currently in that cluster:

$$C_{ik} = \frac{\Sigma X_{ijk}}{N_k}$$

where C_{ik} is the centroid of the i^{th} variable of the k^{th} cluster group,

X_{ijk} is the value of the i^{th} variable of the j^{th} sample in the k^{th} cluster,

and N_k is the number of samples in the k^{th} cluster group.

As this technique, unlike that of MacQueen (1967), recomputes the centroids only after the full data set has been allocated, the results are not affected by the sequence of samples within the data set. Additionally it was found that updating the centroid after each reallocation of a data unit occasionally caused an infinite loop to occur within the computer program, in which one reallocation caused two entire groups to swop their group numbers at some instance once during each iteration.

Iterative relocation

Given a new set of seed points, allocate all n data units to the cluster with the nearest centroid. After all the samples have been assigned the new centroids for the K clusters are calculated. The iterative process then begins again until such time as either the process converges (ie. there is no change in cluster membership) or the maximum number of iterations (specified earlier) is exceeded.

It is considered that the number of iterations required for convergence to occur is related both to the complexity of the data and to the number of samples in the data set. Also as convergence is approached the number of iterations required to partition the different groups tends to decrease. This tends to increase after the optimum number of cluster groups is exceeded.

For each iteration the technique, for the assignment of $\underline{n}$ data units to $\underline{K}$ clusters requires $\underline{nK}$ distance computations and $\underline{n}(\underline{K}-1)$ comparisons of distance. Therefore the computational cost of examining a data set using several different values of $\underline{K}$ is considerably less than that for the hierarchical clustering techniques described earlier.

Convergence occurs when for a given cluster the sum of the squared deviations about the centroid for the k^{th} cluster is at a minimum. The error sum of squares for this may be written as:

$$\varepsilon_k = \sum_{j=1}^{j=m} \sum_{i=1}^{i=n} (x_{ijk} - \bar{x}_{ik})^2$$

where ε_k is the error sum of square deviation for the k^{th} cluster (ie. the sum of the squared Euclidean distances from each data point in that cluster to the mean vector of that cluster),

x_{ijk} is the i^{th} variable of the j^{th} sample in the k^{th} cluster and $\bar{x}_{ik}$ is the mean of the i^{th} variable of all samples in the k^{th} cluster.

For all $\underline{K}$ clusters the total within group error sum of squares is:

$$\varepsilon_{TOT} = \sum_{k=1}^{k=K} \varepsilon_k$$

As the number of clusters is increased (Max=Total number of samples; giving one sample per group only) this total within group error sum of squares tends to decrease. Successive partitions have occasionally been found to have a slightly larger value of ε_{TOT} than their immediate predecessor. Anderburg (1973) describes this value of ε_{TOT} as representing a local minima on a smooth hyper-surface. For convergence to be complete the function has been trapped in one of these depressions. It is for this reason that it is advisable to carry out the K-means procedure several times using different starting parameters in an attempt to avoid local minima. Assessing the results of several attempts at clustering, in this instance, implies a degree of subjectivity.

Selection of optimum number of groups

The value of ε_{TOT} is calculated and output by the program KMN and is used in a refinement of the original work in an attempt to find the optimum number of cluster groups from a data set (Option "O"). This was developed in response to the need to recluster the gabbroic lithologies of the Lizard Complex. This will be discussed in Chapter 6.4 and its influence on the interpretation of the geology will be considered in further detail in Chapter 7.

The method used here to determine the optimum number of groups is an iterative one in which the number of cluster groups to be found is initially set as equal to two, and then progressively incremented by one until the maximum number of groups (pre-selected) is reached. At each iteration the ε_{TOT} is recorded. The seed points for each successive iteration are selected in a similar manner to that described earlier as the method whereby they are well separated by each other. If insufficient samples are selected the minimum distance value between the two cluster groups is automatically reduced by 15%.

When the specified number of iterations have been made, a graph of the ϵ_{TOT} may be plotted against the number of clusters. By studying the curve and any break of slope an indication of the optimum number of groups within the data will be given. This number is then selected and the K-means procedure rerun using this value and the data partitioned. The technique described will also identify outlying data. Figure 30 shows the same 2-dimensional example as used previously but with an extra anomalous sample.

Assessment of relative importance of variables

Using the K-means technique an attempt was made to quantify the relative importance of the variables used during the clustering operation. Two parameters were used to achieve this; the separation between the standardized cluster centroids and the standard deviations of the standardized data contained within each cluster. These were combined in such a way as to give a value, δ, which would provide an indication of the relative importance of the individual variables. It does not, however, take into account the interaction of any other variables. A major difficulty was in deciding the relative weighting that should be given to the two parameters. It was eventually decided to use:

$$\delta_i = \frac{ABS\ [\ C_{ij} - C_{ik}\ ]}{S_p^2}$$

where δ_i is the value of δ for the i^{th} element,

C_{ij} is the standardized value of the i^{th} element at the

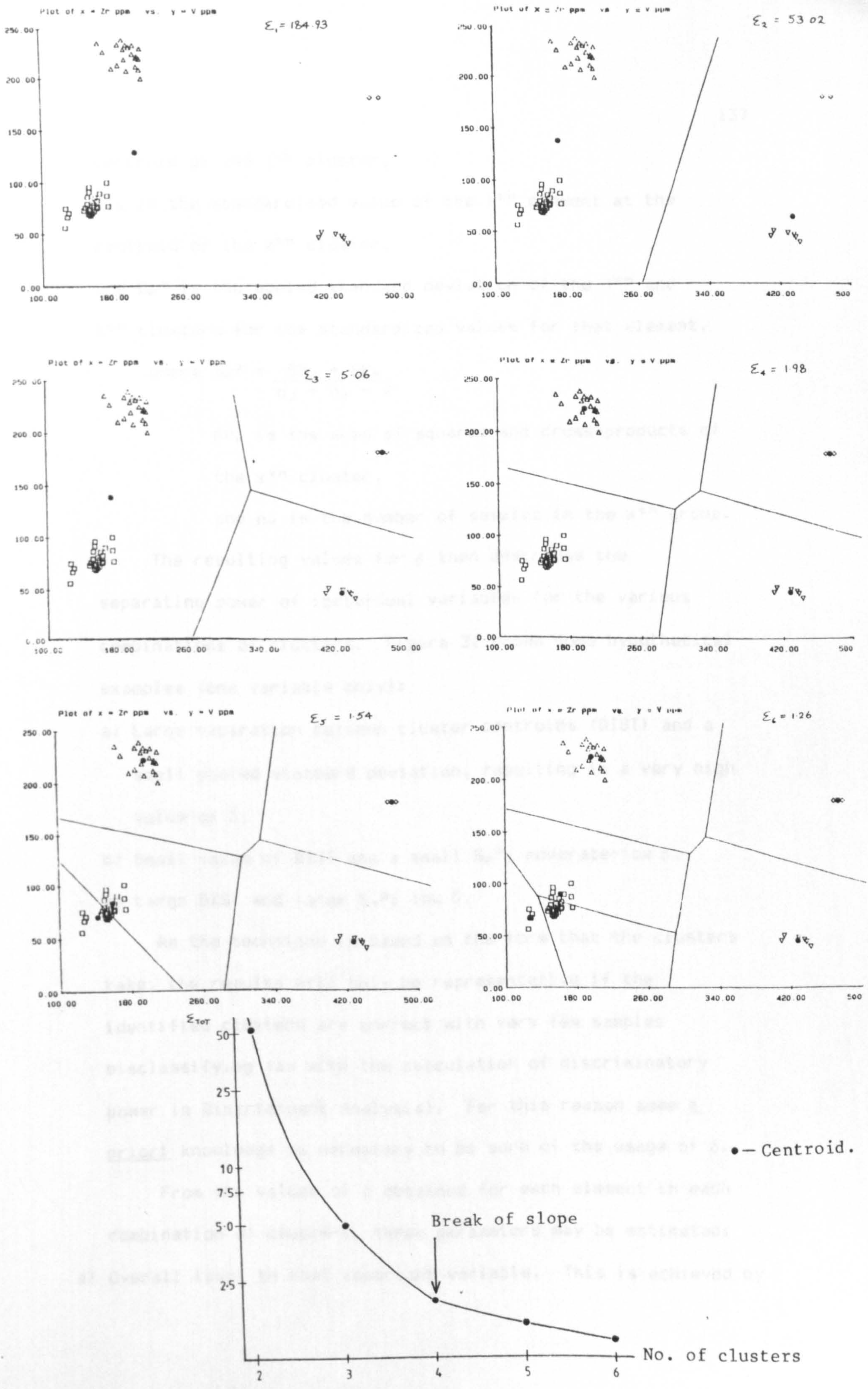


Figure 30. Example of the selection of the optimum number of cluster groups.

centroid of the j^{th} cluster,

C_{ik} is the standardized value of the i^{th} element at the centroid of the k^{th} cluster,

and S_p^2 is the pooled standard deviation of the j^{th} and k^{th} clusters for the standardized values for that element,

where $S_p^2 = \dfrac{SP_j + SP_k}{n_j + n_k - 2}$

SP_x is the sums of squares and cross-products of the x^{th} cluster,

and n_x is the number of samples in the x^{th} group.

The resulting values for δ then describes the separating power of individual variables for the various combinations of clusters. Figure 31 shows some hypothetical examples (one variable only):

a) Large separation between cluster centroids (DIST) and a small pooled standard deviation, resulting in a very high value of δ.

b) Small value of DIST and a small S_p^2; moderate-low δ.

c) Large DIST and large S_p^2; low δ.

As the technique is based on the form that the clusters take, the results will only be representative if the identified clusters are correct with very few samples misclassifying (as with the calculation of discriminatory power in Discriminant Analysis). For this reason some *a priori* knowledge is necessary to be sure of the usage of δ.

From the values of δ obtained for each element in each combination of clusters, three parameters may be estimated:

a) Overall least to most important variable. This is achieved by

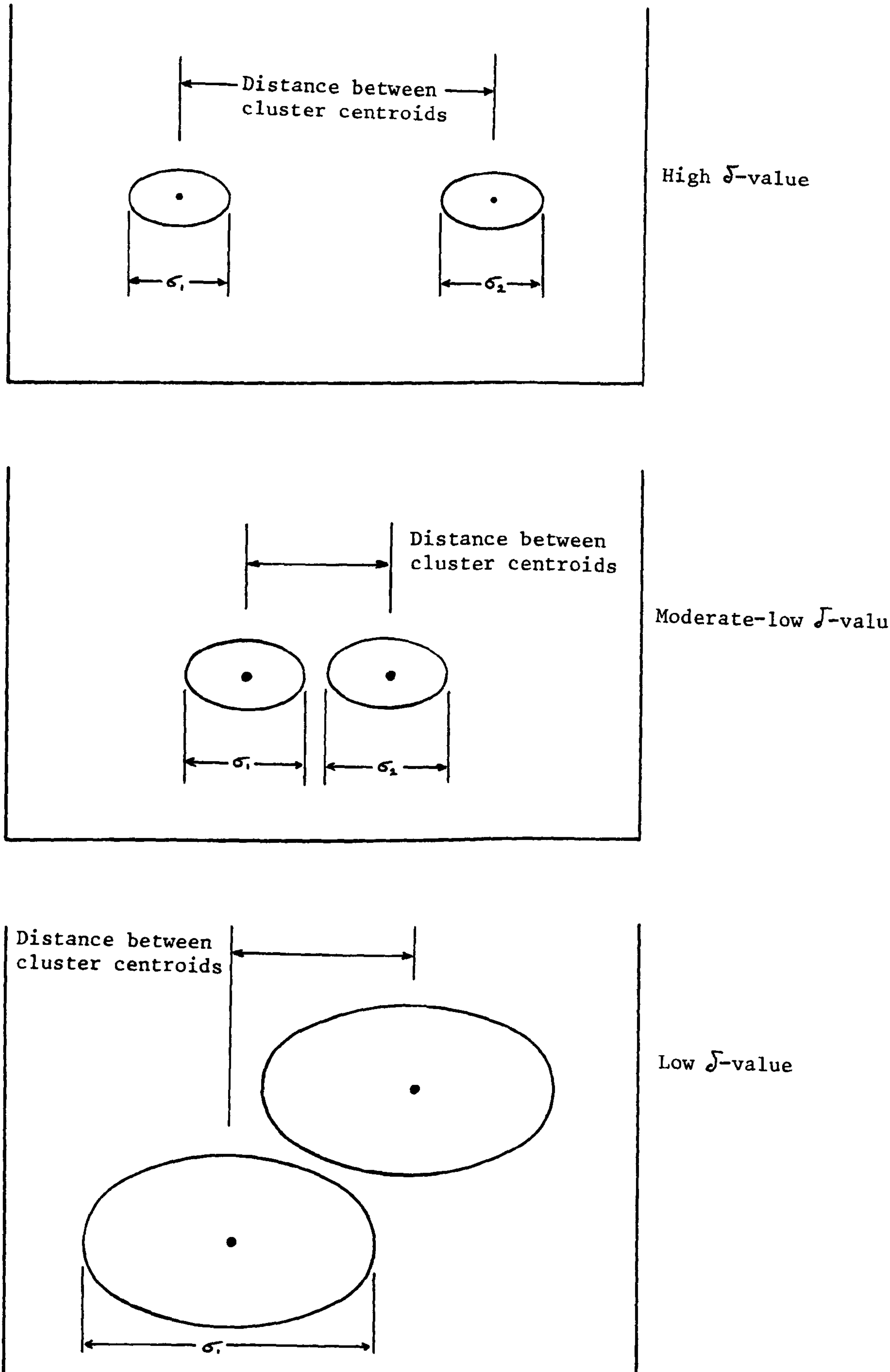


Figure 31. Use of δ to describe the separating power of individual elements.

calculating the mean of the δ values for each element and then sorting them into ascending order.

b) Worst to best elements for the identification of each cluster combination. Individual values of δ are sorted for each cluster combination into ascending order. The δ values for each element are comparable as they have all been standardized against standard deviation.

c) Overall ease of distinguishing various cluster combinations. The mean of all the δ values for each combination are calculated and then sorted into ascending order.

The operation may be described by using a simple 3-group, 2-dimensional example (NAS118,NAS120,NAS121; gabbro, ultrabasic and Lower Landewednack hornblende schist). By using option "A" of KMN, the relative discriminating power of the two variables may be assessed. The results shown in Figure 32b are confirmed by a visual study of the scatter plot (Fig.32a):

1) The relative importance of V alone is confirmed by Figure 32a with a good separation being achieved on the vertical axis alone. The horizontal axis (Zr) if used exclusively would result in several samples being misclassified.

2a) Neither V or Zr is obviously more important at discriminating between the gabbro and the ultrabasic. However, although the distance between the centroids is greatest on the Zr axis, the pooled standard deviation is relatively large. This accounts for the δ_v being slightly larger than that for Zr.

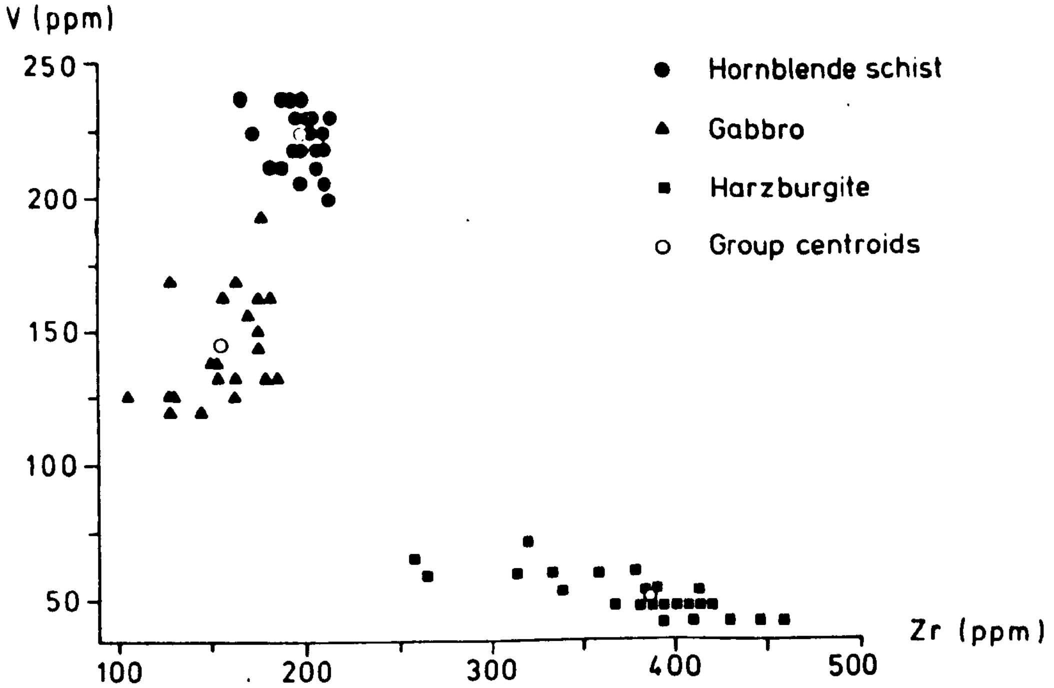


Figure 32a. X-Y plot for samples from the Crousa gabbro, harzburgitic peridotite and lower Landewednack hornblende schist.

```
Summary of results of K-means clustering on 3 groups
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Variables used; V  &  Zr.

              +++++ Summary of delta values +++++

ZR      Overall least important element  5.20 {Mean of delta values}
V       Overall most important element  10.31 {Mean of delta values}

              -:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-

ZR      Worst element for clusters 1 & 2    7.03 {Delta} (δ)
V       Best element for clusters 1 & 2     7.36 {Delta}

ZR      Worst element for clusters 1 & 3    2.32 {Delta}
V       Best element for clusters 1 & 3     5.60 {Delta}

ZR      Worst element for clusters 2 & 3    6.26 {Delta}
V       Best element for clusters 2 & 3    17.98 {Delta}

              -:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-

Clusters 1 & 3  Hardest combination to distinguish     3.76 {Means}
Clusters 1 & 2                                         7.74 {Means}
Clusters 2 & 3  Simplest combination to distinguish   12.12 {Means}

              -:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-
              -:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-
Cluster 1 contains 21 data units
Seed point (if used); S-40      GA

Cluster 2 contains 17 data units
Seed point (if used); S-85      SE

Cluster 3 contains 22 data units
Seed point (if used); S-107     LL

          ::::::::::::::::::::::::::::::::::::::::::::::::
```

Figure 32b. Use of δ in assessing the relative importance of individual elements.

2b) The use of V to discriminate between the gabbro and the hornblende schists can be seen to give the best results. The sole use of Zr would result in approximately half the samples being misclassified.

2c) V again is considered to be the best element in discriminating between between the ultrabasic and hornblende schist for similar reasons to those given in 2a.

3) From Figure 32a the results of the final section are confirmed. The gabbro and hornblende schist are the most similar clusters, followed by the gabbro and ultrabasic, with the ultrabasic and hornblende schist being the least similar.

The use of δ in the assessment of the relative importance of individual variables is returned to again in Chapter 6.2.2.

A second approach may also taken to assess the validity of the use of δ. By selecting the same three groups as described earlier but using all 28 variables (S, Sn and W excluded), it was possible to quantify the δ-value by plotting δ against the number of samples misclassified for each element. The two values were written to a file MCLD.RAW by option "M" of KMN. These were then plotted onto a graph (Fig.33). The graph shows an asymptotic curve with the number of samples misclassified, when one element only is used as a discriminator between two cluster groups, increasing as the value of δ decreases.

<u>Seed files</u>

The concept of seed files was introduced earlier in this

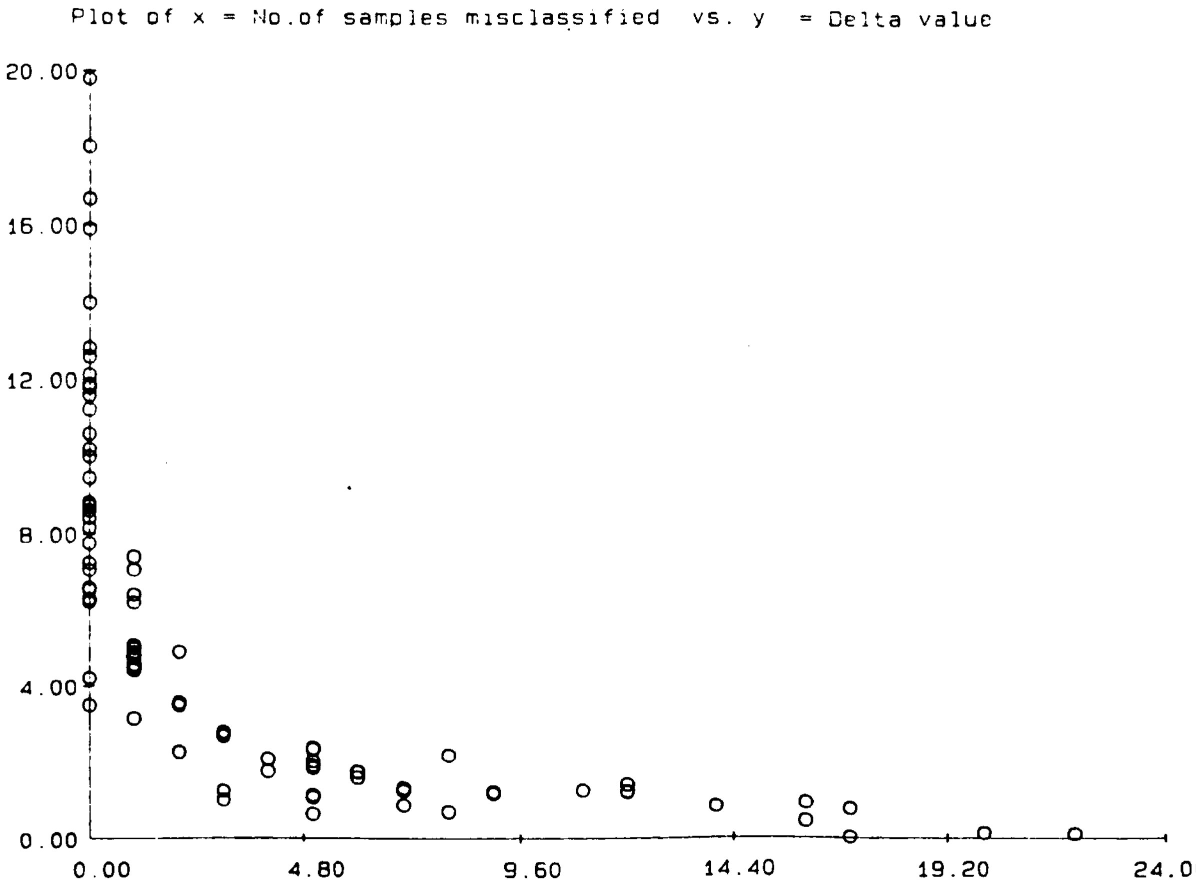


Figure 33. Assessment of δ; plot of δ against the number of samples misclassified by K-means.

section. They are files containing $\underline{K}$ data units which are read prior to any other data and therefore act as the initial point from which the K-means procedure starts. The use of these files tends to increase the speed of the operation and gives the best results. Although previously these seed points have been actual samples, a different approach is taken by the identification procedure (Chapter 5.4). In this instance they are artificial samples designed to aid the identification process. They are calculated by running the K-means algorithm for one lithological unit only. The resulting centroid values which are calculated after the first iteration are then extracted and put into a RAW-file which then may be used as a seed point in its own right. The concept of artificial seed points for use in the identification procedure is dealt with in detail in Chapters 5.4 and 6.

The option "S" of KMN uses the seed-file holding all the centroid data of all the units to indicate the standardized distances between the various groups. This, in turn, describes any possible overlap between cluster groups. This is returned to in Chapter 6 in assessing the ease of identification of the various lithological and exotic units.

<u>Problems of distinguishing similar groups</u>

During the orientation survey (Chapters 3.1 and 6.2) samples were taken from the southern and northern parts of the Crousa gabbro and from the upper Landewednack hornblende schists to the north. It was found during experimentation with the K-means algorithm using unseeded data that it was very difficult to separate the northern part of the gabbro from the hornblende schist.

The reason for this was the manner in which K-means works and the differences in standard deviations of the various lithologies. K-means, as described earlier, creates a partition at a point half-way between any two centroids. If one group has a very large standard deviation, as in the case of the gabbro which is highly differentiated and exhibits a large range in comparison with the hornblende schists, some members of the former group tend to be incorporated within the latter. This problem does not occur if the data are seeded.

In order to avoid this, wherever possible, groups with significantly different standard deviations were not clustered together. For example all the ultrabasic data was removed prior to clustering the the data from all the gabbroic material (Chapter 6.4.2).

5.3 Discriminant analysis

Linear discriminant analysis is one of the most widely used multivariate techniques used in geology. It has been described in many publications dealing with the applications of statistics to geology (eg. Koch and Link, 1971; Davis, 1973; Agterburg, 1974). An extensive bibliography of discriminant analysis as used in a variety of fields may be found in Cacoullos and Styan (1973).

It is a multivariate statistical technique in which the variables are combined in such a way as to maximize the differences between two previously defined groups. The need for an *a priori* knowledge distinguishes it from the clustering techniques described earlier. The Linear Discriminant Function (LDF) computed from these two groups (or training sets) may then be used to allocate new samples of unknown origin to one of the two original groups. The LDF transforms an original set of measurements on a sample into a single discriminant score. This score then represents the position of a particular sample along the line defined by the LDF.

Multivariate Discriminant Analyisis (MDA), in contrast, provides for the simultaneous comparison of several groups in multi-dimensional space. This and other related MDA techniques were not used during the project as only one multivariate, multi-group technique was required for the soil identification procedure (Chapter 5.4). The K-means approach was used as it was best suited to both classificatory and identificatory tasks. The latter uses the K-means approach in a slightly modified form which is described in Chapter 5.4.

Figure 34 diagrammatically shows a hypothetical 2-dimensional example of the LDF. No adequate separation may be made using either variable X_1 or X_2. The groups may however be distinguished by projecting members of the two groups onto the discriminant function line. This line is the one orthogonal to the line which best separates the two groups and minimizes the degree of misclassification.

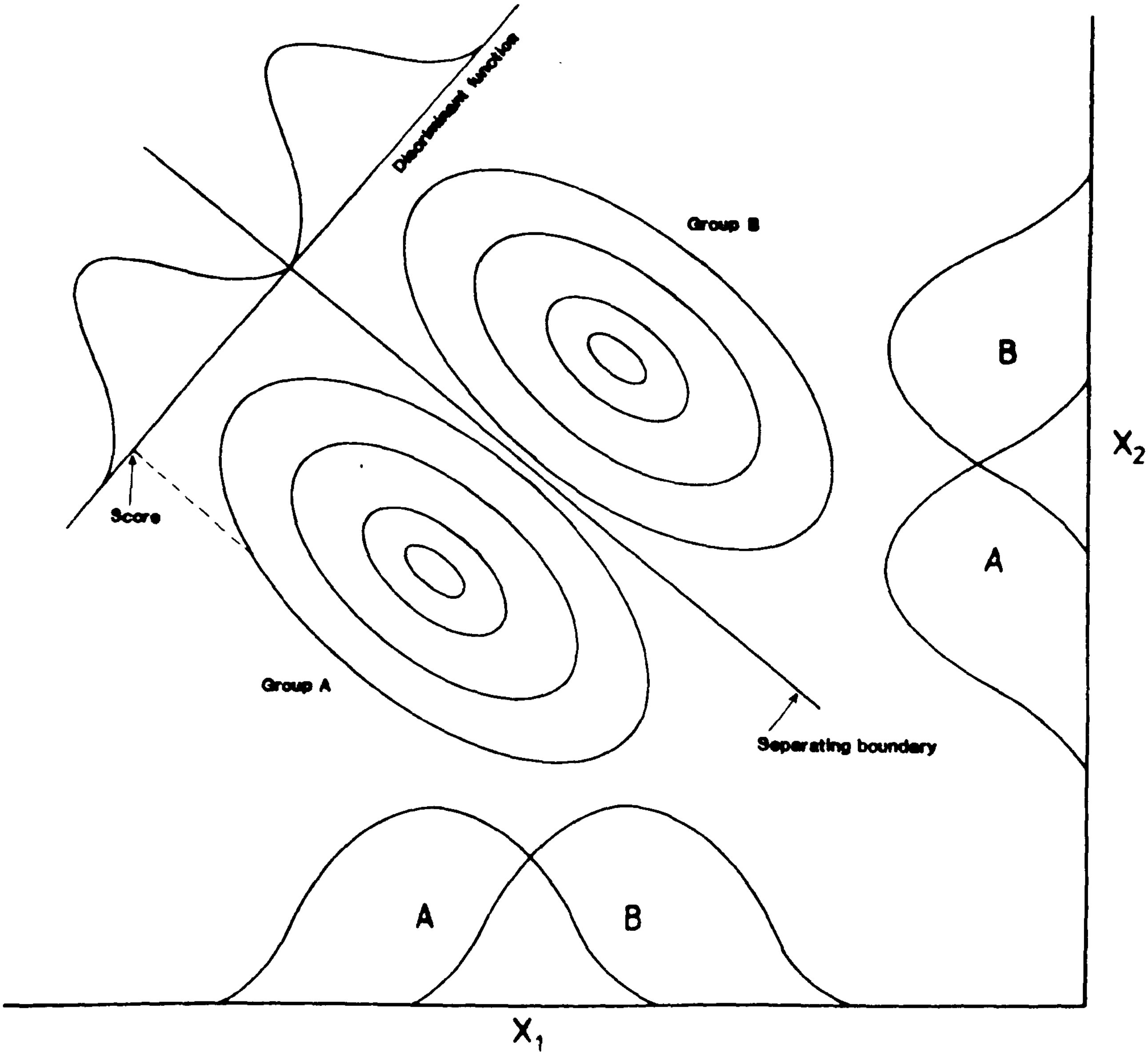


Figure 34. Hypothetical example of a Linear Discriminant Function.

The equation describing the LDF has the form:

$$R = \lambda_1\psi_1 + \lambda_2\psi_2 + \ldots + \lambda_m\psi_m \qquad (5.i)$$

where R is the discriminant score on the sample,

λ_m is the coefficient associated with the m^{th} variable,

and ψ_m is the mean value of the m^{th} variable.

This may be solved by using a similar approach to that of the multiple regression technique used in Chapter 3.3, although the dependant variable is now the differences between the multivariate means of the two groups:

$$[\ D\ ] = [\ S_p^2\ ]\ .\ [\ \lambda\ ]$$

where [D] is the column vector of <u>m</u> differences between the means of the two groups:

$$D_j = \bar{A}_j - \bar{B}_j$$

$$= \frac{\sum_{i=1}^{i=n} A_{ij}}{n} - \frac{\sum_{i=1}^{i=n} B_{ij}}{n}$$

where $\bar{A}_j$ is the mean of the j^{th} variable in group A,

and $\bar{B}_j$ is the mean of the j^{th} variable in group B;

$[\ S_p^2\ ]$ is the <u>m</u> X <u>m</u> matrix of the pooled variances and and covariances of the <u>m</u> variables:

$$[\ S_p^2\ ] = \frac{[\ SPA\ ] + [\ SPB\ ]}{n_1 + n_2 - 2}$$

where SPA is the matrix of sum of squares and cross-products of all variables in [A],

n_1 is the number of samples in [A],

and similarly for [B];

and [λ] is the column vector of <u>m</u> coefficients of the discriminant function. These are equivalent to the α's used by the multiple regression technique.

The equation may be solved by inversion and multiplication:

$[\ \lambda\ ] = [\ S_p^2\ ]^{-1}\ .\ [\ D\ ]$

The values of λ may now be inserted for use in equation 5.i described earlier:

$R = \lambda_1\psi_1 + \lambda_2\psi_2 + \ldots + \lambda_m\psi_m$

The discriminant index R_o is the point along the discriminant function line which is exactly half way between the centres of the groups A and B. Its value may be found by the substitution of the midpoint between the two group means into each ψ_m position of the equation 5.i:

$$\frac{\bar{A}_j + \bar{B}_j}{2}$$

Similarly the value of R_A, the discriminant score describing the centre of group A, may be found by substituting the means of each variable in group A into 5.i:

$R_A = \lambda_1\bar{A}_1 + \lambda_2\bar{A}_2 + \ldots + \lambda_m\bar{A}_m$

The value of R_B may be found in the same way.

The relative contribution of individual variables to the LDF may be measured by using the quantity E_j:

$$E_j = \frac{\lambda_j\ .\ D_j}{D^2}$$

where λ_j is the coefficient of the LDF as described earlier,

D_j is the difference between the j^{th} means of the the two groups,

and D^2 is Mahalanobis' distance.

The latter is a measure of the separation between the two multivariate means expressed in units of the pooled variance, $(R_A - R_B)$.

The value of E_j is a measure only of the direct contribution of the j^{th} variable. It does not take into account the interaction between variables. If two or more variables are not independent, their interactions may contribute to D^2 to a greater extent than the value of E_j suggests. It may be converted to a percentage by multiplication by 100. This parameter is used later in the construction of the identification procedure in selecting the best four elements. In addition to the use of this parameter, an attempt is made to ensure that the variables selected are not highly correlated.

The program DSC (Appendix A) calculates the LDF using selected variables (50 maximum) and a virtually unlimited number of samples in the two groups by the method described above. Summary statistics (R_o, R_A, R_B, D^2, etc.) are outputted either to screen or file together with the details of the individual elements used (ie. λ_j, E_j, $\bar{A}_j$ and $\bar{B}_j$ and their differences). The goodness of fit is also tested by re-running the original training samples as though they were of an unknown origin. Although this has been noted by Howarth (1972) as providing an over-optimistic bias in estimating classifier performance, it is considered to be an acceptable approach here owing to the manner in which the LDF is being applied (Chapter 5.4).

Of considerable importance to the application of the technique is the fact that prior to its use a suitable training set must be selected which represents each class.

Also the inclusion of measurements which poorly distinguish between groups may outweigh the beneficial effects of good discriminators. For this reason they should be removed at the earliest opportunity.

5.4 Soil identification procedure

In order to map on the basis of soil chemistry, an identification procedure was required which allowed the identification of all the units, both lithological and exotic, as described in Chapter 2.3. The aim of this section is to describe the theoretical basis of the identification procedure (IDN), although its actual use and subsequent modifications that arose during the mapping programme are discussed in Chapter 6.

The identification schemes described in this work which are used to identify hidden lithologies on the basis of the overlying residual soil geochemistry may be considered as part of a relatively simple expert system. Such a system is capable of assisting a user in making a well-informed decision although it does not force the acceptance of a particular interpretation (Hawkins, 1983). Any system of this type is based upon information acquired and passed on by a human expert. It must be noted, however, that the results from an expert system should not be accepted as a genuine substitute for human expertise. It has been shown that incorrect identifications can be made (eg.as a result of the sampling of a previously unrecognized lithological unit). A similar result is described in Chapter 6.5.1 due to the mixing of loess with residual soils. Therefore the onus is always on the user for a correct interpretation of any decisions provided by the machine. The machine can only be as well-informed as the user permits.

A major aim in constructing an algorithm to assist in identifying the various units was that it should be able to use a variety of statistical techniques, the choice of which would reflect the degree of difficulty in recognising any particular unit. This approach in turn permitted economical use of computer time. Gross differences between units were identified by simple and rapid discriminatory techniques, whilst at the other extreme the more subtle differences were identified by a more complex technique (a modified K-means algorithm which is described later). The various levels which are incorporated into the identification procedure are described below. These are used by the scheme to identify <u>unknown</u> samples in a progressive or sequential manner. The groups which are most easily distinguished are identified at an early stage using a relatively simple statistical technique whilst the groups which are hardest to identify are isolated using the most powerful statistical methods.

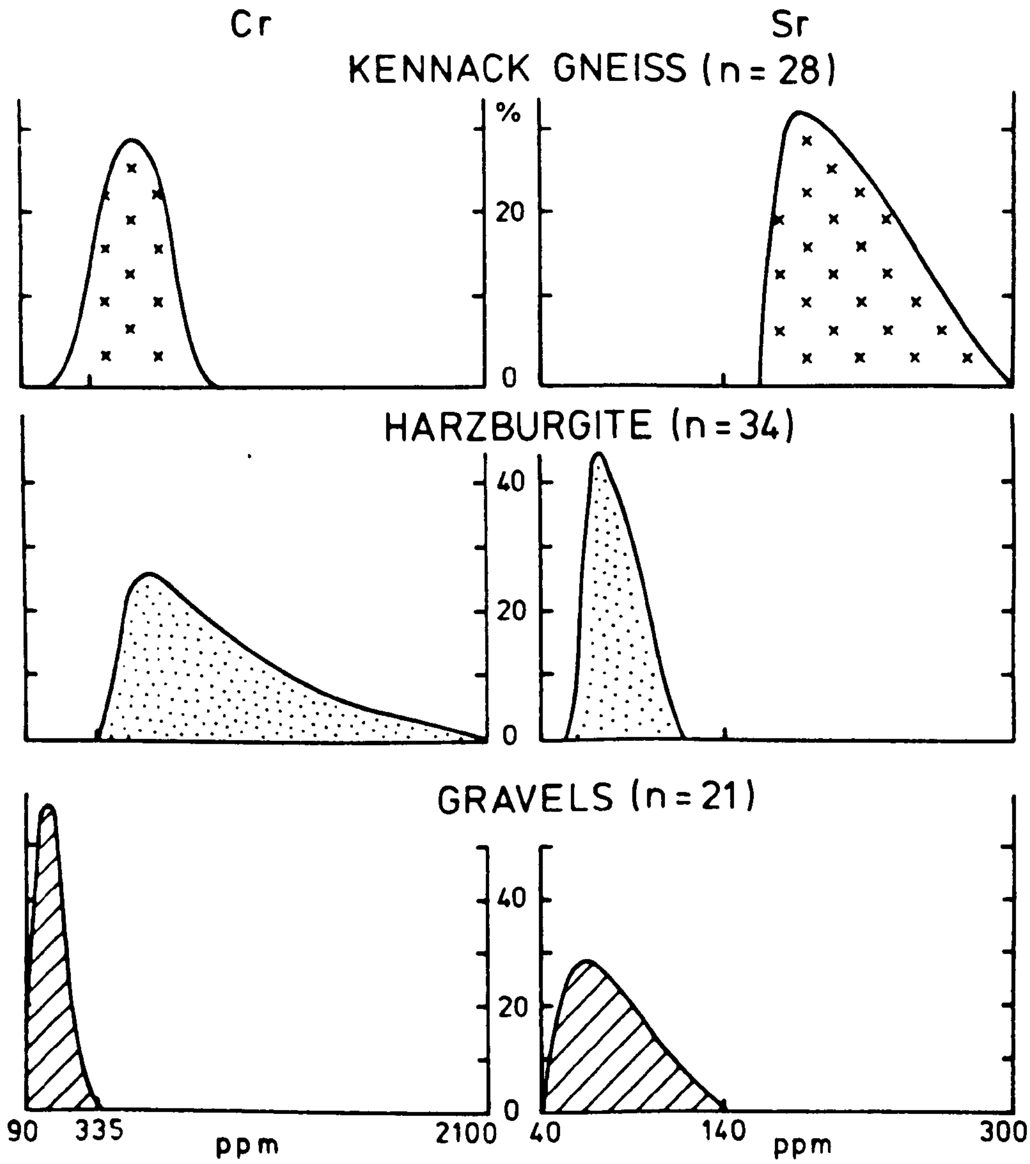
<u>Level 1</u>

The most simple stage in the identification process involves the use of up to five elements individually to distinguish between two groups. This approach may take two forms; either all five statements are correct or at least one is correct.

Figure 35 shows the schematic frequency histograms of three units which, on their own, can be easily distinguished from each other. This example, like the others used in this section, is taken from the traverses collected during the orientation survey. By using the two elements, Cr and Sr, in a set of simple discriminants these three groups could be separated from each other. The Kennack gneiss (NAS137) would be first identified if the Sr value were greater than 140ppm. If less than this value, a check on the Cr value would successfully discriminate between the harzburgitic peridotite (NAS120 and NAS128) and the Crousa gravel (NAS135). If greater than 335ppm the sample would be identified as a peridotite, and if less than 335ppm it would be identified as a member of the gravels group.

Other units which may be separated using this simple technique and thereby removed from the overall scheme at an early stage include those units whose soils have developed over the ultramafic rocks (characteristically high Cr, Ni, Co).

An example using the second approach would be the identification of samples reflecting minor superimposed base-metal vein mineralization (Ba, Cu, Pb and Zn). In this situation only one true response would be required to identify a mineralized sample. Removal of these samples early in the identification process is necessary as they may give rise to anomalous identifications when the more powerful multivariate



Simple discriminants

1. Sr > 140 ppm ➡ KENNACK GNEISS
2. Cr > 335 ppm ➡ HARZBURGITE PERIDOTITE
3. Cr < 335 ppm ➡ CROUSA GRAVELS

Figure 35. Example of use of simple discriminants to isolate three distinct groups.

techniques are used.

Level 2

To identify those units which cannot be distinguished by the previous method a more powerful technique is required. By working with a priori knowledge of the identity of any two groups, a linear discriminant function can be calculated. The number of elements that may be used by the LDF in this instance is limited to four by the identification procedure. It was found that, in the a priori situation, this number of variables gave good results for groups which had a relatively poor separation. In the event of a high rate of misclassification and more variables being required, the modified K-means option (Level 3, below) was seen to be most efficient.

Examples of its potential use would be in separating the harzburgitic and lherzolitic peridotites, or the gabbros and Crousa gravels. The example of the latter two is shown in Figure 36 (NAS119 and NAS135). This describes the four elements selected and the LDF which best discriminates between the two groups. The data values for the four elements used for each sample have been entered into the LDF and its position along the line located. On the basis of this function an excellent separation is achieved compared with that which would result if the elements were used singly.

Level 3

The final stage of the identification procedure identifies those groups whose residual soils are less distinct

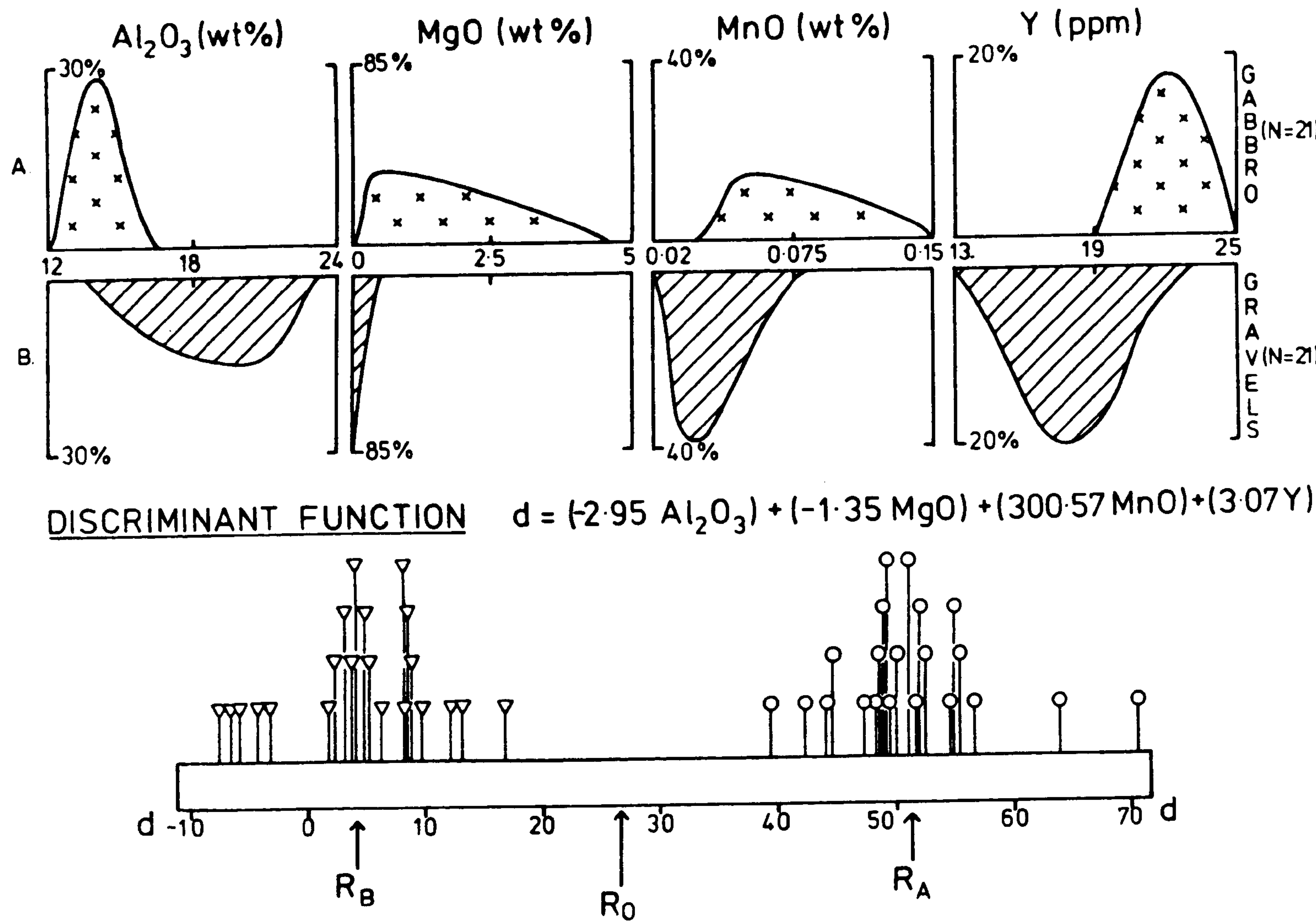


Figure 36. Example of use of an LDF to isolate two chemically similar groups.

chemically and cannot be separated by either of the earlier methods. It uses a modified version of the K-means clustering algorithm described in Chapter 5.2.2.

A simple three group, 2-dimensional example (Figures 37-40) shows the way in which the K-means technique has been modified to identify some of the more similar groups. It should be noted, however, that in the case of mapping on the Lizard Complex 22 elements and in excess of 10 groups are used. The three groups used here are the lower differentiated member of the gabbro, the harzburgitic peridotite collected to the southwest of Coverack, and the Lower Landewednack hornblende schist (NAS118, NAS120 and NAS121 respectively). The technique is based in this instance on a priori knowledge.

Based on this a priori knowledge the 2-dimensional centroid for each cluster may be calculated. These were inserted into a seed-file (described earlier in Chapter 5.2.2) and are shown in Figure 37 together with the data cloud and the linear piecewise boundaries discriminating each group.

A modification of the K-means algorithm avoids the problem of groups with differing variances described in Chapter 5.2.2. If, for each group in turn, the distance between each sample and the group centroid is examined and the results plotted on a frequency histogram (Figure 38), a positively skewed distribution is seen. Taking for example the 95 percentile for each group, it is reasonable to suggest that any sample or unknown with a value greater than this

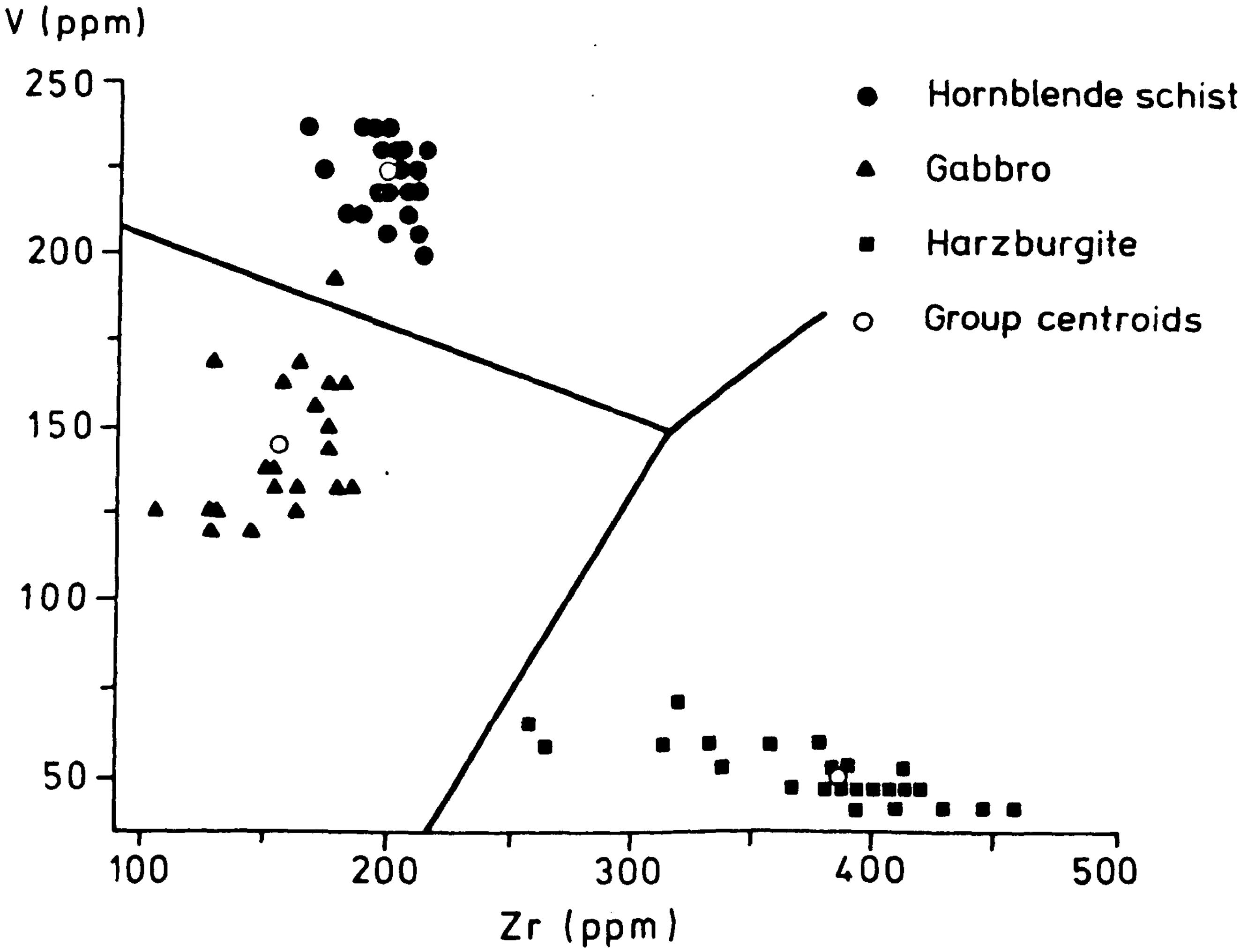


Figure 37. Three group, 2-dimensional example of the modified K-means technique showing group centroids and linear piecewise boundaries separating the different groups.

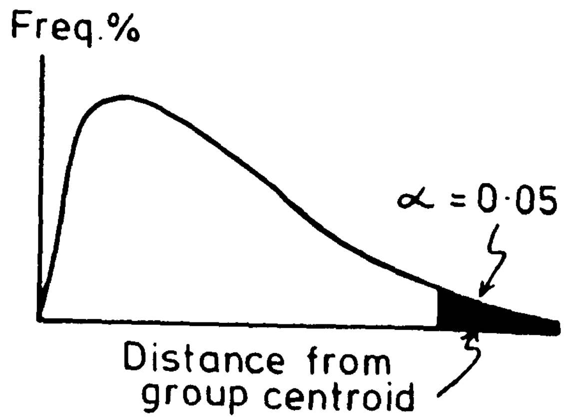


Figure 38. Typical frequency histogram obtained of distance from group centroid.

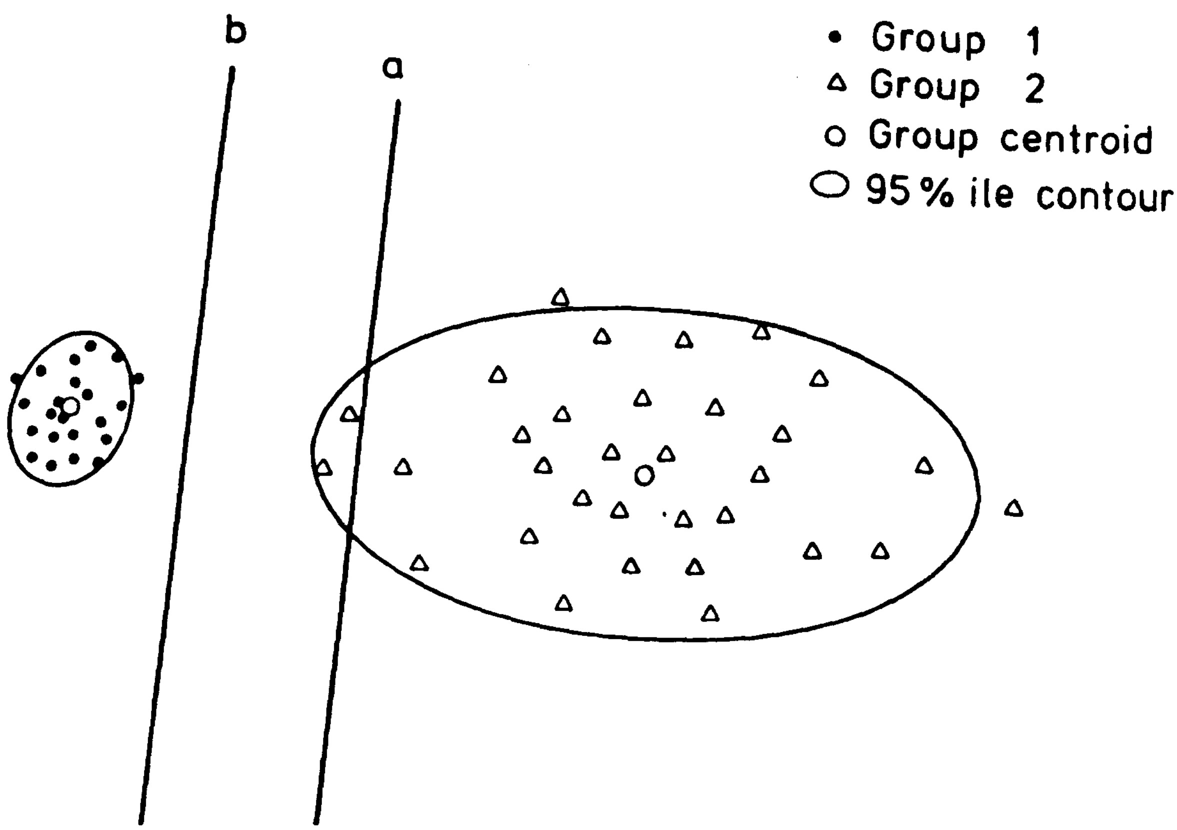


Figure 39. Piecewise boundaries obtained in hypothetical example based on:
a) Distance only.
b) Distance : 95 percentile ratio (see text).

is best classified as not identified. In the 2-dimensional example the result is an ellipse with any unknown falling outside of this ellipse being classified as not identified.

If a ratio of distance from the nearest cluster centroid to this 95 percentile value is used, rather than distance alone as has been used prior to this, the differing variances of the individual groups may be taken into account. The effect of this change in measure can be best shown in an extreme hypothetical example (Figure 39). Just using distance from the group centroid would result in two samples being misclassified. However, by using the ratio, the larger variance of Group 2 is taken into account and the piecewise boundary moves. The result of this is that no samples are misclassified. In the 2-dimensional example the result of using this new measure is the creation of a new set of piecewise boundaries based on the ellipses shown in Figure 40.

IDN

A single computer program (IDN; Appendix A) is used to identify individual samples for mapping purposes. It combines the three techniques described previously and may be used for a wide variety of identificatory tasks. The parameters identifying the previously specified groups are held in a single easily edited file (having the extension .IDN). A Direct Access file structure is used in order to achieve the versatility required for this type of operation. All the other file structures available require the file to be read in its entirety if the final parameter is required. Direct

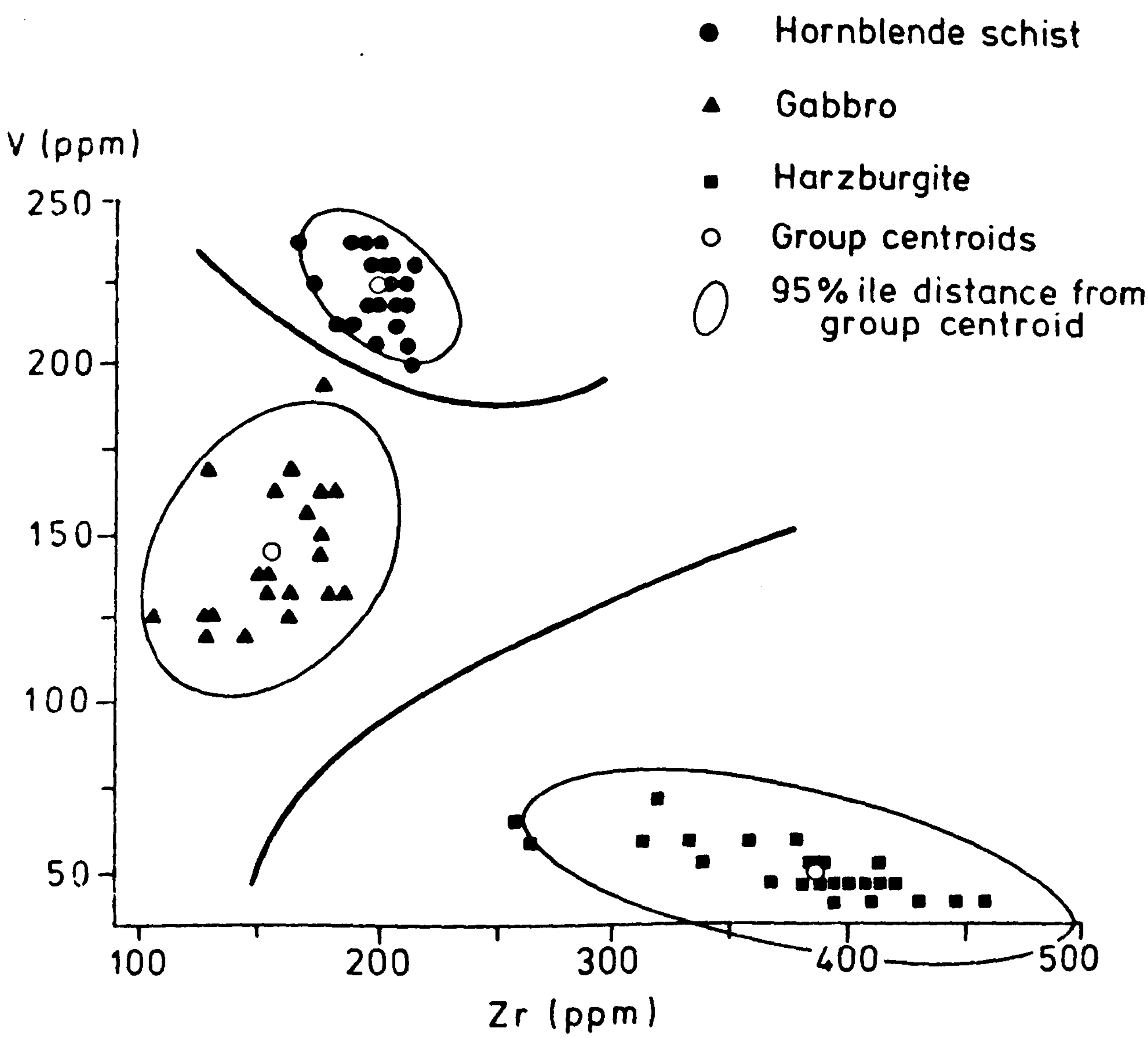


Figure 40. Three group, 2-dimensional example of modified K-means technique showing piecewise boundaries derived from 95 percentile ellipses.

Access files however consist of data statements which are specified by a unique record number. This permits the user to move around within the IDN-file with ease and increases the speed of identification considerably. The manner in which this file structure is used may be best represented by a flow diagram (Figure 41). This approach allows the most distinct units to be removed from the scheme at an early stage whilst those samples which are less distinct chemically accordingly take longer to identify.

Data on individual samples held in RAW-files are read by the subroutine GTREC (Appendix A) and are then individually processed by IDN. The program first reads from the IDN-file the identifying codes for all the groups to be identified together with the details of the ellipsoids for the K-mean option. Each sample is individually identified by IDN using the parameters held in the IDN-file. Each stage within the file contains all the information required for one part of the decision-making process. In the case of the Simple Discriminant and the Discriminant Function, each stage involves a binary decision, the result of which may either identify the unknown (negative value in TR or FA; see below) or pass it onto the next appropriate stage (positive value) until it has been assigned an identity. Both types of calculation may produce a not identified response.

The final stage of treatment uses the modified K-means technique. This uses the centroids from all the known groups (held in a specified seed-file) to isolate those

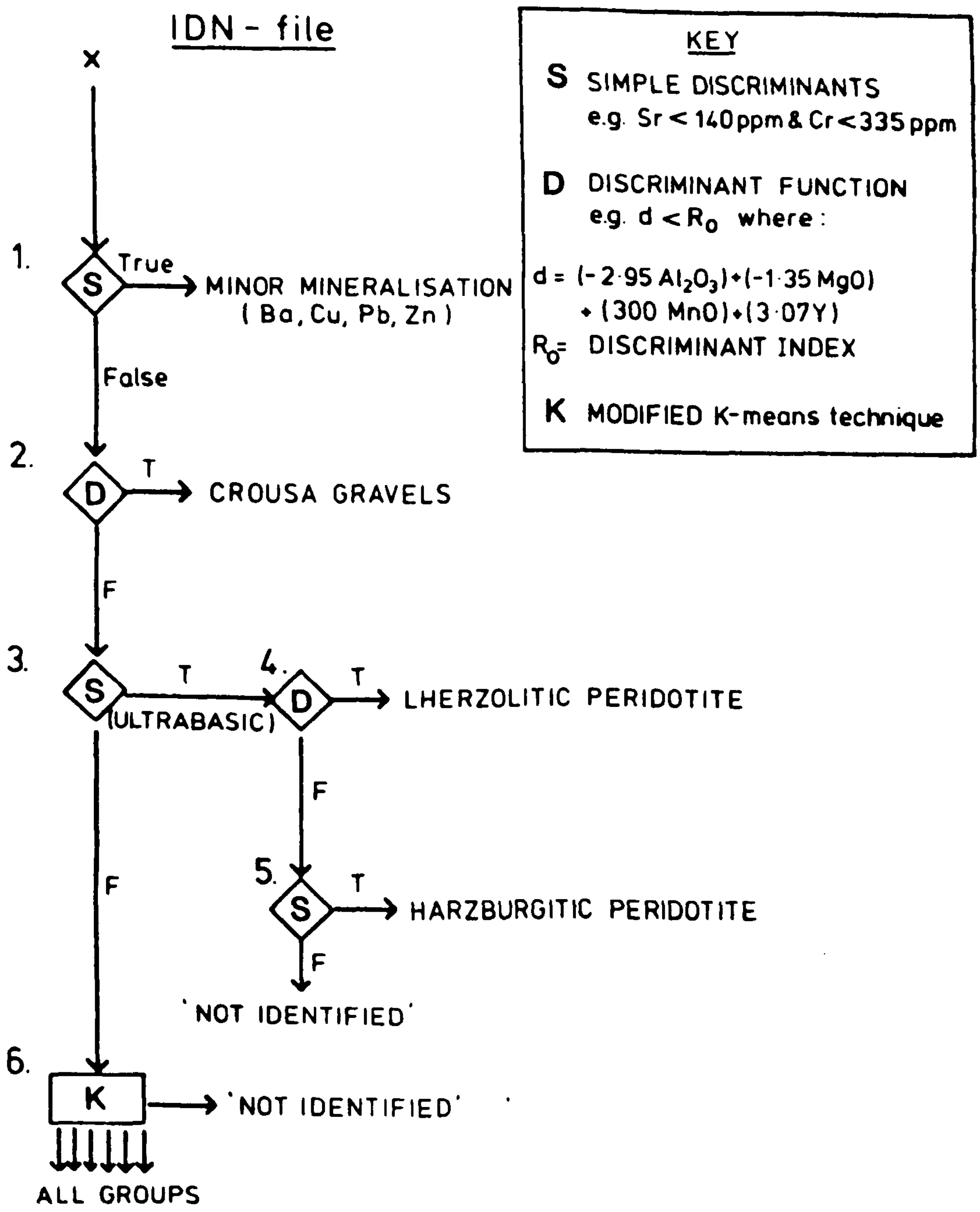


Figure 41. Generalized flowchart showing the identification procedure (IDN).

unknowns which are less distinct chemically. The sample to be identified is compared against the known centroids and it is assigned the identity of the one it resembles most closely. A check may be made at this point against the 95 percentile distance for that group. If in excess of this value its identity is reassigned as not identified.

An example of the format of an IDN-file is given in Figure 42. The first two records may hold up to 24 identification codes (A2) and their maximum distance from the centroid. The latter is the value which is equivalent to the ellipsoids described earlier. This may be set equal to zero if the group is not identified by the clustering algorithm (eg. Mineralized or Not Identified; MN or NI respectively in Fig.42) or if there are no calculated 95 percentile values for a particular identification task.

All subsequent stages (except the K-mean option) are described by two records within the Direct Access file structure. The first contains:

a) The details of the type of calculation required;

NTYPE = 1 .... K-means clustering option.

NTYPE = 2 .... Simple discriminant (at least one statement correct).

NTYPE = 3 .... Simple discriminant (all statements correct).

NTYPE = 4 .... Discriminant function.

b) The number of entries in the next record.

c) The instructions (sample identity or next record address) for both true (TR) and false (FA) responses.

```
File; SYO:FIG42.IDN
Identication       Max distance from centroid
 codes              (KMEAN option)
 - 1     MN            0.000
 - 2     GR            8.000
 - 3     LH           19.000
 - 4     HA           17.000
 - 5     LG           14.350
 - 6     KE            8.800
 - 7     NI            0.000

       +++++++  1 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
    2         4        -1      2
..Element..  ..RO..  ......Value...
  CU           GT          90.000
  PB           GT          80.000
  ZN           GT         300.000
  BA           GT         500.000

       +++++++  2 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
    4         5        -2      3
..Element..  ..RO..  ......Value...
  AL203                     2.943
  MGO                       1.350
  MNO                    -300.570
  Y                        -3.070
               GT          27.200

       +++++++  3 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
    3         3         4      6
..Element..  ..RO..  ......Value...
  CR           GT         335.000
  CO           GT          70.000
  SR           LE         140.000

       +++++++  4 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
    4         5        -3      5
..Element..  ..RO..  ......Value...
  SIO2                     -0.870
  BA                       -0.072
  RB                        0.039
  ZR                        0.023
               GT          61.540

       +++++++  5 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
    3         2        -4     -7
..Element..  ..RO..  ......Value...
  NI           GT         500.000
  Y            LE          30.000


       +++++++  6 +++++++
NTYPE; 1        Id.code for cluster gp 1; -2
NCOND;11        Id.code for cluster gp 2; -3
                Id.code for cluster gp 3; -4
                Id.code for cluster gp 4; -5
                Id.code for cluster gp 5; -6

..Element..  ..Seed filename..
  SIO2         SEEDXX
  AL203
  TIO2
  FE203

  P205
  CR
  NI
  RB
  V

  ZR

       +++++++  9 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   99         0         0      0

  KEY
  ~~~
  MN .... Mineralized sample.
  GR .... Crousa gravel.
  LH .... Lherzolitic peridotite.
  HA .... Harzburgitic peridotite.
  LG .... Lower gabbro.
  KE .... Kennack gneiss.
  NI .... Not identified.
```

Figure 42. IDN-file format.

The second part contains the calculation details. The instruction NTYPE = 2 or 3 consists of NCOND entries of the element requested, the relational operator (GT or LE) and the value (eg. CU.GT.90ppm and SR.LE.140ppm). For the instruction NTYPE = 2 at least one statement must be correct before the instruction contained within TR is used, if none are correct then the instruction in FA is used. For NTYPE = 3, the options are that all of the statements are true (TR) or at least one is false (FA).

The integer 4 in NTYPE instructs the program that a discriminant function is to be used. The second record in this instance contains (NCOND-1) entries of the element names requested and the coefficients for those elements. The final entry holds a relational operator (RO) and a value which describes the discriminant index, R_o. If the calculated value is greater than R_o then the instruction contained within TR is carried out, if less than this value the instruction contained in FA is used.

The final stage of the identification process may be set for the K-means option (NTYPE = 1). This stage is again split into two records but has a different structure to the one used previously. The first record contains the NTYPE value and the number of entries held within the second record (NCOND). However, instead of instructions for both true and false responses, it contains the identification codes for all the groups (corresponding to to the first two records read from the IDN-file) which may be isolated using this technique. The second part contains the name of the seed-file holding the data for the *K* centroids and the elements to be used. The final option uses the KMEAN subroutine (CMD="5"). It assigns the *unknown* to the nearest of the *K* seed centroids read earlier. Only one iteration is required to identify the sample and the seed centroid remains fixed.

The standardized 95 percentile values between the *unknown* and the nearest seed centroid referred to earlier (Fig.38) are found by using the switch "D" in the program IDN. This causes individual samples from known geological groups to be run through the K-means option of the IDN-file (all the other records are bypassed) and the DIST values are then recorded in a file DREF.RAW. These values of DIST ~~are~~ may then be plotted on on histograms and the 95 percentile value read. Any subsequent samples which may be assigned to this group having values of DIST greater than this 95 percentile value (or greater than 1.00 if the ratio is being used) are assigned a "Not Identified" label (NI).

The approach described above is used on each of the groups identified within the identification procedure by the K-means option. This is necessary as the groups are heterogeneous displaying large differences in variance. If a 95 percentile value for any of these groups is not provided the identification program is set automatically to use the distance measure only.

The end of the IDN-file is signalled by the value NTYPE = 99. As soon as this value is read or the *unknown* is identified (ie. a negative value is received) the program returns to the RAW-file for the next sample to be identified and to the third record in the IDN-file and the procedure begins again. As with the first two records, the identifying codes for the clustering option, the element names used and the seed-file data are only read once by the program. The aim of this was to increase the speed of operation of the program. All the remaining records are read as required by the program.

A disadvantage in the use of files with a Direct Access structure is that they are written in binary. Although this has the advantage of increasing the speed at which the file is read, it requires the creation of an editor to create, alter or list the IDN-file (IED; Appendix A).

The construction of an editor which was relatively easy to use became increasingly important as new facts about the geology were recognized. It allowed the identification procedure to become more complicated than originally envisaged. Towards the final stages of the project the 10 units which had originally been recognized increased to 16.

CHAPTER 6

SOIL MAPPING

6.1 Introduction

6.2 Orientation survey

6.2.1 Selection of elements

6.2.2 K-means clustering of orientation survey data

6.2.3 Identification scheme - Model 1

6.3 Power auger programme

6.4 Final mapping stage

6.4.1 Recognition of new units

6.4.2 Identification scheme - Model 2

6.5 Limitations of mapping technique

6.5.1 Mixing of soils

6.5.2 Resolution of technique

6.1 Introduction

The aim of this chapter is to describe the actual task of mapping based on the residual soil geochemistry. It outlines in three stages how the technique developed for use as a mapping tool together with some of the problems which were encountered. It also describes the geochemistry of the various units mapped. In this instance the term unit refers to a particular lithological or exotic group (as described in Chapter 2.3) or sub-group as found in the area.

Additionally the details of two identification schemes are described; the first as developed from the orientation survey, and the second being the final scheme constructed to map the geology of the Lizard Complex using all the soil samples collected during the duration of the project. The relative importance of the variables in discriminating between groups is discussed and the reasons for the final selection of elements given. A measure is provided of the similarity between the different units and the identification of the previously unknown groups in the inland areas described.

The chapter is concluded by a retrospective discussion of the techniques used together with additional work which complimented the mapping process.

6.2 Orientation survey

The soil samples collected during this period were used primarily to achieve two aims. Firstly to prove the concept of mapping hidden lithologies by the collection of shallow soil samples and secondly to construct an identification scheme which would be able to identify soil samples collected for mapping purposes.

By working with an a priori knowledge as to the identity of the previously described units, the task of constructing an identification scheme would be made relatively easy by virtue of the fact that the identity of the groups were already known. If there was no a priori knowledge a classification stage would first be required to isolate potential groups. Once established an identification scheme would then be constructed in a similar way to that described below. This concept will be returned to in Chapter 6.4. The samples collected during this part of the survey were also run through the soil identification procedure as a test set in order to obtain some idea of the probability of misclassification.

6.2.1 Selection of elements

The selection of the majority of the elements used during the project was based largely on their known distribution in the variety of lithologies which were expected to be found during the soil sampling. For example MgO, Co, Cr and Ni would be expected to distinguish those soils developed over ultrabasic material from those developed over the other units. The acid gneisses could be identified using Na_2O, K_2O, Rb and Sr which are generally present in higher concentrations in late stage igneous rocks. SiO_2, TiO_2, Na_2O, K_2O, P_2O_5, Nb, V, Y and Zr are commonly used in a number of igneous classification schemes (eg. Pearce and Cann, 1973; Pearce et al, 1975; Shervais, 1982).

Following work by Malloch (1972) there was some concern over possible contamination from salt spray deposition. This is confirmed by Staines (in press) who describes a relationship between the distance from the sea and the amounts of these elements in the topsoil (Fig.43). It is concluded here, however, that as a total (expressed as a percentage concentration) rather than a partial analysis (expressed as milligram equivilants) is used the effects of sea spray deposition are negligible. Additionally most of the soil sampling was carried out nearer to the more sheltered eastern coast.

Some of the Rare Earth elements were analyzed in order to distinguish the various parts of the differentiated sequence from ultrabasic to basaltic rocks. It was also hoped that they would indicate the presence of epidote and garnet in the Lower Landewednack hornblende schists. The remaining elements, except S, Sn and W, were also seen to show a large range between the ultrabasic and acidic end-members (Wedepohl, 1969-78).

The trace elements together with TiO_2, MnO and P_2O_5 are generally either held within the lattice of the common rock-forming minerals or as minute discrete grains around the grain boundaries of the silicate minerals (eg.Zircon in pyroxenes and amphiboles). In a few instances the chemistry

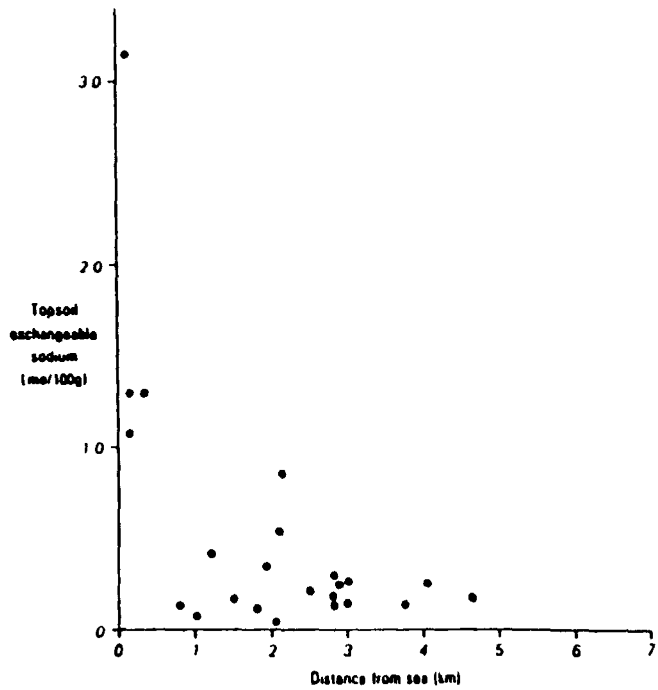


Figure 43. Relationship between Na_2O concentration and distance from coast (After Staines, in press).

· may represent minerals in their own right, for example, apatite, $Ca_5(PO_4)_3(OH,F,Cl)$, ilmenite, $FeTiO_3$, chromite, $FeCr_2O_3$ or zircon, $Zr[SiO_4]$.

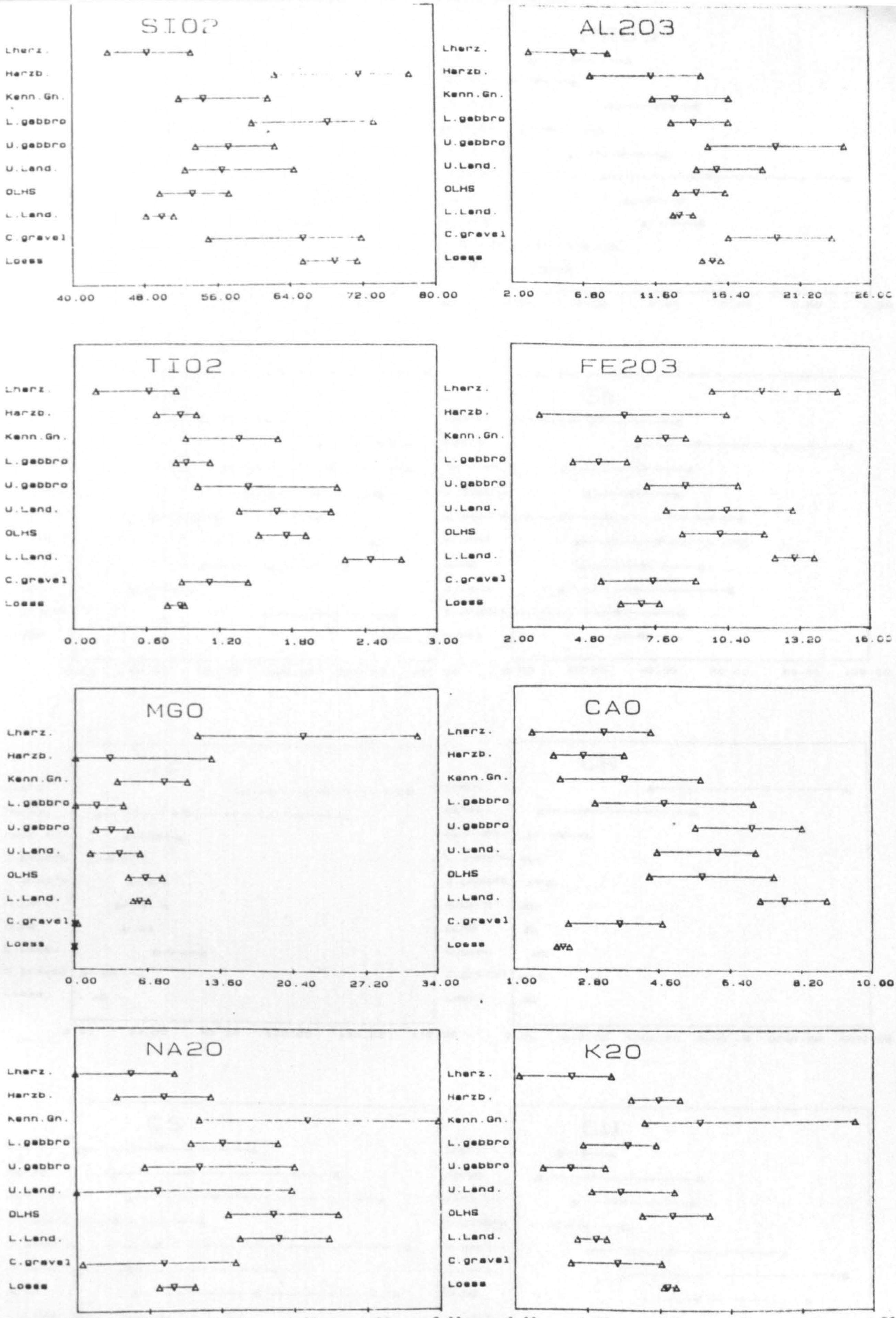
Figure 44 shows the single element graphs of the various units sampled during the orientation survey. By studying these, several elements were selected which were effective in isolating a ~~particularly~~ particular group or groups of samples.

a) Lherzolitic and harzburgitic peridotite

Many of the samples collected from these units may be easily distinguished by the use of MgO, Co, Cr or Ni together with Sr and CaO to remove the likelihood of overlap with other units:

Cr	> 500ppm	
Sr	< 140ppm	
CaO	< 5.00%	Simple discriminant
		All conditions must be true.

The high correlation between MgO, Co, Cr and Ni meant that only one of these needed to be used. Of the two groups the lherzolitic peridotite tends to be the most extreme and therefore most easily identified. By selecting a cut-off value of 500ppm Cr all the lherzolitic and most of the harzburgitic peridotite would be isolated. In order to remove the possibility of the inclusion of the Kennack gneiss, which also has some relatively high concentrations of Cr, a check on the Sr levels was made. The Kennack gneiss may be seen from Figure 44 to exhibit high concentrations of Sr when compared with the ultrabasic material. CaO was also used to prevent



Lherz.	Lherzolite	L.gabbro	Lower gabbro	OLHS	Mica schist
Harzb.	Harzburgite	U.gabbro	Upper gabbro	L.Land.	L.Landewednack
Kenn.Gn.	Kennack gneiss	U.Land.	Upper Landewednack schist	C.gravel	Crousa gravel

Figure 44. Single element graphs of the various units sampled during the orientation survey.

Δ... min/max ∇... mean oxide data in wt %, else ppm

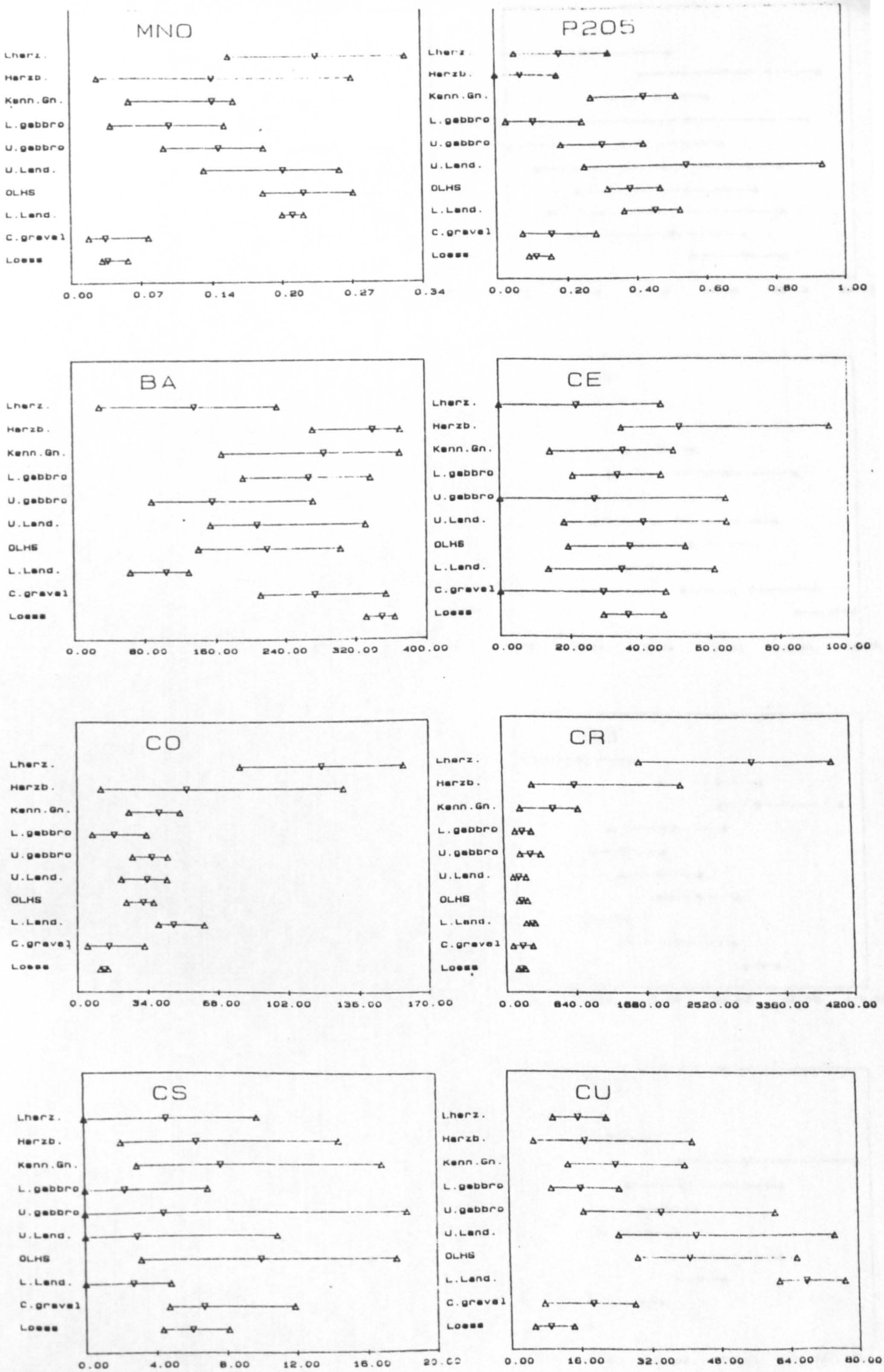


Figure 44 continued.

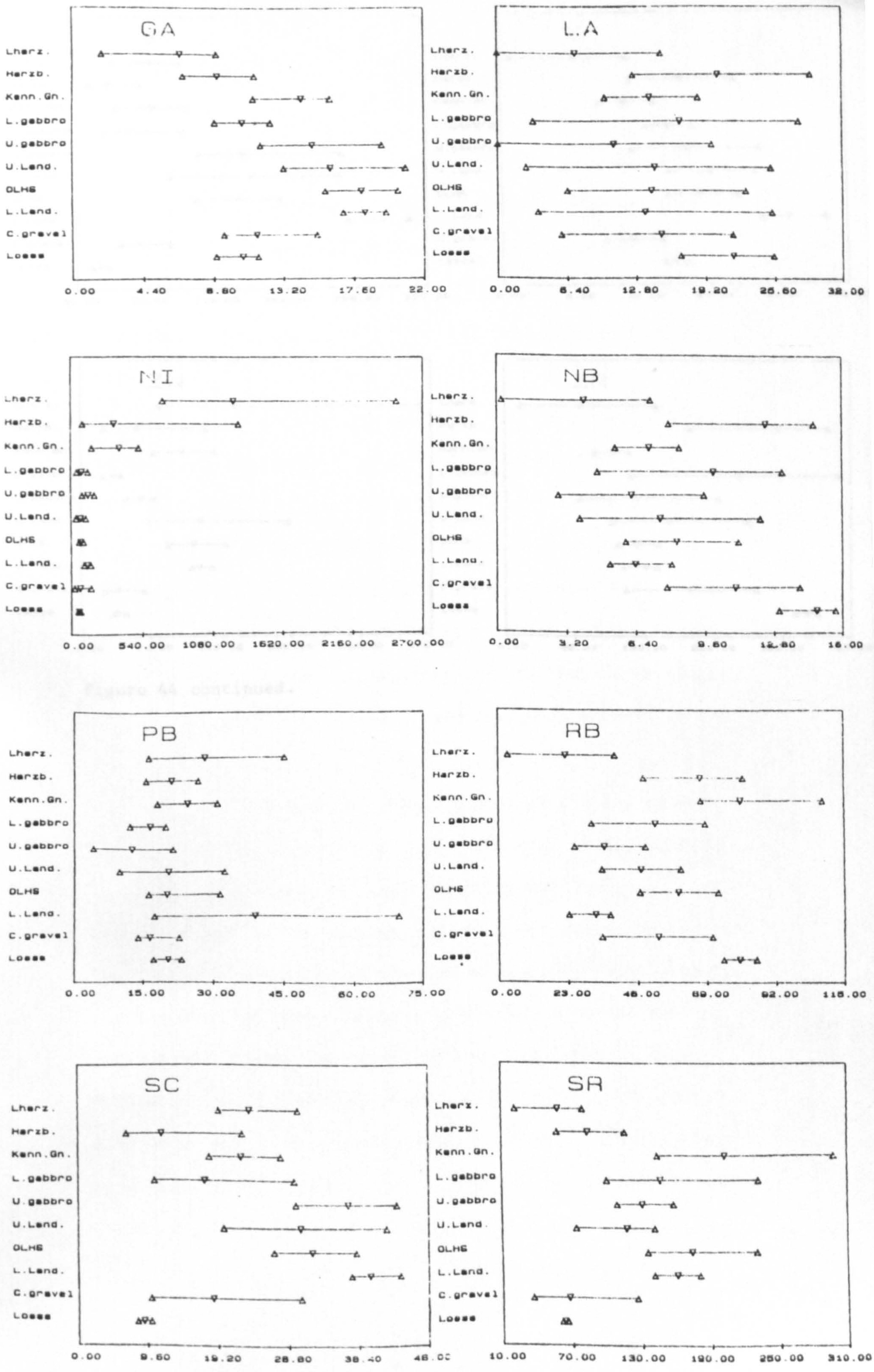


Figure 44 continued.

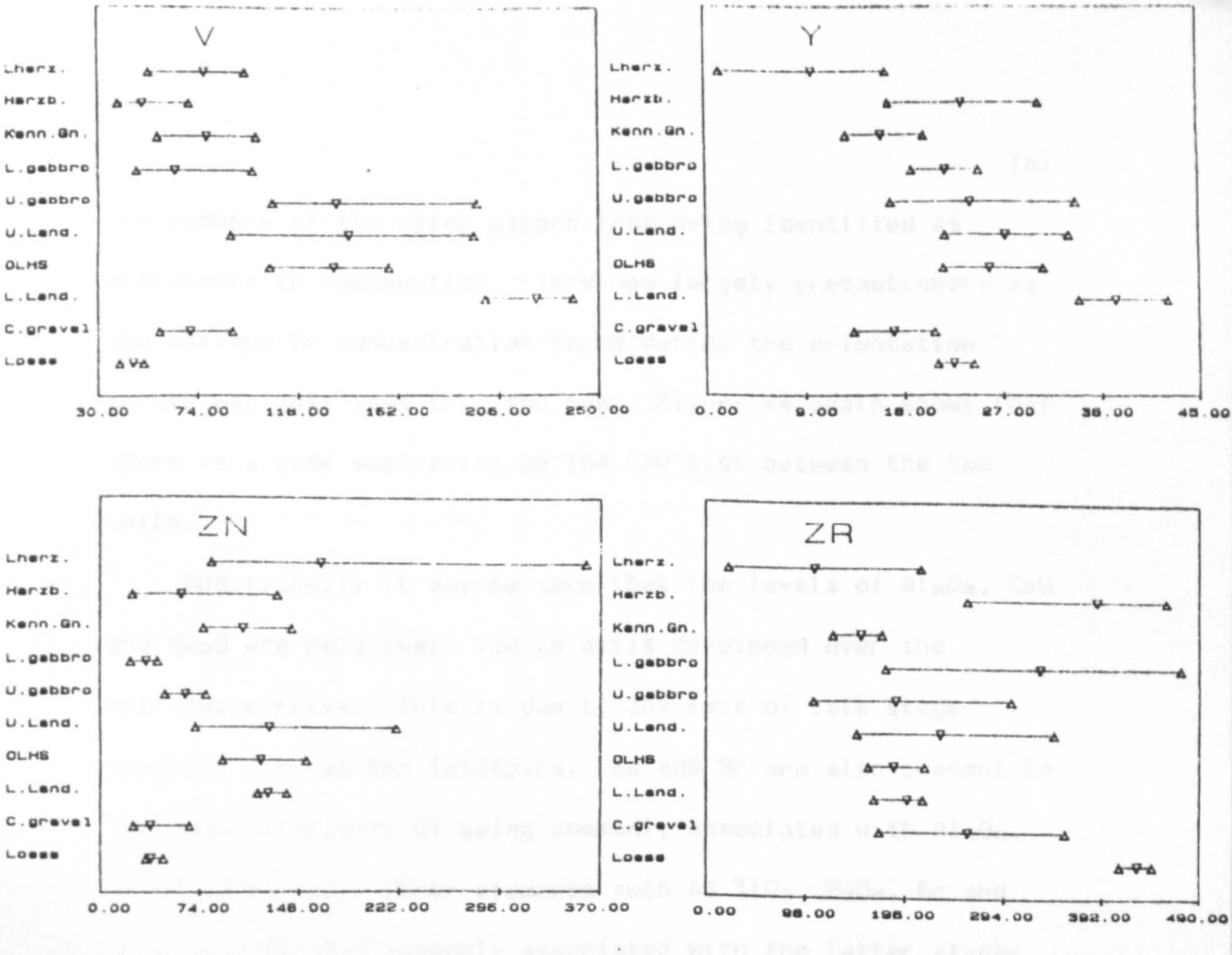


Figure 44 continued.

any members of the upper gabbro from being identified as ultrabasic in composition. This was largely precautionary as the maximum Cr concentration found during the orientation survey was just less than 450 ppm. Figure 44 again shows that there is a good separation on the CaO plot between the two units.

Additionally it may be seen that the levels of Al_2O_3, CaO and Na_2O are relatively low in soils developed over the ultrabasic rocks. This is due to the lack of late stage minerals such as the feldspars. Ga and Sr are also present in low concentrations; Ga being commonly associated with Al_2O_3, and Sr with CaO. Other elements such as TiO_2, P_2O_5, Sc and V, which are also commonly associated with the latter stages of the differentiation process, are also only present in low concentrations.

There is, however, a certain amount of overlap between the two units which required a more powerful statistical technique to be used. A linear discriminant function (LDF) was calculated by the program DSC which was described earlier. The method of selection of the four most significant elements was the same for every calculation of the LDF's for the various combinations of other group(s) described in this chapter. Initially all 28 elements (22 elements in Chapter 6.4) were used in the calculation of the LDF. The results were then studied and those with the greatest values of E_j (described in Chapter 5.3) selected for another run through DSC. Generally between 8 and 12 elements were selected at this stage. After the next calculation of the LDF for the two groups, the elements with the highest values of E_j were again selected for a final run through DSC. This final run then provided the discriminant coefficients and the value of the discriminant index required for use by the identification scheme. There was, however, a degree of flexibility in this approach. If any of the final four elements were highly correlated (eg.K_2O/Rb or CaO/Sr) and there was another element with a similar value of E_j which was not so highly correlated, the latter element would be used to replace one of the initial highly correlated elements.

The elements SiO_2, Ba, Rb and Zr were eventually selected for use in an LDF to separate the lherzolitic and harzburgitic components:

SiO_2 ... 0.870

Ba ... 0.072

Rb ... -0.039

Zr ... -0.023 $D_o = 61.540$

Lherz. < D_o < Harzb.

The relational operator "GT" is used in all the LDF's described in this chapter to assign the "unknown" to one of the two groups. Although the four selected elements show reasonable separations between the two groups, it was decided not to use them in a simple discriminant (eg.Cr>500ppm). This was a response to the small number of samples on which this early identification scheme was based. Additionally it was recognized early in the project that the soils developed over the ultrabasic generally showed the highest degree of variation and so an overlapping relationship may have easily developed.

b) Kennack gneiss

A serious problem was encountered during the sampling of this unit. From the sample site location map in Chapter 3.1 (Fig.4) it will be seen that two traverses were carried out in the coastal area near to Kennack Sands (NAS123 and NAS137). The former was the original orientation survey traverse line. After analysis of the samples it was apparent that the Kennack gneiss visable in the cliffs did not extend back any distance inland. All of the samples showed the characteristically high levels of MgO, Co, Cr and Ni of the ultrabasic. The second traverse was carried out within 10 metres of the cliff edge and gave good results which were considered to truly represent the Kennack gneiss.

As referred to earlier this group also has some elements which may be successfully used to discriminate it from other groups. By the combined use of Ni, K_2O and Zr as a simple discriminant most of the samples from the gneiss may be identified:

Ni > 150ppm

K_2O > 2.20%

Zr < 195ppm Simple discriminant

All conditions must be true.

The use of Ni only would have resulted in some members of the gabbro and possibly later some of the Lower Landewednack hornblende schist and gravels being included with the Kennack gneiss. Any ultrabasic material not identified earlier may also be included by the sole use of Ni as a discriminant. The levels of K_2O are generally considerably higher than for other groups and this also acts to remove the possibility of inclusion of the gabbro, lherzolitic peridotite and hornblende schist. Finally the use of Zr would separate the Kennack gneiss from the harzburgitic peridotite. The use of Na_2O Rb or Sr would also have given a good separation of the gneiss from the other units if it had been required.

c) Gabbro

By studying the graphs of the various elements analyzed it will be seen that there are no obvious individual elements which discriminate between the gabbro and the remaining units. It was also found during experimentation with the data that no four elements would provide a reasonable LDF. For these reasons it was decided to isolate members of this group by the use of the modified K-means technique described earlier in Chapter 5.2.2.

Prior to the calculation of the seed centroid required by the identification scheme for the gabbroic groups, all the samples collected during the orientation survey were clustered by the original K-means algorithm in an exercise to assess the relative importance of the individual elements to the clustering technique (Chapter 6.2.2). One of the results of this exercise was that a relatively poor separation of the gabbroic group occurred. Whilst most of the groups were successfully classified the gabbroic samples were split between two other groups. The samples from the coastal area just to the north of Coverack tended to be classified with those soils derived from the harzburgitic peridotite. Similarly the soils from near to Dean Quarry and the West of England Quarry just south of Portoustock were classified with the Upper Landewednack hornblende schist. The reason, as first discussed in Chapter 2.3.2, is the highly differentiated nature of the gabbro.

In response to this the gabbro was split into a southerly lower unit (NAS119) and a northerly upper unit (NAS129 and NAS118) for the calculation of the seed centroids by the K-means algorithm (KMN, option "K", one cluster group only).

d) <u>Upper Landewednack schists and Old Lizard Head Series</u>

These two groups may be seen from Figure 44 to possess similar compositions. As described earlier they may both be found in the northern part of the Complex although the Old Lizard Head Series or mica schists, as they may also be called, are also to be found at the southwestern corner of the district.

These groups are isolated in two stages. By using P_2O_5, V, TiO_2, Ni and Zn many of the samples from these two groups may be separated from those belonging to the other groups:

P_2O_5 > 0.03%

V > 100ppm

TiO_2 < 2.20%

Ni < 150ppm

Zn > 95ppm Simple discriminant

All conditions must be true.

The level of P_2O_5 separates all the mica schists and most of the hornblende schists from most of the other groups. Use of the remaining four elements removes the likelihood of inclusion of lherzolite (V, Ni), Kennack gneiss (V, Ni), upper gabbro (Zn) and lower Landewednack hornblende schist (TiO_2).

The second stage involves the separation of the upper Landewednack hornblende schist and the mica schist. As there was no obvious simple set of simple discriminants which would achieve this an LDF was calculated:

MgO ... 0.078

K20 ... -10.687

Rb ... -0.296

Sr ... -0.269 D_o = -73.176

OLHS < D_o < Upper landewednack schist.

e) <u>Lower landewednack hornblende schist</u>

The chemistry of this group of samples may be seen from Figure 44 to be notably different from that of the other groups. In particular there is a considerable difference between the upper Landewednack schists with which it was compared by Green (1964). It may be identified by the use of a set of simple discriminants:

$TiO_2 > 2.20\%$

$V > 195ppm$

$Y > 34ppm$

$Zn > 115ppm$

$Ba < 140ppm$ Simple discriminant

All conditions must be true.

Although the TiO_2 concentration would successfully separate this group, three other groups have similar maximum values to the lower limits of the lower Landewednack hornblende schist. Use of the remaining elements would remove any possibility of overlap with these other groups; upper gabbro (Zn), upper Landewednack (V and Ba) and mica schists (Ba, V and Y).

f) Crousa gravels

The soils developed over the gravels tend to show characteristically low MgO and MnO concentrations and high levels of Al_2O_3. Additionally there are moderately low concentrations CaO, Co, Sr and Zn and moderately high levels of SiO_2. However, although there appears to be a number of elements which would identify this group, it was decided to use the modified K-means technique.

The reason for this was that during the use of the original K-means clustering technique it became apparent that there was a relatively poor separation between the gravels and the lower gabbro (and to a lesser extent the harzburgitic peridotite). This was partly seen from the overall results of the clustering and the assessment of the relative importance of variables, and from the use of the option "S" in KMN. This latter option records the standardized distances between the various cluster groups involved in the modified K-means technique. A summary of the results of both this and the assessment of the relative importance of variables is provided later.

g) Loess

This unit may be easily identified by the use of a set of simple discriminants. From Figure 44 they may be seen to possess the following characteristics; low concentrations of MgO, MnO, Sc, Sr, V and Zn, and moderately high to high levels of K_2O, Nb, Rb and Zr. Four elements were selected from this list to isolate any loess samples:

MgO < 0.01%

Zr > 400ppm

CaO < 2.70%

Cr < 200ppm Simple discriminant

All conditions must be true.

The sole use of MgO would cause the inclusion of several other groups. These would include harzburgitic peridotite (removed by the additional use of Cr or Ni), the lower gabbro (CaO or K_2O) and the Crousa gravels (Zr or V).

This group is not, however, identified by the modified K-means technique. It was found during clustering that this group is not isolated, even after seeding, from the group containing the harzburgitic peridotite. This is considered to be a reflection of some degree of intermixing between the soils developed over the peridotite and the loess sheets.

In addition to the above information relating to a few elements for the ten groups, Table 13 provides a summary of all those elements which could be used to separate the various units. The graphs shown in Figure 44 were used in constructing this table.

6.2.2 K-means clustering of orientation survey data

Prior to clustering the data from the orientation survey the data was checked for any anomalous samples which may have given rise to spurious groupings. Univariate screening was carried out on all the samples although not with the same degree of sophistication as demonstrated by Sinclair (1976). It was achieved by the visual examination of the data from the various groups. Histograms were used to identify any obvious outlying data and the data sorted into ascending order to rapidly locate the anomalous sample(s). (Both of these operations were carried out by the program STA; Appendix A). The K-means technique itself will also identify multivariate anomalies within the data, as demonstrated earlier in Chapter 5.2.2. In this instance any such sample or group of samples will form a cluster group of its own and may therefore be easily recognized.

In order to assess the relative importance of the elements to the K-means technique the program KMN (option "A") was used. This was described earlier in Chapter 5.2.2 and uses the standardized distance between the various seed centroids and the pooled standard deviations of any two

Full list of elements used (excluding S, Sn & W).

Si	Al	Ti	Fe
Mg	Ca	Na	K
Mn	P	Ba	Ce
Co	Cr	Cs	Cu
Ga	La	Ni	Nb
Pb	Rb	Sc	Sr
V	Y	Zn	Zr

KEY

LHERZ .... Lherzolitic peridotite
HARZB .... Harzburgitic peridotite
LANDEW ... Landewednack hornblende schist
O.L.H.S .. Old Lizard Head Series

	LHERZ.	HARZB.	KENNACK GNEISS	LOWER GABBRO	UPPER GABBRO	UPPER LANDEW.	O.L.H.S.	LOWER LANDEW.	CROUSA GRAVELS
HARZB.	K Ba Rb Y Zr								
KENN. GNEISS	Al Mg Ca K Co Cr Ga Ni Rb Sr	Fe P Ga Sr Zr							
LOWER GABBRO	Al Fe Mg Ca Mn Co Cr Ga Ni Sr Y Zr	Cr	Fe P Ni Zn Zr						
UPPER GABBRO	Si Al Mg Ca Co Cr Ga Ni Sc Sr V Y Zn	Al Ca K P Ba Ga Rb Sc V	K Ni Rb Sc V Zn	Fe Sc V Zn					
UPPER LANDEW.	Al Mg Ca Co Cr Cu Ga Ni Y	Ca P Cr Ga Ni Sr V	Ni Rb Y	Fe P Cu Ga					
O.L.H.S.	Al Mg Na K P Co Cr Cu Ga Ni Rb Sr V Y	Si Ca Na P Cr Ga Ni Sc Sr V Zr	Mn Ni V Y	Si Fe Mg Mn P Cu Ga V	Mg K Mn Ni				
LOWER LANDEW.	Al Mg Ca Na P Co Cr Cu Ga Ni Sc Sr V Y	Si Fe Ca Na K P Cr Cu Ga Nb Rb Sc Sr V Y Zr	Fe Ca K Mn Cu Ga Ni Rb Sc V Y	Si Fe Mg Ca Mn P Co Cu Ga Sc V Y	Si Al Fe Mg Mn Cu V Y	Si Al Ca Cr Sr V Y	Fe K Co Cr Rb V Y		
CROUSA GRAVEL	Si Al Ti Fe Mg Co Cr Ga Ni Nb Zn	Al Cr	Al Mg Ni Sr Zn Zr		Mg Ca Mn V	Mg Mn V Y Zn	Al Ti Mg Mn P Cu Ga Sr V Y Zn	Si Al Ti Fe Mg Ca Na Mn P Ba Co Cu Ga Nb Sc Sr V Y Zn	
LOESS	Si Al Fe Mg Na K Mn Ba Co Cr Ga La Ni Nb Rb Sc V Y Zn Zr	Cr Ni	Si Ti Mg Ca Mn P Co Cr Cu Ga Ni Nb Sc Sr V Y Zn Zr	Ca K Rb Sc Sr	Si Ti Mg Ca K Mn P Ba Co Cr Cu Ga Ni Nb Rb Sc Sr V Zn Zr	Si Ti Fe Mg Ca Mn P Ba Co Cu Ga Nb Rb Sc Sr V Zn Zr	Si Ti Fe Mg Ca Na Mn P Ba Co Cu Ga Nb Rb Sr V Zn Zr	Si Al Ti Fe Mg Ca Na K Mn P Ba Co Cr Cu Ga Ni Nb Rb Sc Sr V Y Zn Zr	Al Ti Ca K Rb Sc V Y Zr

Table 13. Summary of elements which may be used to separate the various units sampled during the orientation survey. (Based on Figure 44).

combinations of groups. Figure 45 provides a summary of some of the results obtained from KMN. This used all 28 elements originally selected for analysis (excluding S, Sn and W). When a seed file was used only 3 out of 248 samples were misclassified. With this low rate of misclassification the results from the assessment of the relative importance of variables are considered to be representative. The mean of the δ-values for individual elements (Fig.45) show that Nb, Cs, La and Ce have notably lower values than those of the other elements. This implies that these elements are not significantly useful in isolating the various cluster groups. This is confirmed by the single element plots in Figure 44. It is considered here that the removal of these elements from a multivariate calculation such as the K-means technique is beneficial to the accuracy of the technique as it removes the effect of noise from the system. The mean of the δ-values for Pb is also relatively low compared with most of the other elements. This element was, however, rejected earlier on the basis of its poor analytical precision.

The remaining elements are retained for use in the modified K-means approach even though some still have relatively low mean values of δ. Although Na_2O has a small mean δ-value it is recognized as being of particular use in the discrimination between the upper Landewednack and Old Lizard Head Series, the harzburgite and lower gabbro, and to a lesser extent between the lower gabbro and the gravels, and the upper gabbro and the upper Landewednack schists.

Files read:
All files containing data collected during orientation survey except loess group (NAS136a).

Variables used:
28 variables as plotted in Figure 44 (S,Sn & W excluded).

5 iterations required for convergence.
Summed deviation about seed points = 0.22047920E+04

Summary of delta values
****

Overall relative importance of variables.	Relative ease in distinguishing various combinations of groups.
Overall least important element. {Mean of delta values}	Hardest combination to distinguish {Means of all delta values for each combination}
NB ... 0.06	U.Land./OLHS ... 0.88
CS ... 0.06	L.Gabb./Gravel ... 0.89
LA ... 0.06	Harzb./L.Gabb. ... 1.15
CE ... 0.06	U.Gabb./U.Land. ... 1.30
PB ... 1.19	Harzb./Gravel ... 1.56
NA2O ... 2.12	U.Gabb./OLHS ... 1.60
NI ... 2.33	Kenn.Gn./OLHS ... 1.85
K2O ... 2.39	L.Land./OLHS ... 1.92
CO ... 2.64	L.Gabb./U.Gabb. ... 2.18
BA ... 2.66	Harzb./Kenn.Gn. ... 2.19
ZR ... 2.66	Kenn.Gn./U.Gabb. ... 2.20
ZN ... 2.70	L.Gabb./U.Land. ... 2.24
SR ... 2.76	Kenn.Gn./U.Land. ... 2.26
RB ... 2.92	Kenn.Gn./L.Gabb. ... 2.28
CR ... 2.95	Kenn.Gn./Gravel ... 2.30
CU ... 2.97	U.Land./Gravel ... 2.30
AL2O3 ... 2.99	U.Gabb./Gravel ... 2.35
FE2O3 ... 3.06	L.Gabb./OLHS ... 2.36
MNO ... 3.08	U.Gabb./L.Land. ... 2.52
P2O5 ... 3.25	Lherz./Gravel ... 2.55
SIO2 ... 3.28	U.Land./L.Land. ... 2.63
CAO ... 3.41	Lherz./Kenn.Gn. ... 2.70
SC ... 3.49	Lherz./Harzb. ... 2.73
MGO ... 3.51	OLHS/Gravel ... 2.73
Y ... 3.72	Harzb./U.Land. ... 2.78
GA ... 3.87	Harzb./U.Gabb. ... 2.78
V ... 4.82	Lherz./L.Gabb. ... 2.86
TIO2 ... 4.98	Harzb./OLHS ... 2.93
Overall most important element	Lherz./U.Gabb. ... 3.00
	Lherz./OLHS ... 3.06
	Lherz./U.Land. ... 3.19
	Kenn.Gn./L.Land. ... 3.89
	Lherz./L.Land. ... 4.53
	L.Gabb./L.Land. ... 4.93
	Harzb./L.Land. ... 5.47
	L.Land./Gravel ... 5.64
	Simplest combination to distinguish

Figure 45. Summary of the results of K-means clustering of orientation survey data and an assessment of the relative importance of variables.

Small selection of combinations of some individual delta values

U.Land./OLHS.	L.Gabb./Gravel	Harzb./L.Gabb.	U.Gabb./U.Land.	Harzb./L.Land.	L.Land./Gravel	
PB ... 0.00	NB ... 0.00	NB ... 0.09	CE ... 0.02	CS ... 0.10	CE ... 0.01	Worst element for
BA ... 0.06	LA ... 0.00	LA ... 0.09	LA ... 0.02	NB ... 0.10	LA ... 0.01	cluster group combination
CS ... 0.09	CS ... 0.00	CS ... 0.09	NB ... 0.02	LA ... 0.10	CS ... 0.01	
NB ... 0.09	CE ... 0.00	CE ... 0.09	CS ... 0.02	CE ... 0.10	NB ... 0.01	
LA ... 0.09	BA ... 0.02	CU ... 0.15	V ... 0.14	CO ... 0.32	K20 ... 1.41	
CE ... 0.09	RB ... 0.04	Y ... 0.52	SI02 ... 0.25	NI ... 1.09	PB ... 1.80	
CO ... 0.20	PB ... 0.05	MGO ... 0.65	GA ... 0.68	AL203... 1.18	ZR ... 1.94	
NI ... 0.23	CR ... 0.10	P205 ... 0.73	CU ... 0.75	MGO ... 1.41	NI ... 2.27	
V ... 0.37	ZN ... 0.19	FE203... 0.74	CO ... 0.76	PB ... 1.57	CR ... 2.34	
CU ... 0.38	SC ... 0.28	TI02 ... 0.78	MGO ... 0.85	CR ... 1.58	RB ... 3.05	
CAO ... 0.39	CO ... 0.31	MNO ... 0.81	PB ... 1.03	MNO ... 1.68	NA20 ... 3.36	
ZN ... 0.40	NI ... 0.42	ZR ... 0.90	ZR ... 1.08	ZN ... 3.65	AL203... 4.48	
FE203... 0.41	CU ... 0.45	SI02 ... 0.93	TI02 ... 1.10	NA20 ... 4.32	SI02 ... 4.67	
AL203... 0.52	P205 ... 0.61	NI ... 1.32	SR ... 1.11	ZR ... 5.25	SR ... 4.85	
MNO ... 0.61	V ... 0.64	SC ... 1.33	Y ... 1.19	K20 ... 5.63	CU ... 5.03	
Y ... 0.84	GA ... 0.66	ZN ... 1.37	FE203... 1.34	FE203... 5.72	SC ... 5.35	
CR ... 0.91	K20 ... 0.69	GA ... 1.43	BA ... 1.39	RB ... 5.89	FE203... 5.67	
SC ... 1.16	SI02 ... 0.73	V ... 1.44	CAO ... 1.56	SR ... 6.02	BA ... 5.69	
RB ... 1.17	CAO ... 1.12	PB ... 1.47	NA20 ... 1.60	Y ... 6.27	P205 ... [illegible]	
TI02 ... 1.35	TI02 ... 1.32	CO ... 1.56	AL203... 1.98	CU ... 6.76	GA ... 6.17	
P205 ... 1.40	ZR ... 1.48	RB ... 1.56	SC ... 2.14	SI02 ... 7.30	CAO ... [illegible]	
SI02 ... 1.4[illegible]	NA20 ... [illegible]	AL203... 1.74	P205 ... 2.36	P205 ... 9.13	CU ... 9.51	
GA ... [illegible]	K20 ... [illegible]	K20 ... [illegible]	CR ... [illegible]	SC ... [illegible]	ZN ... [illegible]	
ZR ... 1.57	FE203... 2.13	CR ... 1.90	NI ... 2.47	GA ... 9.45	TI02 ... 9.89	
SR ... 2.03	MNO ... 2.39	NA20 ... 2.19	ZN ... 2.52	CAO ...10.93	Y ...10.67	
K20 ... 2.10	SR ... 2.53	BA ... 2.21	MNO ... 2.82	BA ...11.35	MNO ...14.12	
MGO ... 2.15	Y ... 2.61	SR ... 2.45	RB ... 3.04	TI02 ...17.97	V ...15.60	Best element for
NA20 ... 3.22	AL203... 3.49	CAO ... 2.51	K20 ... 3.10	V ...19.85	MGO ...17.52	cluster group combination

-:-

Working with @a priori$Y knowledge 3/248 samples misclassified (1.56%).

-:-
-:-

Figure 45 continued.

These groups may be seen from Figure 45 as being the four most difficult combinations to distinguish. The individual δ-values for these combinations are also provided, together with those of the two combinations of groups which are considered by KMN to be the most easily identified (harzburgitic peridotite and lower Landewednack schists, and the lower Landewednack schists and gravels). Although this is difficult to confirm graphically Figure 44 tends to support the conclusions given above. The K_2O δ-value is also ignored for similar reasons. The elements Ni and Co are also retained as they are particularly useful in distinguishing soils developed over the ultrabasic.

6.2.3 Identification scheme - Model 1

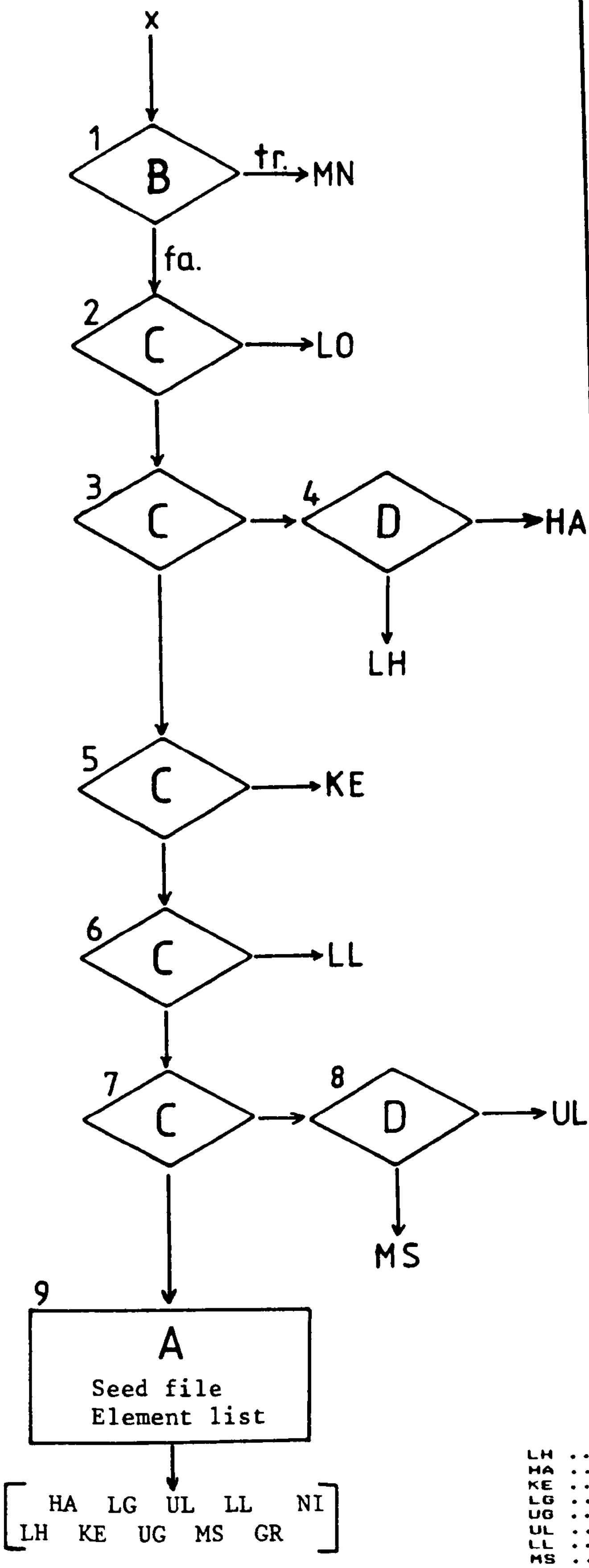
Figure 46 shows in detail the scheme used to identify samples on the basis of their residual soil geochemistry. The parameters controlling the identification of the various units are those as described in Chapter 6.2.1. It was intended that this early version of the IDN-file would serve to identify the lithologies of any future soil samples collected from the Lizard Complex. Additionally the seed file on which the modified K-means option is based is listed in Table 14.

The values of the maximum distance from the seed centroids shown in Figure 46 refer to the standardized distances inside of which 95% of the data from a particular group is expected to lie. The procedure to calculate these values, which was described towards the end of Chapter 5.4., A Modified k-mean technique

B Simple discriminant (At least one condition true)

C Simple discriminant (All conditions true)

D Linear discriminant function




```
File:   SYO:NASX1.IDN
Identication          Max distance from centroid
 codes                  (KMEAN ortion)
 - 1       LH           14.500
 - 2       HA           12.000
 - 3       KE            9.000
 - 4       LG            8.700
 - 5       UG            9.350
 - 6       UL           15.300
 - 7       LL           10.200
 - 8       MS            7.250
 - 9       GR            7.250
 -10       LO            0.000
 -11       MN            0.000
 -12       NI            0.000

         +++++++  1 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    2          3        -11      2
..Element..      ..RO..     ......Value...
  CU              GT              90.000
  PB              GT              80.000
  ZN              GT             300.000

         +++++++  2 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    3          4        -10      3
..Element..      ..RO..     ......Value...
  MGO             LE               0.010
  ZR              GT             400.000
  CAO             LE               2.700
  CR              LE             200.000

         +++++++  3 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    3          3          4      5
..Element..      ..RO..     ......Value...
  CR              GT             500.000
  SR              LE             140.000
  CAO             LE               5.000

         +++++++  4 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    4          5         -2     -1
..Element..      ..RO..     ......Value...
  SIO2                             0.870
  BA                               0.072
  RB                              -0.039
  ZR                              -0.023
                  GT              61.540

         +++++++  5 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    3          3         -3      6
..Element..      ..RO..     ......Value...
  NI              GT             150.000
  K2O             GT               2.200
  ZR              LE             195.000

         +++++++  6 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    3          5         -7      7
..Element..      ..RO..     ......Value...
  TIO2            GT               2.200
  V               GT             195.000
  Y               GT              34.000
  ZN              GT             115.000
  BA              LE             140.000

         +++++++  7 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    3          5          8      9
..Element..      ..RO..     ......Value...
  P2O5            GT               0.300
  V               GT             100.000
  TIO2            LE               2.200
  NI              LE             150.000
  ZN              GT              95.000

         +++++++  8 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
    4          5         -6     -8
...Element..     ..RO..     ......Value...
  MGO                              0.078
  K2O                            -10.687
  RB                              -0.296
  SR                              -0.269
                  GT             -73.176

         +++++++  9 +++++++
NTYPE: 1          Id.code for cluster nr 1: -1
NCOND:25          Id.code for cluster nr 2: -2
                  Id.code for cluster nr 3: -3
                  Id.code for cluster nr 4: -4
                  Id.code for cluster nr 5: -5
                  Id.code for cluster nr 6: -6
                  Id.code for cluster nr 7: -7
                  Id.code for cluster nr 8: -8
                  Id.code for cluster nr 9: -9

 ..Element..      ..Seed filename..
   SIO2             SEEDX1
   AL2O3
   TIO2
   FE2O3

   MGO              P2O5              GA              SR
   CAO              BA                NI              V
   NA2O             CO                PB              Y
   K2O              CR                RB              ZN
   MNO              CU                SC              ZR

         +++++++ 14 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   99          0          0      0
```

```
LH ..... Lherzolitic peridotite
HA ..... Harzburgitic peridotite
KE ..... Kennack gneiss
LG ..... Lower gabbro
UG ..... Upper gabbro
UL ..... Upper Landewednack schist
LL ..... Lower Landewednack schist
MS ..... Old Lizard Head Series
GR ..... Crousa gabbro
LO ..... Loess
MN ..... Mineralized sample
NI ..... Not identified
```

Figure 46. Identification scheme (Model 1) based on orientation survey data.

Var.\ID:	LH	HA	KE	LG	UG	UL	LL	MS	GR
SIO2	48.90	71.65	54.49	68.15	57.22	56.47	49.85	53.27	65.43
AL2O3	6.27	11.38	12.96	14.18	19.67	15.84	13.16	14.30	19.66
TIO2	0.62	0.88	1.36	0.93	1.44	1.67	2.44	1.75	1.12
FE2O3	11.73	6.41	7.90	5.43	8.77	10.35	12.99	10.10	7.70
MGO	21.23	3.19	8.28	1.96	3.36	4.12	5.99	6.54	0.03
CAO	3.24	2.72	3.74	4.73	6.93	6.08	7.75	5.69	3.62
NA2O	0.31	0.49	1.27	0.81	0.68	0.45	1.14	1.08	0.48
K2O	0.76	1.91	2.47	1.50	0.74	1.40	1.07	2.09	1.36
MNO	0.24	0.14	0.14	0.10	0.14	0.21	0.21	0.23	0.03
P2O5	0.18	0.07	0.42	0.11	0.30	0.54	0.45	0.38	0.15
BA	137	340	285	267	156	208	108	219	274
CO	118	53	39	18	36	33	46	32	15
CR	3001	859	593	220	312	168	318	197	203
CU	17	17	24	16	35	42	68	41	19
GA	7	9	14	11	15	16	18	18	11
NI	1242	326	369	82	128	71	119	70	66
PB	28	22	24	16	21	20	51	22	16
RB	22	67	80	52	35	47	32	59	53
SC	23	12	22	17	37	30	40	32	19
SR	58	84	203	147	132	117	161	174	67
V	77	50	78	64	135	140	222	134	71
Y	10	23	16	22	24	27	37	26	17
ZN	164	60	106	34	63	126	126	119	37
ZR	107	387	153	331	187	231	198	185	258

KEY

LH ... Lherzoltic peridotite
HA ... Harzburgitic peridotite
KE ... Kennack gneiss
LG ... Lower gabbro
UG ... Upper gabbro
UL ... Upper Landewednack hornblende schist
LL ... Lower Landewednack hornblende schist
MS ... Mica schist (Old Lizard Head Series)
GR ... Crousa gravel

Table 14. Seed-file (SEEDX1.RAW) used by identification scheme (Model 1; NASX1.IDN) based on orientation survey data.

uses the early version of Model 1. This early version has values of 0.000 in place of the maximum distance. If the switch "D" in IDN (Appendix A) is set the maximum distance value is automatically ignored and the conventional standardized measure used (ie. not a ratio of the standardized measurement against the 95 percentile). The program requests which unit is being run and writes the results to a file DREF.RAW for further examination. When the 95 percentile values for each unit has been selected, it is a simple task to edit the IDN-file (using the editor IED) to include these values.

Although Figure 45 in the previous section provides an assessment of the ease of distinguishing the various groups by taking the mean value of δ (all in units of standard deviation) for all the elements for each combination of cluster groups, an alternative method may be used. This uses the option "S" in the program KMN to calculate the standardized distances between each of the cluster centroids. These are calculated following the input of the seed file which is accessed by the identification procedure. Table 15 provides a summary of the results. The estimation of the varying degrees of overlap between the various combinations of cluster groups (described by the asterisks) are calculated by comparing the computed standardized distance measurement with the sum (*) and the mean (**) of the 95 percentile described in the listing of Model 1 (Fig.46).

The results of this exercise are comparable with those

File read; SEEDX1.RAW (seed file used in first IDN model).

Using all 24 variables as described in Figure 46b.

	Lherz. (14.50)	Harzb. (12.00)	Kenn.Gn. (9.00)	L.Gabb. (8.70)	U.Gabb. (9.35)	U.Land. (15.30)	L.Land. (10.20)	OLHS (7.25)
Harzb. (12.00)	77.71							
Kenn.Gn. (9.00)	79.67	35.26						
L.Gabb. (8.70)	90.95	10.24**	27.50					
U.Gabb. (9.35)	74.38	42.36	33.90	22.06				
U.Land. (15.30)	74.31	41.89	28.22	32.33	9.95**			
L.Land. (10.20)	100.93	92.02	56.35	71.54	26.42	19.49		
OLHS (7.25)	82.38	45.17	13.02*	32.56	17.14	8.57**	19.67	
Gravel (7.25)	89.68	16.57*	35.49	8.93*	20.33	30.88	76.85	39.26

** .... Significant degree of overlap between two groups.
(Based on combined 95 percentile values for groups, Figure 46b and shown in brackets).

* ..... Moderate degree of overlap between two groups.

Lherz. ..... Lherzolitic peridotite
Harzb. ..... Harzburgitic peridotite
Kenn.Gn. ... Kennack gneiss
L.Gabb. .... Lower gabbro
U.Gabb. .... Upper gabbro
U.Land .... Upper Landewednack schist
L.Land. .... Lower Landewednack schist
OLHS ..... Old Lizard Head Series
Gravel ..... Crousa gabbro

Table 15. Standardized distances between cluster centroids used by Model 1.

using the mean of the δ-values. The groups which in multivariate space show some degree of overlap are (from the combination with the highest degree of overlap first):

i) Upper Landewednack schists / Old Lizard Head Series (1)

ii) Upper Landewednack schists / Upper gabbro (4)

iii) Lower gabbro / Crousa gravels (2)

iii) Harzburgitic peridotite / Lower gabbro (3)

The numbers in brackets shows their position in Figure 45. The easiest groups to distinguish using the modified K-means technique are (the easiest combination is shown first this time):

i) Upper gabbro / Lherzolitic peridotite (8)

ii) Lower Landewednack schists / Crousa gravels (1)

iii) Lherzolitic peridotite / Crousa gravels (17)

iv) Lower Landewednack schists / Lherzolitic peridotite (4)

The number in brackets again shows their position in Figure 45, although the order is now reversed from best to worst combination. The results are again confirmed by a visual examination of the single element graphs drawn in Figure 44.

The result of using the training set as a test set was a misclassification rate of 1.56% (ie. 4 out of 256 samples). Additionally a further 7 samples were assigned the label of "Not identified". These samples were all products of the K-means option and fell outside of the ellipsoid (described in 5..4) which was calculated for individual groups. On the basis of these results it was decided to continue with the mapping programme by sampling in the inland areas.

6.3 Power auger programme

In excess of 500 samples were collected during a power auger programme carried out between October and December 1983. This included the collection of both shallow and basal samples and some aspects of this were discussed in Chapter 4.4. The shallow samples, particularly from the Trelan area, were additionally used for mapping purposes and this section deals primarily with this aspect of the work.

The analytical measurements for the samples which were collected in the Trelan area were processed through the program IDN using the files NASX1.IDN and SEEDX1.RAW which were described previously. The result of this exercise was that over 70% of the unknowns were assigned the "Not Identified" label. Figure 47 shows an example of the output from the identification program. The data shown is from the traverse line NAS145. It records the name of the IDN-file used in the identification process and the name(s) of the RAW-files as they were input. The integer to the left records the stage in the IDN-file at which the sample was assigned an identity prior to the program reading the data belonging to the next sample. The sample name and its assigned identity then follows. If the sample is "Not Identified" the ratio of the standardized distance against the 95 percentile value for the nearest cluster centroid is given.

In attempting to make an interpretation of the nature of

```
IDN-filename; SYO:NASX1.IDN

RAW-filename; SYO:NAS145.RAW
4  BXS3099   ....... LH
9  BXS3098   ....... not identified.   (DIST;  2.52 from UL)
4  BXS3097   ....... LH
9  BXS3096   ....... not identified.   (DIST;  2.82 from UL)
4  BXS3095   ....... LH
9  BXS3094   ....... not identified.   (DIST;  3.92 from UL)
1  BXS3093   ....... MN
4  BXS3092   ....... LH
1  BXS3091   ....... MN
9  BXS3079   ....... not identified.   (DIST;  4.09 from UL)
9  BXS3078   ....... not identified.   (DIST;  2.43 from UL)
9  BXS3077   ....... not identified.   (DIST;  3.49 from UL)
9  BXS3076   ....... not identified.   (DIST;  2.82 from UL)
4  BXS3075   ....... LH
9  BXS3074   ....... not identified.   (DIST;  2.68 from UL)
9  BXS3073   ....... not identified.   (DIST;  2.76 from LH)
9  BXS3072   ....... not identified.   (DIST;  2.38 from UG)
9  BXS3041   ....... not identified.   (DIST;  2.88 from UL)
9  BXS3040   ....... not identified.   (DIST;  2.87 from UL)
9  BXS3039   ....... not identified.   (DIST;  1.87 from UG)
9  BXS3038   ....... not identified.   (DIST;  1.42 from UG)
9  BXS3037   ....... not identified.   (DIST;  1.60 from UL)
9  BXS3036   ....... LG
9  BXS3035   ....... LG


       Identification codes
       """"""""""""""""""""
       LH  .....  Lherzolitic peridotite.
       LG  .....  Lower gabbro.
       UG  .....  Upper gabbro.
       UL  .....  Upper Landewednack schists.
       MN  .....  Mineralized sample (Ba,Cu,Pb,Zn).
       'not identified' ...... Standardized distance from nearest cluster
                               centroid recorded.
```

Figure 47. Example of output from the identification program (IDN).

the problem the samples were first split into two groups with the aid of option "C" of the program KMN. This was described in detail in Chapter 5.2.2 and selects k seed points from the data set which are well separated. The largest group to be formed was gabbroic in composition whilst the other was ultrabasic. Two temporary RAW-files were then created from this information for further examination. The data held in the gabbroic file were run through IDN three times using the switch "D". This recorded the standardized distance from the three specified cluster centroids held in the file SEEDX1.RAW (lower gabbro, upper gabbro and upper Landewednack hornblende schist). On each run the distance measurement was written to DREF.RAW for further interpretation. The latter group was included as many of the samples which were labelled as "Not Identified" were closest to this group. A similar exercise was carried out on the ultrabasic samples although these were compared with the lherzolitic and harzburgitic peridotite cluster centroids.

The data from each of the five files containing the standardized distance measurements were then plotted as histograms (Fig.48). These all show distinct multimodal distributions. Two possible reasons for this may be suggested:

i) The samples collected from the Trelan area represent new, previously unidentified lithological units.

ii) The samples are derived from lithologies similar to those sampled near to the coast. This would in turn suggest that

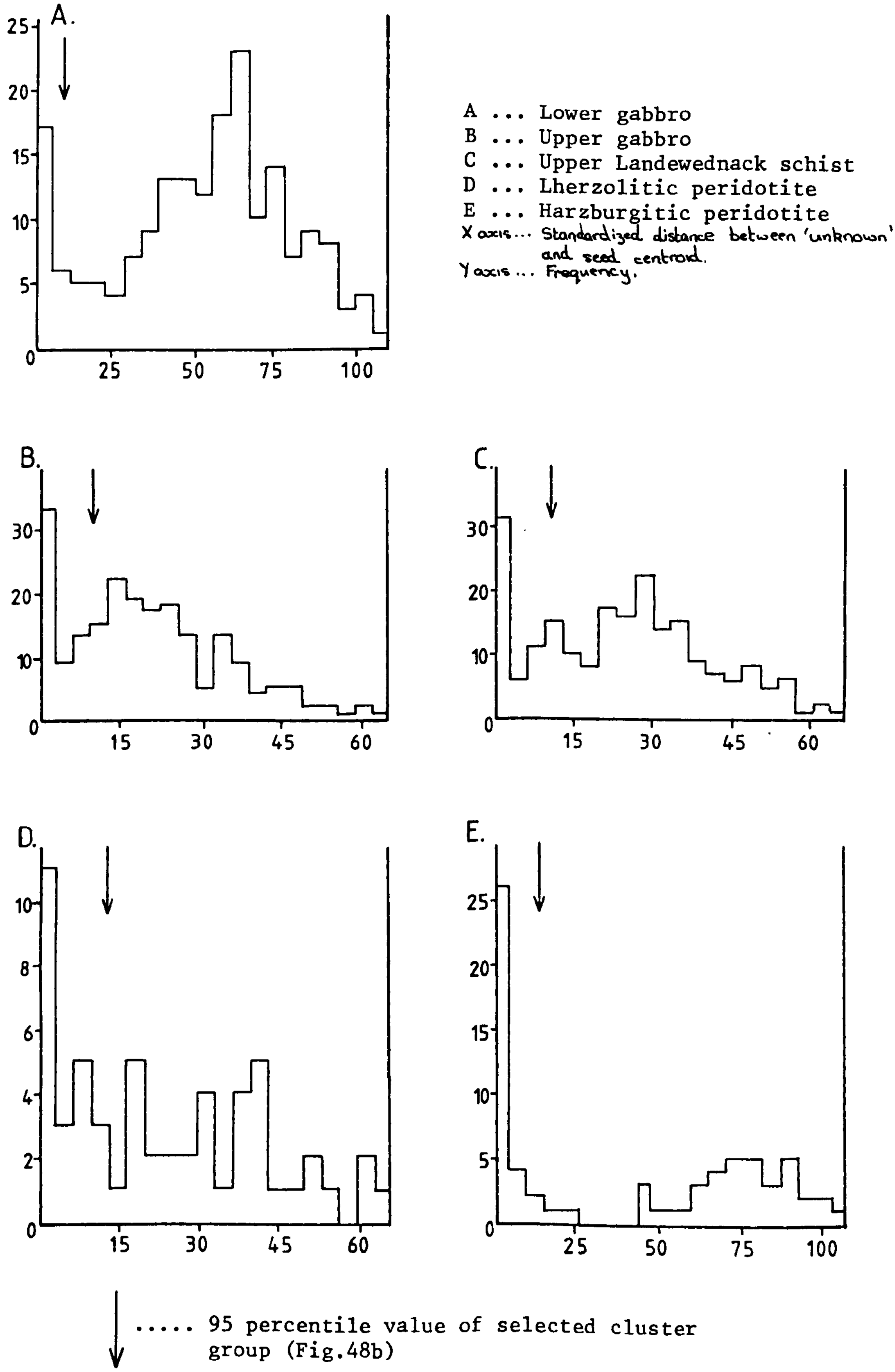


Figure 48. Histograms showing standardized distance between Trelan area "unknowns" together with orientation survey data and various seed centroids from the identification scheme (Model 1).

the original sampling was insufficient and that the variation within those units with a large areal extent is considerably greater than previously indicated.

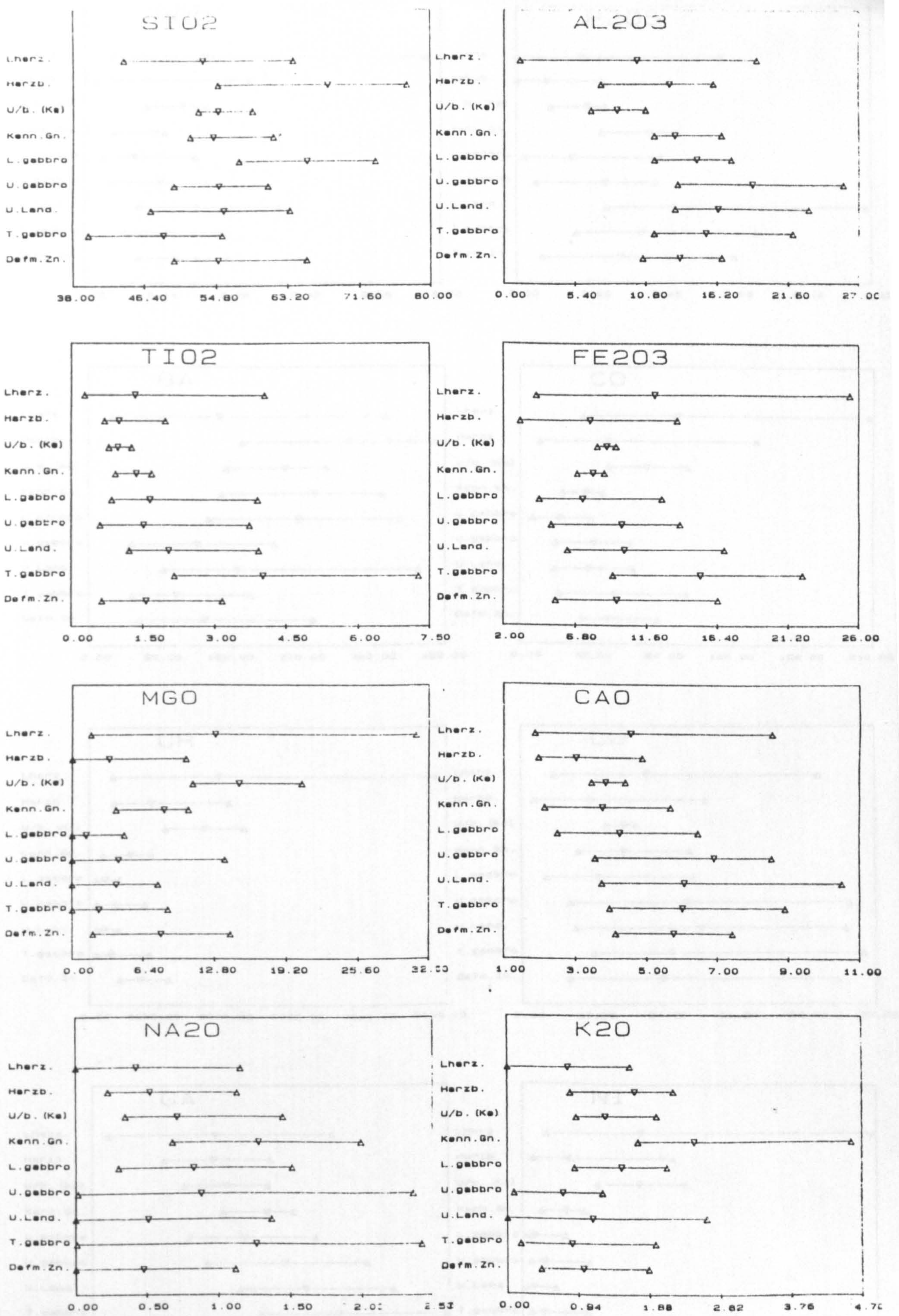
An attempt was made to identify any new lithological units using the Trelan data. This made use of the KMN clustering technique although few details are given here. Three new gabbroic and one new ultrabasic group were isolated. These all showed unimodal distributions. Additionally from the data many samples were recognized as having high concentrations of TiO_2 and V.

The inclusion of these groups into the identification scheme was achieved with the use of the editor IED which was described in Chapter 5.4. This resulted in several cluster groups being poorly separated and for this reason the attempt was abandoned. It was, however, recognized that the best solution would be to recluster all of the gabbroic material at the end of the sampling period. It was also decided that a similar approach would be used for the ultrabasic material.

6.4 Final mapping stage

This section provides a description of the final identification scheme selected to identify the soil samples taken from the Lizard Complex. This involved the reclassification of some of the gabbroic and ultrabasic samples using the KMN algorithm together with the recognition of other new units. Descriptions of the new classificatory units are provided in the text where appropriate. Following the recognition of these groups a revised IDN-file is presented. Additionally, new 95 percentile values are calculated and the distances between the various combinations of seed centroids discussed. Finally a series of pre-interpretation traverse line map is presented for the Lizard Complex based solely on the results of the IDN program.

The following three pages are used to provide simple one element graphs of the 9 groups (both new and old) which are referred to in detail in this section. The Old Lizard Head Series, lower Landewednack hornblende schists, Crousa gravels and loess are not represented here as they remain the same as described in Chapter 6.2. Some of the features from these graphs will be highlighted in the text.



Lherz. Lherzolite
Harzb. Harzburgite
U/b. (Ke) Ultrabasic + gneiss
Kenn.Gn. Kennack gneiss
L.gabbro Lower gabbro
U.gabbro Upper gabbro
U.Land. U.landewednack schist
T.gabbro Trelan gabbro
Defm.Zn. Deformation zone

Figure 49. Single element graphs of the new/revised lithological units as recognized during the latter stages of mapping.

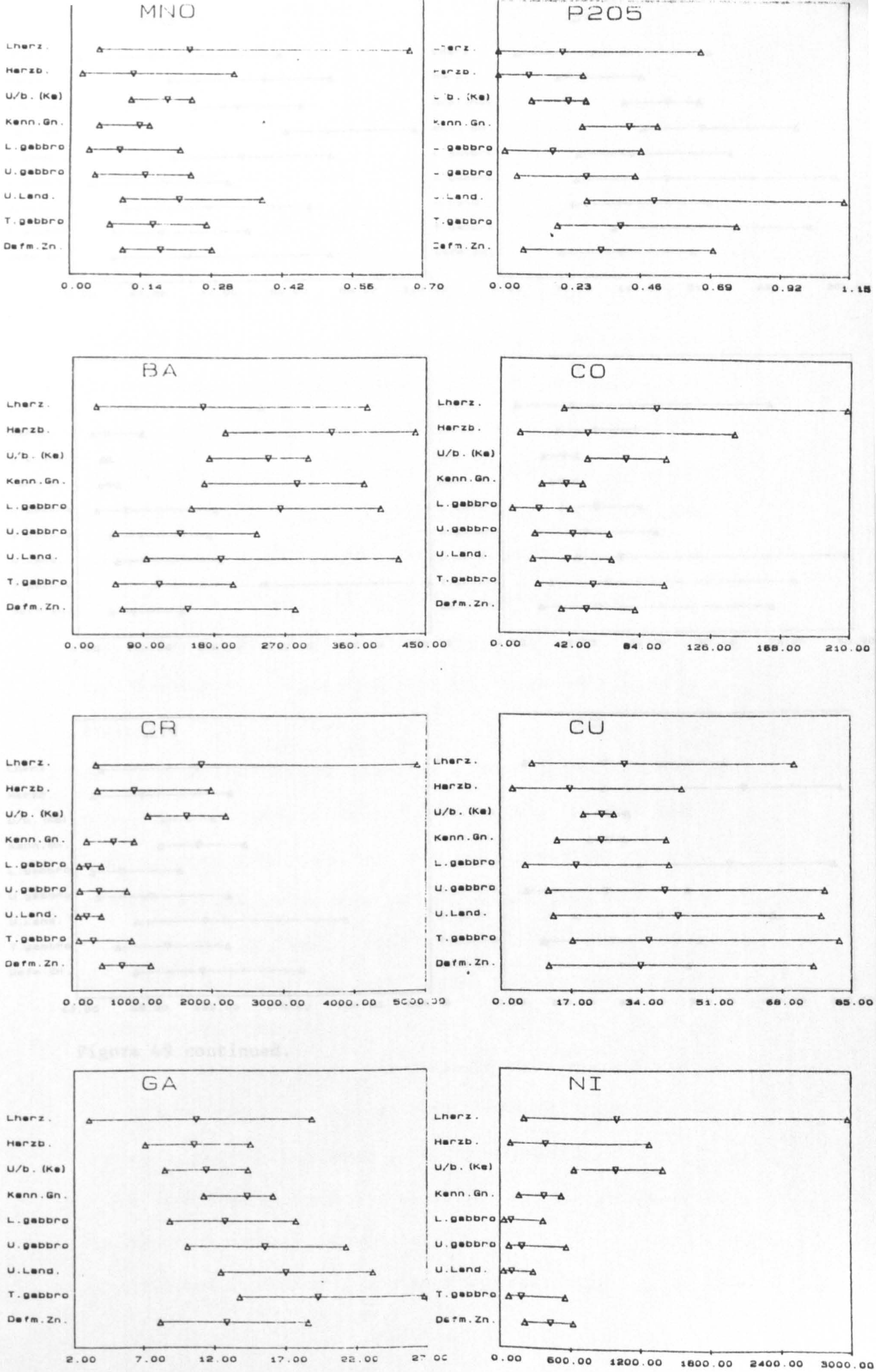


Figure 49 continued.

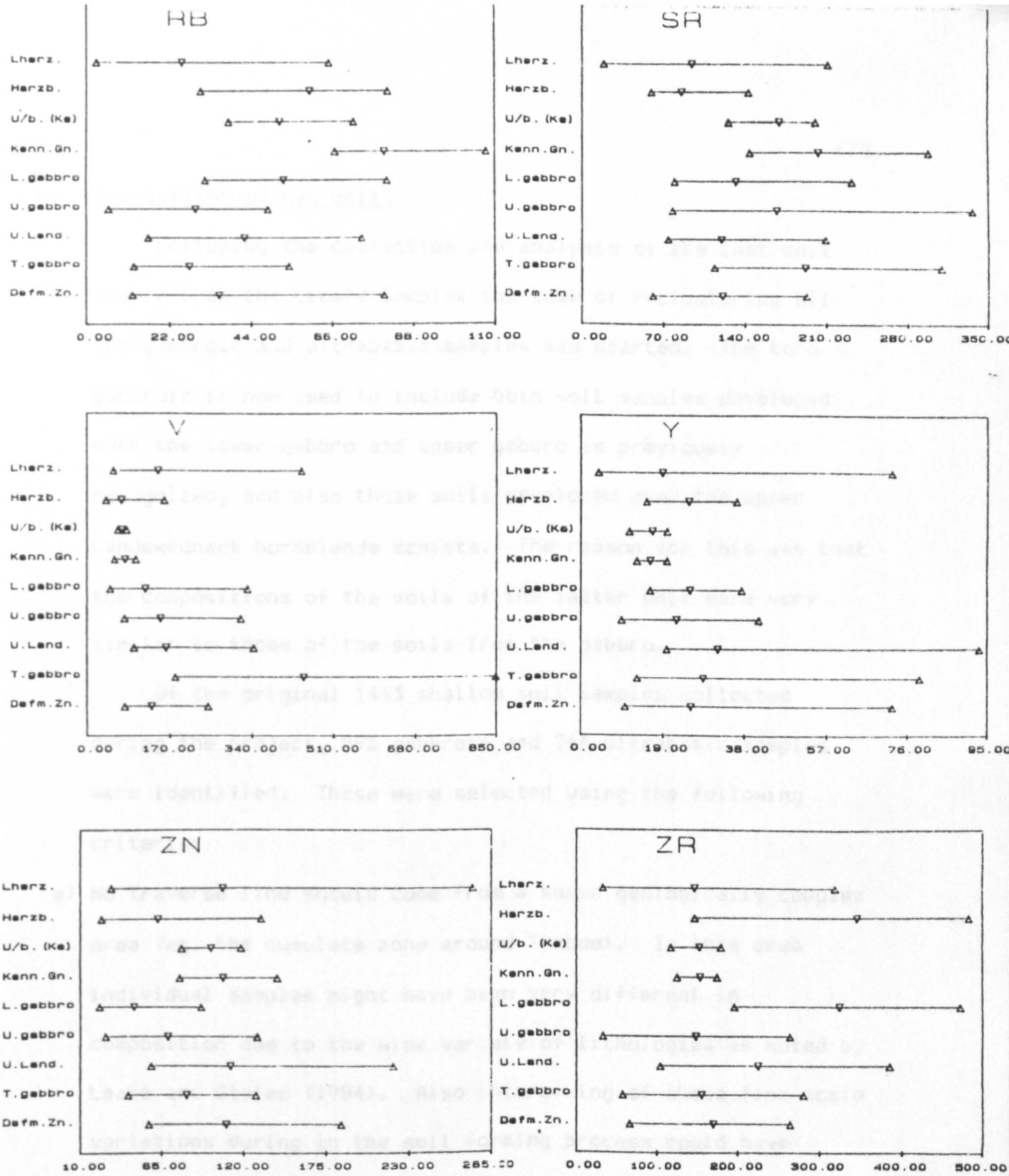


Figure 49 continued.

6.4.1 Recognition of new units

Following the collection and analysis of the last soil sample from the Lizard Complex the task of reclustering all the gabbroic and ultrabasic samples was started. The term gabbroic is now used to include both soil samples developed over the lower gabbro and upper gabbro as previously recognized, and also those soils developed over the upper Landewednack hornblende schists. The reason for this was that the compositions of the soils of the latter unit were very similar to those of the soils from the gabbro.

Of the original 1463 shallow soil samples collected during the project, 595 gabbroic and 264 ultrabasic samples were identified. These were selected using the following criteria:

a) No traverse line should come from a known geologically complex area (eg. the cumulate zone around Traboe). In this area individual samples might have been very different in composition due to the wide variety of lithologies as noted by Leake and Styles (1984). Also intermixing of these fine scale variations during in the soil forming process could have caused severe problems.

b) Any traverse lines which were close to the known outcrop of the Crousa gravels or showed signs of a significant gravel component should be removed prior to clustering.

c) There should be no traverses which include the west coast Landewednack hornblende schists.

d) No traverses including ulltrabasic material should come close to known exposures of the Kennack gneiss.

e) Any samples showing evidence of minor base-metal mineralization should be removed.

Following the removal of any traverse lines or samples which did not satisfy the above requirements, the remaining data was run through the identification program (IDN) using two new IDN-files. The first was designed to isolate the gabbroic samples (GAB.IDN) and the second the ultrabasic samples (UBC.IDN). Figure 50 shows the two IDN-files used for this purpose. All the identification parameters were based on the data obtained from the orientation survey (Chapter 6.2).

K-means clustering of the gabbroic samples

A summary of the results of the clustering exercise using the program KMN (option "O") is shown in Figure 51. It shows the name(s) of the RAW-file which was read for the clustering operation and the names of any samples removed. The three samples listed had previously been recognized as anomalous by the K-means technique. By inserting "*" in place of the first character of each sample name KMN automatically removes them. This is then followed by a list of the variables used. In this instance Ce, Cs, La, Nb, Pb, Sc, S, Sn and W were removed prior to the calculation using the switch "R" in KMN. The graph shown in Figure 51 shows the value of the summed deviation about the seed points (Σ_{TOT}) for each iteration of the program (the maximum number of groups in this instance was set at 15). The first major break in slope from this graph can be seen to occur at 5 groups. It is therefore suggested

```
File; SYO:GAB.IDN
Identication      Max distance from centroid
 codes               (KMEAN option)
 - 1     .            0.000
 - 2    UB            0.000
 - 3    GR            0.000
 - 4    MN            0.000
 - 5    NI            0.000

     +++++++  1 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   2         4        -4      2
..Element..  ..RO..  ......Value...
  CU           GT           90.000
  PB           GT           80.000
  ZN           GT          300.000
  BA           GT          500.000

     +++++++  2 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   2         5        -2      3
..Element..  ..RO..  ......Value...
  AL2O3        LE           10.000
  TIO2         LE            0.400
  MGO          GT           15.000
  CAO          LE            2.000
  CR           GT         1150.000

     +++++++  3 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   2         4        -2      4
..Element..  ..RO..  ......Value...
  CO           GT          110.000
  GA           LE            6.000
  NI           GT          675.000
  SR           LE           50.000

     +++++++  4 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   3         2        -2      5
..Element..  ..RO..  ......Value...
  CR           GT          350.000
  V            LE          100.000

     +++++++  5 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   3         2        -3      6
..Element..  ..RO..  ......Value...
  MGO          LE            0.010
  SR           LE          100.000

     +++++++  6 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   3         2        -3     -1
..Element..  ..RO..  ......Value...
  MGO          LE            0.010
  Y            LE           18.000

     +++++++  7 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
  99         0         0      0
```

```
File;  SYO:UBC.IDN
Identication      Max distance from centroic
 codes               (KMEAN option)
 - 1     .            0.000
 - 2    GA            0.000
 - 3    GR            0.000
 - 4    MN            0.000
 - 5    NI            0.000

     +++++++  1 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   2         4        -4      2
..Element..  ..RO..  ......Value...
  CU           GT           90.000
  PB           GT           80.000
  ZN           GT          300.000
  BA           GT          500.000

     +++++++  2 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   2         5        -1      3
..Element..  ..RO..  ......Value...
  AL2O3        LE           10.000
  TIO2         LE            0.400
  MGO          GT           15.000
  CAO          LE            2.000
  CO           GT          110.000

     +++++++  3 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   2         3        -1      4
..Element..  ..RO..  ......Value...
  CR           GT         1150.000
  GA           LE            6.000
  NI           GT          675.000

     +++++++  4 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   2         4        -2      5
..Element..  ..RO..  ......Value...
  AL2O3        GT           16.000
  NA2O         GT            0.900
  CR           LE          340.000
  GA           GT           17.000

     +++++++  5 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
   3         2        -3     -1
..Element..  ..RO..  ......Value...
  MGO          LE            0.010
  CR           LE          330.000

     +++++++  6 +++++++
..NTYPE.. ..NCOND.. ..TR.. ..FA..
  99         0         0      0
```

```
GA or (.) ...... Gabbroic sample
UB or (.) ...... Ultrabasic sample
GR ............. Crousa gravel
MN ............. Mineralized sample
NI ............. Not identified
```

Figure 50. IDN-files used in identifying gabbroic (GAB.IDN) and ultrabasic (UBC.IDN) samples prior to reclustering of data.

Non-hierarchical convergent K-means cluster analysis

```
************************************************

Files read; SYO:GAB.RAW.       #-32, #-531 & #-950 removed.

Variables used;  SIO2    AL2O3    TIO2    FE2O3    MGO    CAO    NA2O    K2O    MNO    P2O5    BA
                 CO      CR       CU      GA       NI     RB     SR      V      Y      ZN      ZR

X-axis; No.of cluster groups selected
      |---------|---------|---------|---------|---------|---------|---------|
  1.00 o
  2.00 |                                                                 o
  3.00 |                                                        o
  4.00 |                                               o
  5.00 |                                          o
  6.00 |                                          o
  7.00 |                                         o
  8.00 |                                     o
  9.00 |                                   o
 10.00 |                                 o             Seed points selected by FSEED
 11.00 |                               o               S-1     S-66     BXS3094   BXS3047   S-1324
 12.00 |                              o                Min distance between seed points set at  85.00
 13.00 |                             o                  10 iterations required for convergence
 14.00 |                            o                  Summed deviation about seed points =   0.69396636E+04
 15.00 |                            o
      |---------|---------|---------|---------|---------|---------|---------|   Y-axis; TDIST
    0.00               3136.71             6273.42             9410.13
             1568.36             4705.07             7841.78             10978.49
```

Cluster 1 contains275 data units

Centroid coordinates

0.5571E+02 0.1626E+02 0.2036E+01 0.1010E+02 0.3976E+01 0.6056E+01 0.5103E+00 0.1130E+01 0.2170E+00 0.5049E+00 0.1880E+03

0.4075E+02 0.2002E+03 0.4281E+02 0.1700E+02 0.9767E+02 0.4244E+02 0.1199E+03 0.1621E+03 0.3175E+02 0.1112E+03 0.2241E+03

Membership list; Seed point (if used); S-1

S-825 S-2 S-3 S-5 S-7 S-8 S-9 S-10 S-11 S-12 S-13 S-14 S-15 S-16 S-18 S-20
S-21 S-22 S-23 S-24 S-25 S-126 S-130 S-131 S-132 S-133 S-134 S-135 S-136 S-139 S-140 S-141
S-142 S-143 S-144 S-145 S-146 S-147 S-148 S-149 S-150 S-254 S-255 S-363 S-532 S-533 S-534 S-535
S-536 S-537 S-538 S-539 S-540 S-542 S-543 S-905 S-906 S-907 S-908 S-909 S-910 S-911 S-1060 S-1061
S-1062 S-1063 S-1064 S-1065 S-1067 S-1068 S-1069 S-1070 S-1071 S-1072 S-1073 S-1074 S-1075 S-1076 S-1077 S-1078
S-1079 S-1080 S-1081 S-1082 S-1083 S-1084 S-1085 S-1341 S-1339 S-1338 S-811 S-810 S-809 S-808 S-801 S-800
S-799 S-798 S-797 S-796 S-795 S-760 S-759 S-758 S-757 S-756 S-755 S-754 S-753 S-752 S-751 S-750
S-749 S-587 S-588 S-589 S-590 S-591 S-592 S-593 S-595 S-596 S-597 S-598 S-599 S-600 S-601 S-602
S-612 S-613 S-614 S-617 S-1120 S-1121 S-1122 S-1123 S-1124 S-1125 S-1126 S-1127 S-1128 S-1129 S-1130 S-1131
S-1132 S-1133 S-1134 S-1135 S-1136 S-1137 S-1138 S-1139 S-1140 S-1141 S-1142 BXS3027 BXS3028 BXS3082 BXS3083 BXS3084
BXS3085 BXS3088 BXS3100 BXS3101 BXS3102 BXS3103 BXS3104 BXS3105 BXS3106 BXS3108 BXS3111 BXS3114 BXS4002 BXS4003 BXS4006 BXS4055
BXS4057 BXS4058 BXS4059 BXS4060 BXS4062 BXS4068 BXS4069 BXS4070 BXS4071 BXS4072 BXS4073 BXS4074 BXS4077 BXS4078 BXS4079 BXS4080
BXS4081 BXS4082 S-656 S-655 S-653 S-652 S-651 S-650 S-649 S-647 S-609 S-610 S-1106 S-1108 S-1109 S-1111
S-1112 S-1113 S-1114 S-1115 S-1116 S-1117 S-1118 S-1119 S-761 S-762 S-763 S-764 S-765 S-766 S-767 S-768
S-769 S-771 S-772 S-773 S-774 S-775 S-777 S-778 S-779 S-1037 S-1036 S-1035 S-1034 S-1033 S-1032 S-1031
S-1030 S-1029 S-1028 S-1027 S-1026 S-1025 S-783 S-784 S-785 S-786 S-787 S-788 S-789 S-790 S-791 S-792
S-793 S-794 S-824 S-827 S-833 S-834 S-835 S-1038 S-1039 S-1088 S-1089 S-1090 S-1095 S-1097 S-1098 S-1100
S-1101 S-1102

Cluster 2 contains 80 data units

Centroid coordinates

0.6553E+02 0.1462E+02 0.1651E+01 0.7304E+01 0.1226E+01 0.4227E+01 0.8282E+00 0.1515E+01 0.9844E-01 0.1759E+00 0.2637E+03

0.2403E+02 0.2382E+03 0.1826E+02 0.1271E+02 0.9101E+02 0.5274E+02 0.1319E+03 0.1198E+03 0.2532E+02 0.4625E+02 0.3243E+03

Membership list; Seed point (if used); S-66

S-1312 S-4 S-6 S-17 S-51 S-53 S-54 S-55 S-56 S-57 S-58 S-59 S-60 S-61 S-64 S-65
S-67 S-68 S-69 S-70 S-72 S-73 S-74 S-360 S-369 S-370 S-1345 S-1344 S-1343 S-1340 S-807 S-806
S-804 S-803 S-802 S-594 S-615 S-616 BXS3000 BXS3001 BXS3002 BXS3003 BXS3004 BXS3005 BXS3007 BXS3022 BXS3023 S-1308
S-1307 BXS3039 BXS3038 BXS3037 BXS3036 BXS3035 BXS3034 BXS3033 BXS3032 S-1186 S-1187 S-1188 S-1190 S-1191 S-1198 S-1205
BXS4007 BXS4010 BXS4011 BXS4015 BXS4053 BXS4054 S-654 S-776 S-832 S-1178 S-956 S-1099 S-1279 S-1281 S-1283

Figure 51. Summary of results of reclustering of gabbroic data by K-means algorithm.

Cluster 3 contains 66 data units

Centroid coordinates

0.4865E+02 0.1536E+02 0.4006E+01 0.1525E+02 0.2420E+01 0.6009E+01 0.1262E+01 0.8592E+00 0.1652E+00 0.3951E+00 0.1105E+03
0.5576E+02 0.2953E+03 0.3572E+02 0.1924E+02 0.1773E+03 0.2735E+02 0.1917E+03 0.4463E+03 0.2834E+02 0.3191E+02 0.1553E+03

Membership list; Seed point (if used); BXS3094

BXS4001 BXS3077 BXS4013 BXS4038 S-1066 BXS3008 BXS3009 BXS3010 BXS3020 BXS3021 BXS3024 BXS3025 S-929 BXS3079 BXS3078 BXS3076
BXS3074 BXS3041 BXS3040 BXS3090 BXS4000 BXS4004 BXS4005 BXS4008 BXS4009 BXS4012 BXS4014 BXS4016 BXS4017 BXS4018 BXS4019 BXS4020
BXS4021 BXS4022 BXS4023 BXS4025 BXS4026 BXS4027 BXS4028 BXS4039 BXS4040 BXS4041 BXS4042 BXS4043 BXS4044 BXS4045 BXS4046 BXS4047
BXS4048 BXS4049 BXS4050 BXS4051 BXS4052 BXS4056 BXS4061 BXS4063 BXS4066 BXS4067 BXS4075 S-828 S-829 S-830 S-953 S-957
S-1087

Cluster 4 contains133 data units

Centroid coordinates

0.5515E+02 0.1885E+02 0.1519E+01 0.9924E+01 0.4143E+01 0.6896E+01 0.8793E+00 0.7392E+00 0.1492E+00 0.2840E+00 0.1371E+03
0.4359E+02 0.3753E+03 0.3964E+02 0.1550E+02 0.1819E+03 0.2905E+02 0.1674E+03 0.1507E+03 0.2220E+02 0.6919E+02 0.1480E+03

Membership list; Seed point (if used); BXS3047

BXS3063 S-193 S-26 S-29 S-30 S-31 S-33 S-34 S-35 S-36 S-39 S-40 S-41 S-42 S-43 S-44
S-45 S-46 S-47 S-48 S-49 S-50 S-63 S-181 S-182 S-185 S-186 S-187 S-188 S-189 S-190 S-191
S-192 S-194 S-195 S-196 S-199 S-200 S-201 S-202 S-203 S-204 S-205 S-231 S-234 S-235 S-236 S-237
S-238 S-239 S-240 S-241 S-242 S-243 S-244 S-245 S-248 S-249 S-250 S-251 S-252 S-253 S-347 S-348
S-349 S-350 S-351 S-352 S-353 S-354 S-358 S-359 S-361 S-362 S-364 S-365 S-368 S-371 S-546 S-904
S-1086 S-1342 S-1337 S-805 BXS3006 BXS3011 BXS3012 BXS3013 BXS3014 BXS3016 BXS3017 BXS3018 BXS3072 BXS3031 BXS3030 BXS3029
BXS3080 BXS3086 BXS3087 BXS3089 BXS3107 BXS3109 BXS3110 BXS3112 BXS3113 BXS3126 BXS3125 BXS3068 BXS3067 BXS3062 BXS3061 BXS3050
BXS4064 BXS4065 BXS4076 S-826 S-836 S-926 S-925 S-924 S-923 S-922 S-1166 S-1167 S-1168 S-1169 S-1170 S-1172
S-1174 S-1176 S-1177 S-951

Cluster 5 contains 38 data units

Centroid coordinates

0.5504E+02 0.1334E+02 0.1572E+01 0.9589E+01 0.8031E+01 0.5761E+01 0.4771E+00 0.1003E+01 0.1800E+00 0.3312E+00 0.1462E+03
0.5196E+02 0.7206E+03 0.3372E+02 0.1284E+02 0.4229E+03 0.3530E+02 0.1208E+03 0.1329E+03 0.2549E+02 0.1084E+03 0.1698E+03

Membership list; Seed point (if used); S-1324

S-1044 S-952 S-541 S-544 S-545 S-611 BXS3044 BXS3043 BXS3042 S-1184 S-780 S-781 S-782 S-947 S-948 S-954
S-955 S-1040 S-1041 S-1042 S-1091 S-1092 S-1093 S-1094 S-1096 S-1103 S-1104 S-1105 S-1274 S-1321 S-1322 S-1323
S-1325 S-1326 S-1327 S-1328 S-1329

Figure 51 continued.

that this represents the optimum number of groups. The subsequent gentle reduction in the value of Σ_{TOT} describes the further splitting of the five groups. After the output of this graph to screen the number of cluster groups is selected by the user (5), and the actual seed points selected for that number of groups and their minimum distance value written to file. The number of iterations required for convergence and the Σ_{TOT} value for the 5 group situation are then recorded. The cluster centroid coordinates and the membership details are then recorded to file. These cluster group membership lists then become the basis of identification of the gabbroic samples. The following comments may be made on the nature of the groups:

a) Group 1. This is the largest of the various groups and includes most of the orientation survey samples which originated from the upper Landewednack hornblende schists (NAS117 and NAS122). Very few samples from the power auger programme are found in this group. The exceptions are some samples from the north of the Trelan area, particularly the northern ends of the traverse lines NAS143, NAS145 and NAS155. Samples within this group may be noted in Figure 49 as exhibiting moderately high to high levels of P_2O_5, MnO, Ba, Zn, TiO_2, Ga and V. Additionally they show relatively low concentrations of Na_2O, Cr and Sr. The abundance of many of the elements referred to above tends to suggest that these samples belong to the higher levels in the differentiation sequence (especially the levels of TiO_2, P_2O_5 and V).

b) Group 2. This group includes the samples from the lower gabbro taken just north of Coverack (NAS119). Figure 49 shows members of this group as having relatively high concentrations (compared with the other gabbroic groups) of SiO_2, K_2O, Ba, Rb and Zr, together with low concentrations of Fe_2O_3, MgO, CaO, MnO, P_2O_5, Co, Cu, V and Zn. These levels are compatible with the suggested position of this group low in the differentiation sequence.

c) Group 3. A notable feature of this group is the predominance of samples collected from the Trelan area. They characteristically show high levels of TiO_2 (mean = 4.01%) and V (mean = 446ppm). Additionally a strong correlation exists between TiO_2 and/or V with Fe_2O_3, Sc and Ga. Moderately high concentrations of P_2O_5 and Co may also he seen in Figure 49. A strong negative correlation exists between TiO_2 and/or V with SiO_2, Ba and Zr. The name "Trelan gabbro", slightly modified after Smith and Leake (1984), is given to members of this distinctive group during the remainder of this work.

d) Group 4. This group includes most of the orientation survey samples from the upper gabbro (NAS118 and NAS129). In comparison with Group 2 (lower gabbro), samples within this group possess high levels of Al_2O_3 and CaO together with such elements as MgO, Na_2O, Cr and Ni. They also have lower concentrations of K_2O, Ba, Rb, Y and Zr. This again suggests this group exists at a relatively high level in the differentiation sequence.

e) Group 5. This is the smallest of the five groups and contains none of the original orientation survey data. It does, however, include all the gabbroic samples from the traverse line at Carrick Luz (NAS119, S.1321 to 1329) and many of the samples from the Trembraze line (NAS190, S.1091 to 1105). The former is an area where a gabbro dyke has been stongly deformed (locally mylonitic). The Trembraze line crosses the supposed outcrop of the Treleague quartzite northwest of St.Keverne. This is also recognized as an area which has undergone relatively intense deformation. Looking at the other sample names held in this group it can be seen that many of the others also come from areas close to lithological or tectonic contacts. These include sections from:

i) NAS139; northeast of St.Keverne (S.541, 544-545) which are close to the supposed boundary of the gabbro and upper Landewednack hornblende schist. This boundary has been described by Bromley (1975) as a low angle thrust.

ii) NAS147; southern part of the Trelan Gate line (BXS3044-42 and S.1184) close to the basic-ultrabasic contact. In the field these samples appeared distinctly different and were comprised of very fine cleavage flakes of either mica or pyroxene.

iii) NAS176; east of Tregaminion Farm (S.780-82) close to the supposed contact with the Old Lizard Head Series in the northeast of the Complex.

iv) NAS184; Coverack (S.947-48) at the contact between the gabbro and the ultrabasic.

v) NAS185; southwest of Gwenter (S.952, 954-55) near to the tectonic contact between the gabbro and the ultrabasic.

vi) NAS189; west of Trelan (S.1040-42, 1044) as v).

The close proximity to the ultrabasic in many of these cases might explain the relatively high levels of MgO, Co, Cr and Ni together with low concentrations of Al_2O_3 and Ga shown by Figure 49.

On the basis of the above information it is suggested that this group may represent zones of deformation. It is believed that this change in geochemistry is a direct result of the deformation.

K-means clustering of the ultrabasic samples

A similar approach using option "O" of KMN was taken for 264 samples which were obviously ultrabasic in composition. Figure 52 summarizes the results from the exercise. The break in slope of the graph occurs at 3 cluster groups and upon selection of this number, the three groups shown in Figure 52 were formed. The intention of this process was that these cluster groups should then become the basis for the identification of all the ultrabasic samples.

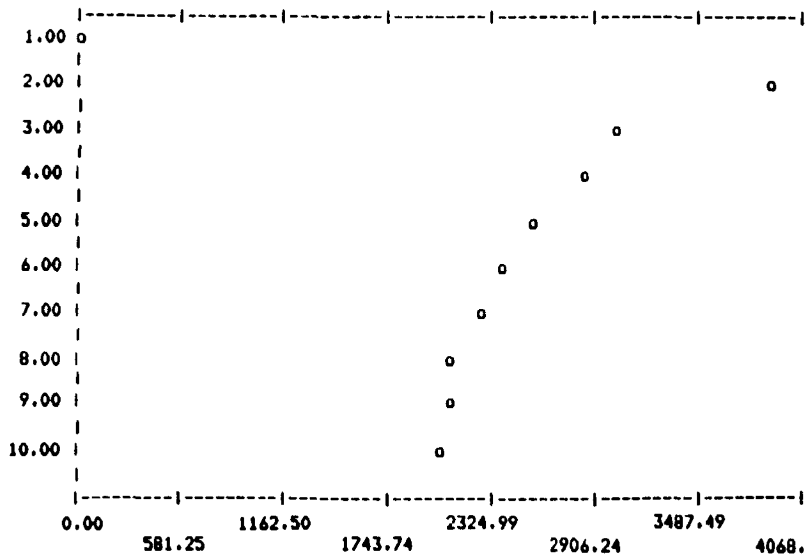
a) Group 1. This is the largest of the three groups and includes most of the orientation survey samples collected from the harzburgitic peridotite (NAS120 and NAS128). No samples from the power auger programme are included in this group.

b) Groups 2 and 3. Cluster group 2 includes all the samples which were collected from the lherzolitic peridotite at Kynance Cove (NAS125). There is, however, no clear separation of any traverse lines into one particular cluster group. Additionally the cluster centroids for the two groups are

```
Non-hierachical convergent K-means cluster analysis
***************************************************
Files read: SYO:UBC.RAW

Variables used: SI02     AL203    TI02     FE203    MGO      CAO      NA20     K20      MNO      P205     BA
                CO       CR       CU       GA       NI       RB       SR       V        Y        ZN       ZR

X-axis: No.of cluster groups selected
```




```
Seed points selected by FSEED
S-76     S-228    S-934
Min distance between seed points set at 100.00
6 iterations required for convergence
Summed deviation about seed points =    0.30040989E+04

Cluster 1 contains125 data units
Centroid coordinates
  0.6792E+02  0.1255E+02  0.1006E+01  0.7897E+01  0.3308E+01  0.3006E+01  0.5206E+00  0.1687E+01  0.1240E+00  0.9753E-01  0.3286E+03
  0.5202E+02  0.9052E+03  0.1677E+02  0.1058E+02  0.3830E+03  0.5993E+02  0.8776E+02  0.7106E+02  0.2506E+02  0.6234E+02  0.3455E+03
Membership list: Seed point (if used): S-76
S-77    S-80    S-81    S-82    S-83    S-84    S-85    S-86    S-94    S-95    S-96    S-97    S-98    S-99    S-305   S-308
S-309   S-310   S-311   S-312   S-313   S-314   S-315   S-318   S-319   S-320   S-321   S-322   S-323   S-324   S-325   S-326
S-1315  S-1314  S-1313  S-1312  S-1311  S-1310  S-1309  S-1307  S-1306  S-1305  S-1304  S-1303  S-1301  S-1185  S-1189  S-1192
S-1193  S-1197  S-1199  S-1200  S-1202  S-708   S-706   S-705   S-704   S-703   S-702   S-700   S-699   S-698   S-992   S-995
S-997   S-998   S-999   S-1000  S-1002  S-1003  S-1004  S-719   S-718   S-717   S-716   S-715   S-714   S-712   S-1149  S-903
S-899   S-898   S-896   S-895   S-893   S-1011  S-1012  S-1013  S-1175  S-1179  S-1180  S-1181  S-944   S-946   S-956   S-958
S-961   S-962   S-963   S-1048  S-1049  S-1054  S-1055  S-1056  S-1057  S-1058  S-1059  S-1207  S-1209  S-1211  S-1212  S-1217
S-1218  S-1220  S-1222  S-1223  S-1274  S-1275  S-1276  S-1277  S-1278  S-1282  S-1330  S-1331

Cluster 2 contains 70 data units
Centroid coordinates
  0.5249E+02  0.7580E+01  0.8214E+00  0.1168E+02  0.1772E+02  0.3863E+01  0.2568E+00  0.7533E+00  0.2596E+00  0.1653E+00  0.1668E+03
  0.1096E+03  0.2414E+04  0.2555E+02  0.8063E+01  0.1311E+04  0.2313E+02  0.6956E+02  0.1032E+03  0.1487E+02  0.1228E+03  0.1250E+03
Membership list: Seed point (if used): S-228
BXS3048 S-900   S-937   S-90    S-206   S-207   S-208   S-209   S-210   S-211   S-213   S-214   S-215   S-216   S-217   S-219
S-220   S-222   S-224   S-225   S-226   S-227   S-230   BXS3099 BXS3097 BXS3058 BXS3057 BXS3055 BXS3053 BXS3051 BXS3049 BXS3046
BXS3045 BXS4031 BXS4032 BXS4034 BXS4035 BXS4036 BXS4037 S-991   S-993   S-996   S-713   S-1145  S-1148  S-1150  S-894   S-892
S-940   S-941   S-942   S-943   S-959   S-960   S-1047  S-1051  S-1052  S-1053  S-1210  S-1215  S-1336  S-1335  S-1334  S-1333
S-1332  S-1317  S-1318  S-1319  S-1320

Cluster 3 contains 69 data units
Centroid coordinates
  0.5406E+02  0.1273E+02  0.1875E+01  0.1263E+02  0.7926E+01  0.5192E+01  0.5924E+00  0.8580E+00  0.2096E+00  0.2486E+00  0.1633E+03
  0.7625E+02  0.1247E+04  0.3429E+02  0.1342E+02  0.6842E+03  0.2763E+02  0.1233E+03  0.1894E+03  0.2282E+02  0.8924E+02  0.1671E+03
Membership list: Seed point (if used): S-934
S-1044  S-1316  BXS3054 BXS4030 S-1300  S-939   S-938   S-936   S-935   S-933   S-932   S-931   S-930   S-928   S-927   BXS3098
BXS3096 BXS3095 BXS3092 BXS3075 BXS3073 BXS3124 BXS3071 BXS3070 BXS3069 BXS3066 BXS3065 BXS3064 BXS3059 BXS3056 BXS3052 BXS3044
S-1184  BXS4029 BXS4033 S-994   S-1005  S-1006  S-854   S-1143  S-1144  S-1146  S-1151  S-1152  S-1154  S-1155  S-837   S-839
S-1008  S-1009  S-1010  S-1014  S-1015  S-1016  S-1017  S-1020  S-877   S-947   S-948   S-949   S-950   S-954   S-955   S-1040
S-1043  S-1045  S-1046  S-1050
```

Figure 52. Summary of results of reclustering of ultrabasic data by K-means algorithm.

generally similar. Due to the above facts it was decided to run the KMN program a second time specifying only two cluster groups (option "C" in KMN). The result of this was the merging of cluster groups 2 and 3.
It was the two cluster centroids (1 and 2+3) from this run which were used in the construction of the seed file. This new seed file would accompany the new IDN-file (described later) in identifying all the samples collected from the Lizard Complex.

The geochemistry of the two units is similar to that described in Chapter 6.2 for the lherzolitic and harzburgitic peridotites. The lherzolitic component again appears to be the more extreme with larger elemental ranges. It will be seen, however, from Figure 49 that the lherzolitic peridotite characteristically has significantly lower levels SiO_2, K_2O, Ba, Rb and Zr.

<u>Recognition of the ultrabasic/Kennack gneiss group</u>

Earlier in Chapter 6.2 the initial problems of attempting to sample the Kennack gneiss were discussed. During sampling in inland areas where the Kennack gneiss is supposed to outcrop, it became apparent from studying the analytical data that many samples showed both high levels of MgO, Co, Cr and Ni. The same samples also show significantly high levels of Sr together with less significant increases in the levels of K2O, Ba and Rb . For this reason it was decided to create a new unit which would describe any soils developed over the ultrabasic but which obviously had a strong Kennack gneiss influence. Any such group could be used to identify those areas where the Kennack gneiss was present close to the surface. In this instance it is considered that the more mobile elements such as Sr, together with such elements as the halogens, would infiltrate the ultrabasic rocks.

The training set describing this unit were the samples taken from the coastal traverse near to Kennack Sands (NAS123) which was referred to earlier in Chapter 6.2.1. The single element plots in Figure 49 describe the chemistry of this group in more detail. The data from this traverse line were used in the construction of the new IDN-file.

6.4.2 Identification scheme - Model 2

Due to the recognition of new lithological units a revised identification scheme was required. This is shown both as a flow chart and a computer listing in Figure 53. The parameters controlling the identification of the various units are generally very similar to those of the previous model although the 95 percentile values have been recalculated. This used the same approach as in Chapter 6.2.3.

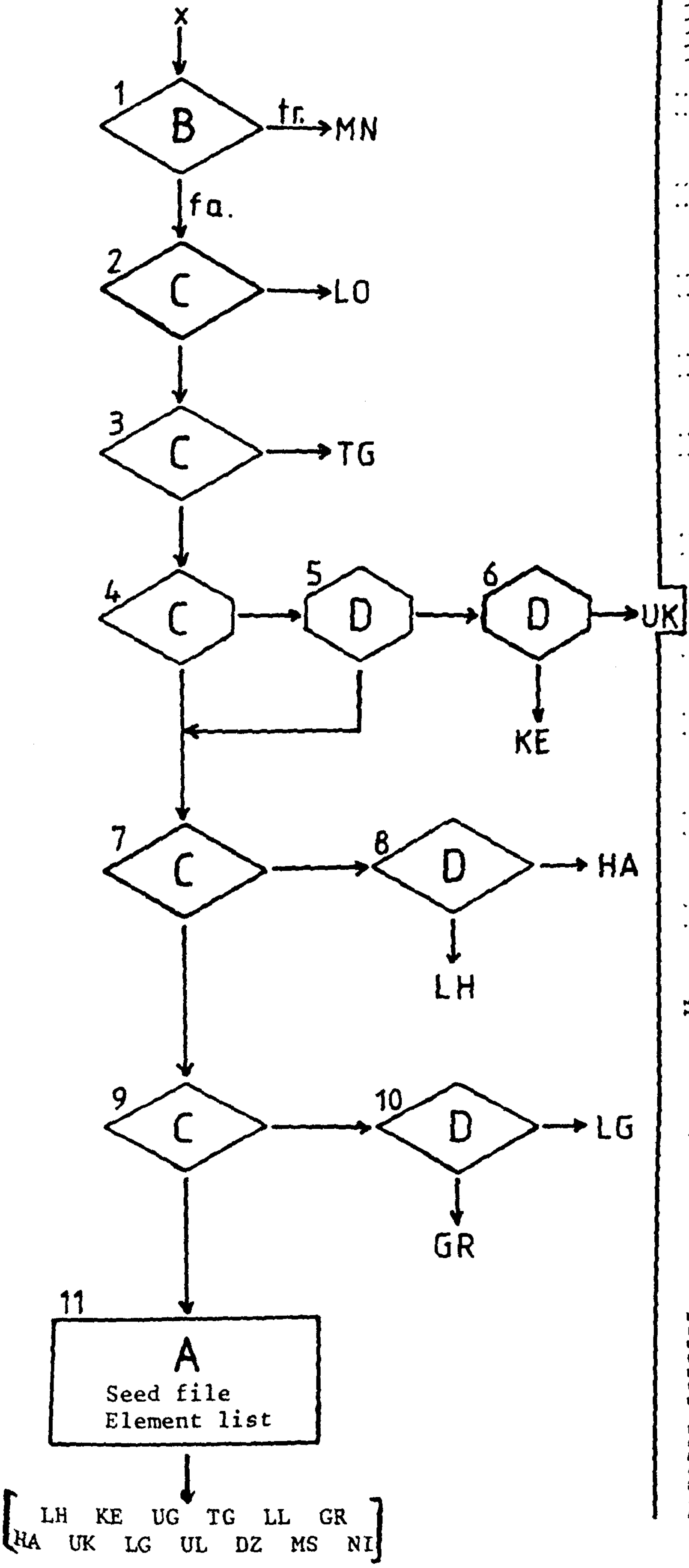
As in the earlier model many of the samples belonging to the most easily distinguished groups are identified at an early stage. The identification scheme controlled by the program IDN first isolates any mineralized samples. This now includes Ba in the list of elements. Following this any loess samples are isolated using the same parameters as used earlier during the orientation survey.

A Modified k-means technique

B Simple discriminant (At least one condition true)

C Simple discriminant (All conditions true)

D Linear discriminant function




```
File:   SYO:NASX2.IDN
Identication            Max distance from centroi
 codes                       (KMEAN option)
  - 1        HA              22.500
  - 2        LH              34.700
  - 3        UK              13.000
  - 4        KE              11.500
  - 5        LG              18.180
  - 6        UG              17.280
  - 7        UL              17.000
  - 8        TG              21.200
  - 9        DZ              20.900
  -10        LL               5.000
  -11        MS               8.500
  -12        GR               7.000
  -13        LD               0.000
  -14        MN               0.000
  -15        NI               0.000

      +++++++  1 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   2           4        -14      2
..Element..   ..RO..   ......Value...
  BA            GT         500.000
  CU            GT          90.000
  PB            GT          80.000
  ZN            GT         360.000

      +++++++  2 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   3           4        -13      3
..Element..   ..RO..   ......Value...
  MGO           LE           0.010
  ZR            GT         400.000
  CAO           LE           2.700
  CR            LE         200.000

      +++++++  3 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   3           3         -8      4
..Element..   ..RO..   ......Value...
  V             GT         350.000
  TIO2          GT           3.000
  CR            LE         800.000

      +++++++  4 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   3           3          5      7
..Element..   ..RO..   ......Value...
  V             LE         100.000
  Y             LE          20.000
  BA            GT         165.000

      +++++++  5 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   4           5          6      7
..Element..   ..RO..   ......Value...
  SIO2                      -0.105
  RB                         0.309
  SR                         0.062
  ZR                        -0.049
                GT          10.244

      +++++++  6 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   4           5         -3     -4
..Element..   ..RO..   ......Value...
  AL2O3                      4.995
  MGO                       -3.803
  P2O5                     -98.108
  NI                         0.056
                GT         -91.396

      +++++++  7 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   3           3          8      9
..Element..   ..RO..   ......Value...
  CR            GT        1140.000
  NI            GT         550.000
  SR            LE         125.000

      +++++++  8 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   4           5         -1     -9
..Element..   ..RO..   ......Value...
  SIO2                       0.531
  CAO                       -0.996
  NA                         0.012
  RB                         0.082
                GT          34.748

      +++++++  9 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   3           4         10     11
..Element..   ..RO..   ......Value...
  MGO           LE           0.010
  CR            LE         335.000
  V             LE         100.000
  BA            GT         210.000

      +++++++ 10 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   4           5         -5    -12
..Element..   ..RO..   ......Value...
  AL2O3                     -3.473
  NA2O                       7.497
  SR                         0.057
  Y                          0.587
                GT         -36.534

      +++++++ 11 +++++++
NTYPE: 1             Id.code for cluster nr 1:  -1
NCOND:23             Id.code for cluster nr 2:  -2
                     Id.code for cluster nr 3:  -3
                     Id.code for cluster nr 4:  -4
                     Id.code for cluster nr 5:  -5
                     Id.code for cluster nr 6:  -6
                     Id.code for cluster nr 7:  -7
                     Id.code for cluster nr 8:  -8
                     Id.code for cluster nr 9:  -9
                     Id.code for cluster nr10: -10
                     Id.code for cluster nr11: -11
                     Id.code for cluster nr12: -12

 ..Element..     ..Seed filename..
   SIO2            SEEDX2
   AL2O3
   TIO2
   FE2O3

   MGO             P2O5            BA            Y
   CAO             NA              NI            ZN
   NA2O            CO              RB            ZR
   K2O             CR              SR
   MNO             CU              V

      +++++++ 12 +++++++
..NTYPE..  ..NCOND..  ..TR..  ..FA..
   99          0          0      0

 HA  .....  Harzburgitic peridotite
 LH  .....  Lherzolitic peridotite
 UK  .....  Ultrabasic + Kennack gneiss
 KE  .....  Kennack gneiss
 LG  .....  Lower gabbro
 UG  .....  Upper gabbro
 UL  .....  Upper Landewednack schist
 TG  .....  Trelan gabbro
 DZ  .....  Deformation zones
 LL  .....  Lower Landewednack schist
 MS  .....  Old Lizard Head Series
 GR  .....  Crousa gabbro
 LO  .....  Loess
 MN  .....  Mineralized sample
 NI  .....  Not identified
```

Figure 53. Identification scheme (Model 2) used in identifying all shallow soil samples collected during the Lizard project.

Any soil samples which have developed over the Trelan gabbro are then identified. This uses TiO_2 and V together with Cr:

V > 350ppm

TiO_2 > 3.00%

Cr < 800ppm Simple discriminant

All conditions must be true.

The latter removes any possibility of overlap with soils which may have developed over the ultrabasic.

The next stage is the recognition of any samples associated with the Kennack gneiss. The identification of samples with such an affiliation takes place in two stages. This uses both a simple discriminant and a linear discriminant function (LDF):

V < 100ppm

Y < 20ppm

Ba > 165ppm Simple discriminant

All conditions must be true.

SiO_2 ... -0.105

Rb ... 0.309

Sr ... 0.062

Zr ... -0.049 D_o = 10.244

Not U/b(Ke) < D_o < U/b(Ke).

The manner of calculation of the LDF remains the same as that used during the orientation survey. If the response to both of these sets of parameters is "true" then a second LDF is used to discriminate between the ultrabasic (including a Kennack gneiss component) and the Kennack gneiss:

Al_2O_3 ... -4.935

MgO ... -3.803

P_2O_5 ... -98.108

Ni ... 0.056 D_o = -91.396

U/b(Ke) < D_o < Kenn.Gn.

An attempt is then made to identify some of the ultrabasic material. A similar sieving technique to that described above is again used. A simple discriminant first identifies an individual sample as being ultrabasic in composition:

Cr > 1140ppm

Ni > 550ppm

Sr < 125ppm Simple discriminant

All conditions must be true.

Sr is used in this instance to remove the possibility of overlap with any unrecognized component with a Kennack gneiss component. An LDF is then used to discriminate between the lherzolitic and harzburgitic peridotites:

SiO_2 ... 0.531

CaO ... -0.996

Ba ... 0.012

Rb ... 0.082 D_o = 34.768

Lherz. < D_o < Harzb.

Some members of the Crousa gravels and the lower gabbro are next identified. Although this stage was designed primarily to identify soils developed over the gravels, a small degree of overlap tended to include samples from the lower gabbro. For this reason identification of these groups takes place in two stages (Simple discriminant followed by an LDF):

MgO	< 0.01%	
Cr	< 335ppm	
V	< 100ppm	
Ba	> 210ppm	Simple discriminant
		All conditions must be true.

Al2O3 ...	-3.473	
Na2O ...	7.497	
Sr ...	0.057	
Y ...	0.587	$D_o = -36.534$
		Gravel < D_o < L.Gabb.

The final stage of the identification process is the use of the modified K-means technique. This will identify all the groups with the exception of the loess (LO) and mineralized samples (MN). It uses 22 elements in total and a seed file (SEEDX2.RAW) is listed in Table 16.

The use of the option "S" in the program KMN on the seed file SEEDX4.RAW allowed for an assessment to be made of the ease of distinguishing the various groups. This approach was described earlier in some detail in Chapter 6.2.2 and Table 17 provides a summary of the results. Although the multivariate nature of the data is studied the results tend to be confirmed

Var.\ID:	HA	LH	UK	KE	LG	UG	UL	TG	DZ	LL	MS	GR
SIO2	67.92	53.27	55.08	54.49	65.53	55.15	55.71	48.65	55.04	49.85	53.27	65.43
AL2O3	12.55	10.14	8.60	12.96	14.62	18.85	16.26	15.36	13.34	13.16	14.30	19.66
TIO2	1.01	1.34	0.98	1.36	1.65	1.52	2.04	4.01	1.57	2.44	1.75	1.12
FE2O3	7.90	12.16	8.86	7.90	7.30	9.92	10.10	15.25	9.59	12.99	10.10	7.70
MGO	3.31	12.86	14.96	8.28	1.23	4.14	3.98	2.42	8.03	5.99	6.54	0.03
CAO	3.01	4.52	3.83	3.74	4.23	6.90	6.06	6.01	5.76	7.75	5.69	3.62
NA2O	0.52	0.42	0.71	1.27	0.83	0.88	0.51	1.26	0.48	1.14	1.08	0.48
K2O	1.69	0.81	1.30	2.47	1.51	0.74	1.13	0.86	1.00	1.07	2.09	1.36
MNO	0.12	0.23	0.19	0.14	0.10	0.15	0.22	0.17	0.18	0.21	0.23	0.03
P2O5	0.10	0.21	0.23	0.42	0.18	0.28	0.50	0.40	0.33	0.45	0.38	0.15
BA	329	165	248	285	264	137	188	111	146	108	219	274
CO	52	93	75	39	24	44	41	56	52	46	32	15
CR	905	1835	1635	593	238	375	200	295	721	318	197	203
CU	17	30	24	24	18	40	43	36	34	68	41	19
GA	11	11	11	14	13	16	17	19	13	18	18	11
NI	383	1000	990	369	91	182	98	177	423	119	70	66
RB	60	25	52	80	53	29	42	27	35	32	59	53
SR	88	96	174	203	132	167	120	192	121	161	174	67
V	71	146	73	78	120	151	162	446	133	222	134	71
Y	25	19	16	16	25	22	32	28	25	37	26	17
ZN	62	106	98	106	46	69	111	82	108	126	119	37
ZR	346	146	152	153	324	148	224	155	170	198	185	258

KEY

LH ... Lherzoltic peridotite
HA ... Harzburgitic peridotite
UK ... Ultrabasic + Kennack gneiss component
KE ... Kennack gneiss
LG ... Lower gabbro
UG ... Upper gabbro
UL ... Upper Landewednack hornblende schist
TG ... Trelan gabbro
DZ ... Deformation zones
LL ... Lower Landewednack hornblende schist
MS ... Mica schist (Old Lizard Head Series)
GR ... Crousa gravel

Table 16. Seed-file (NASX2.RAW) used by identification scheme (Model 2; NASX2.IDN).

File read; SY0:SEEDX4 [illegible] (seed file used in second IDN model).

Using all 22 variables as described in Figure 53b.

Lherz. (34.70)	53.72*						
U/b(Ke) (13.00)	38.91	13.69**					
Kn.Gn. (11.50)	42.95	63.63	29.45				
L.Gabb. (18.18)	10.63**	69.30	51.53	35.11			
U.Gabb. (17.28)	51.53	44.75	45.45	41.73	29.95*		
U.Land. (17.00)	47.93	49.13	52.13	41.72	32.96*	15.54**	
T.Gabb. (21.20)	100.32	72.12	82.69	71.29	69.17	30.33*	34.43
Def.Zn. (20.90)	35.67*	19.14**	22.55*	34.98	30.34*	11.93**	10.60**
L.Land. (5.00)	90.88	63.19	71.50	63.37	67.26	26.18	16.19*
OLHS (8.50)	49.70	57.02	42.18	16.23*	33.51	21.53*	12.73**
Gravel (7.00)	19.18*	81.67	69.00	52.26	11.08**	38.61	49.13
	Harzb. (22.50)	Lherz. (34.70)	U/b(Ke) (13.00)	Kn.Gn. (11.50)	L.Gabb. (18.18)	U.Gabb. (17.28)	U.Land. (17.00)

Def.Zn. (20.90)	41.82*			
L.Land. (5.00)	23.23*	26.89		
OLHS (8.50)	38.96	19.34*	21.64	
Gravel (7.00)	95.98	42.58	97.60	56.06
	T.Gabb. (21.20)	Def.Zn. (20.90)	L.Land. (5.00)	OLHS (8.50)

** .... Significant degree of overlap between two groups.
(Based on combined 95 percentile values for groups, Figure 53b & shown in brackets).

* ..... Moderate degree of overlap between two groups.

Harzb. ..... Harzbursitic peridotite
Lherz. ..... Lherzolitic peridotite
U/b(Ke) .... Ultrabasic + Kennack gneiss
Kn.Gn. ..... Kennack gneiss
L.Gabb. .... Lower gabbro
U.Gabb. .... Upper gabbro
U.Land. .... Upper Landewednack schist
T.Gabb. .... Trelan gabbro
Def.Zn. .... Deformation zones
L.Land. .... Lower Landewednack schist
OLHS .... Old Lizard Head Series
Gravel ..... Crousa gabbro

Table 17. Standardized distances between cluster centroids used by Model 2.

by a visual examination of the single element graphs shown in Figure 44 and Figure 49 (Chapter 6.2).

The groups which in multivariate space show some degree of overlap are (from the combination with the highest degree of overlap first):

i) Lower gabbro / Harzburgitic peridotite

ii) Deformation group (DZ) / Upper Landewednack schists

iii) Ultrabasic (Kenn.Gn) / Lherzolitic peridotite

iv) Deformation group (DZ) / Upper gabbro

v) Deformation group (DZ) / Lherzolitic peridotite

vi) Crousa gravel / Lower gabbro

vii) Upper Landewednack schists / Upper gabbro

viii) Old Lizard Head Series / Upper Landewednack schists

The combination together with the latter three were noted as having significant overlapping relationships during the orientation survey. The remaining combinations involve some of the new groups. It is considered reasonable that the ultrabasic (+ Kennack component) and the lherzolitic peridotite should be difficult to distinguish as the former is in fact the lherzolitic material with an overprinting effect due to near-surface Kennack gneiss. The group which has been described as possibly representing deformation zones is involved in the three other combinations. It is again likely that this group should be difficult to isolate as it is comprised of mixtures of the upper Landewednack schists, upper gabbro and peridotite involved in complex deformation zones. It will be seen from Table 17 that most combinations (except the gravels and possibly the Kennack gneiss and lower Landewednack schists) involving this group show a degree of overlap.

The groups which appear to be most easily distinguish are the Crousa gravels (not against the harzburgitic peridotite or lower gabbro); the lower Landewednack schists (except against the upper Landewednack schists and the Trelan gabbro), the Kennack gneiss (not against the Old Lizard Head Series from which it was suggested earlier it may be derived); and the Trelan gabbro (except against the upper gabbro, those samples from deformation zones and the lower Landewednack schists).

Soil mapping

Following the development of the revised IDN-file (NASX2.IDN) all the shallow soil samples collected during the project were processed by the program IDN. The results of this exercise are presented in three maps. Figure 54a shows the gabbroic groups (lower and upper Crousa gabbro, upper Landewednack schists, Trelan gabbro and the deformation zone samples), the Crousa gravels and any samples which showed high base metal concentrations (Ba, Cu, Pb, Zn). Figure 54b shows the inset map of those samples analyzed during the power auger programme in the Trelan and Traboe area. Finally Figure 54c shows the ultrabasic groups (lherzolitic and harzburgitic peridotites and the ultrabasic/Kennack gneiss group) together with those samples identified as being members of the Kennack gneiss, Old Lizard Head Series, lower Landewednack schists and loess groups. Samples which were assigned as "Not Identified"

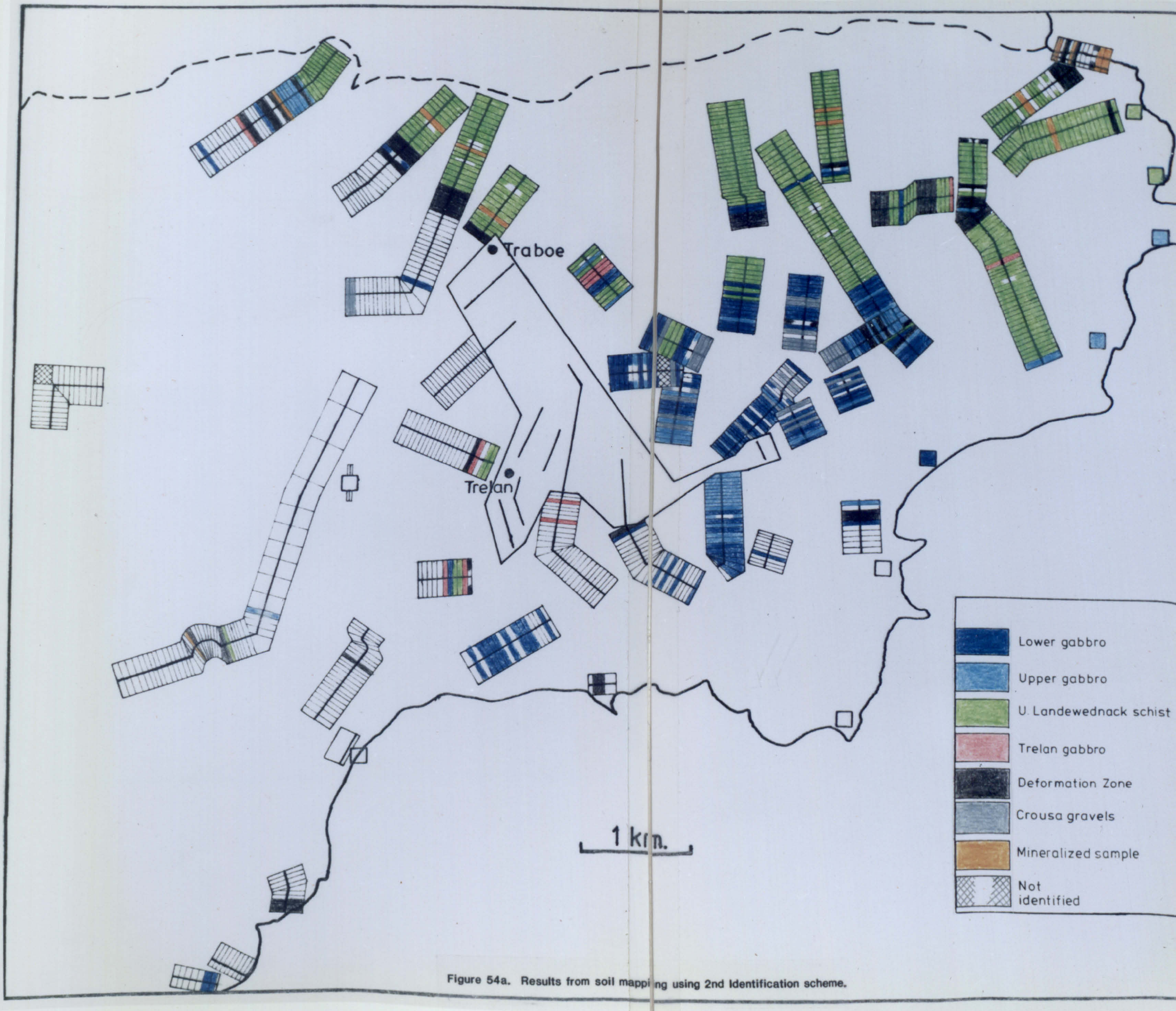


Figure 54a. Results from soil mapping using 2nd Identification scheme.

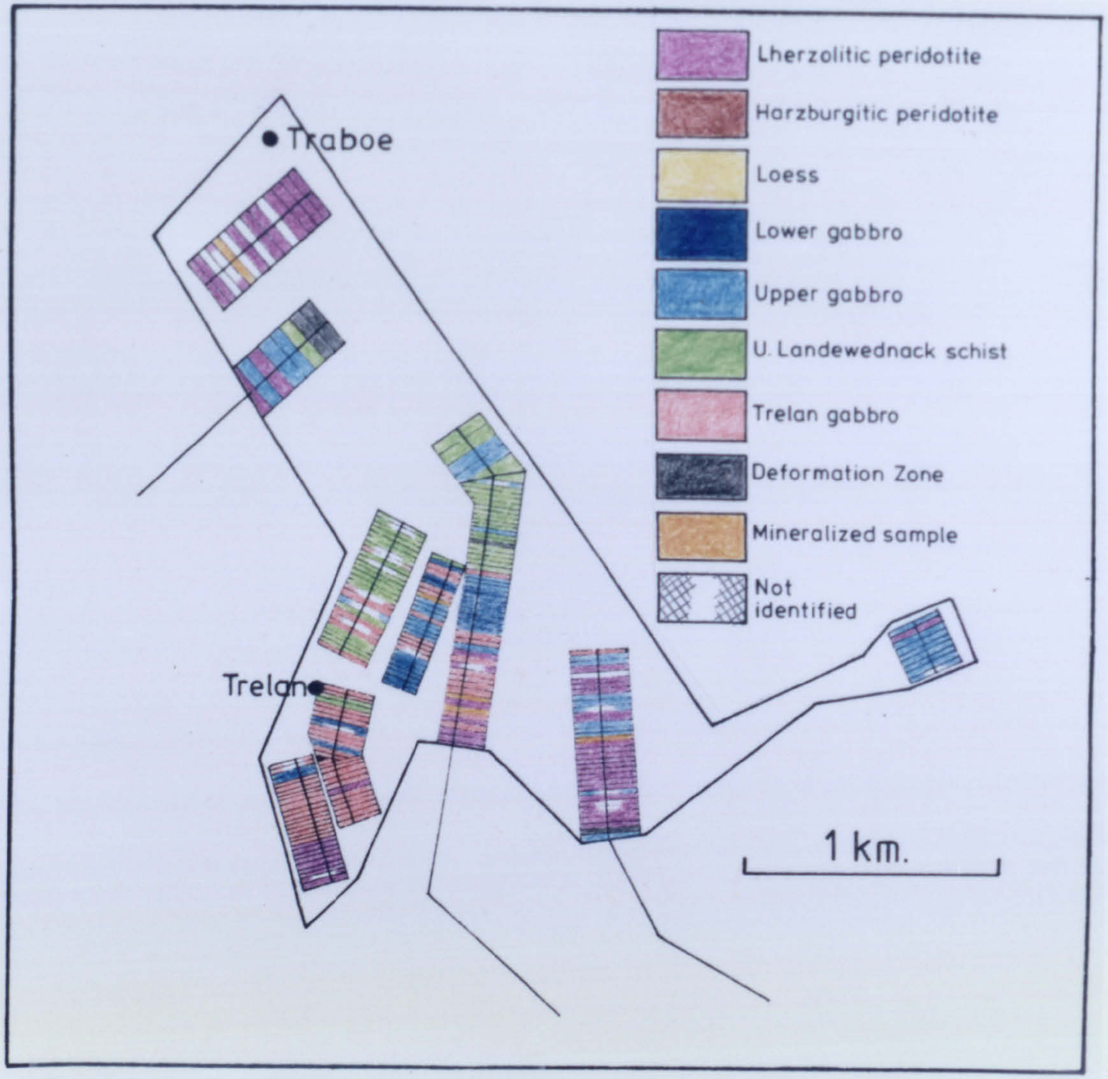


Figure 54b. Results from power augering programme.

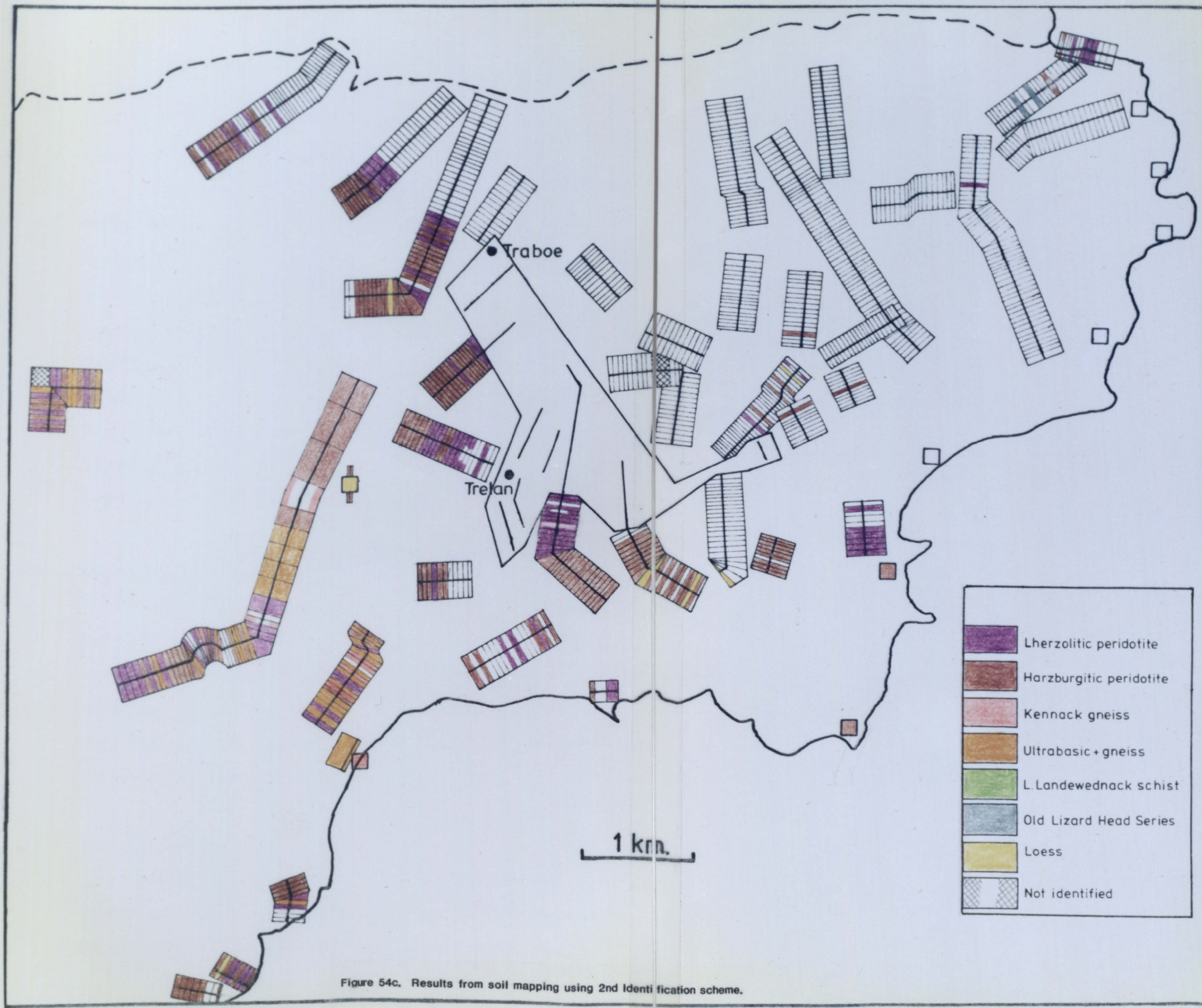


Figure 54c. Results from soil mapping using 2nd Identification scheme.

are included in all the maps although a colour code identifying the group to which they are most similar is provided. No attempt is made in this section to interpret the results presented in these maps.

In conclusion it is considered that the use of an expert system as described in Chapter 5.4 was justified. It allowed for a large number of geochemical measurements to be studied and for a provisional identification to be made for each unknown. This was accomplished far more quickly than could be done by a user by eye. Following the creation of the second identification scheme it took less than 90 minutes to identify 1463 samples. Additionally it can be easily modified for other tasks (these need not necessarily be connected with residual soil geochemistry).

6.5 Limitations of mapping technique

It is intended in this section to highlight some of the additional work which complimented the mapping process. This includes a discussion relating to the potential mapping resolution of this technique and the potentially serious problem arising as a result of mixing of soils developed over the different units.

6.5.1 Mixing of soils

Studying the maps produced in the previous section (Fig.54 a,b,c) many inconsistencies in the identification of the units may be seen when the known geology of the area is taken into account. This is particularly relevant in the areas adjacent to the Crousa gravels. It is suggested that due to the close proximity of the gravels in this area there may be some intermixing of residual soil with gravel-derived material. It was noted in Chapter 4.4 that some of the soils in the Trelan area appeared to show a gravel-derived component (relatively low MgO together with high Ba and Zr).

In addition to the above inconsistency the ultrabasic rocks to the southwest of Traboe is identified by the identification scheme as being predominantly harzburgitic. Conversely the supposed harzburgitic to the south and southeast of Trelan is identified as largely lherzolitic in composition. Both of these suggested identities differ from the views of Kirby (1978a), who suggested that the bulk of the ultrabasic between Carrick Luz and Coverack was harzburgitic, and from those of Green (1964), who described the Goonhilly Down ultrabasic body as lherzolitic.

On the basis of the above observations it was decided to artificially mix and identify the average soil compositions of the various units. This calculation was based on the cluster centroids (or vector means) of the various groups as used by the modified K-means technique (SEEDX2.RAW; Table 16). It additionally used the vector mean of the loess group (not used in the modified K-means part of IDN). The calculation was achieved by the use of the program MIX (Appendix A). This program was written to combine the vector means of all the various units in a variety of proportions (1/1, 2/1, 1/2, 3/1, 1/3). A Direct Access file structure was used to enable rapid reading of the various combinations of vector means. The results of this calculation were then sent to a new file (MIX.RAW) for further interpretation.

The file MIX.RAW was processed by the identification scheme described in the last section (NASX1.IDN). In most instances the major component of the mixed groups was identified (eg. 3UG/1LG = UG identified). A number of combinations, however, resulted in either a different group or the minor component being identified. These are summarized in Figure 55. For ease of interpretation the results are sorted on the basis of the identification of the combination. Whilst in many instances the combination is relatively unlikely to occur in the study area, several are of considerable importance in the interpretation of the results shown in the last section.

The most significant effects of mixing may be seen to occur when the exotic material (ie. loess- and gravel-derived) is mixed with residual soils. The groups representing harzburgitic peridotite, the lower gabbro and deformation zones are most easily produced by combining other combinations of groups.

The harzburgitic peridotite is in most cases produced when one of the components is the loess. The other component is most frequently another ultrabasic unit or a soil developed close to a deformation zone. Additionally it may be a soil developed over the Kennack gneiss or over the lower gabbro.

Summary of IDN results on MIX.RAW

a) Neither component recognized

MIX.CLD/OUTPUT:A.CLD U1$

```
11   U4/LO   ....... U1
11   UK/LO   ....... U1
11  2UK/LO   ....... U1
11  2G1/U4   ....... U1
11  2LO/U4   ....... U1
11  2LO/UK   ....... U1
11  2LO/KE   ....... U1
11  2LO/DZ   ....... U1
11  3LO/U4   ....... U1
11  3LO/UK   ....... U1
11  3LO/KE   ....... U1
11  3LO/G1   ....... U1
11  3LO/DZ   ....... U1
```

MIX.CLD/OUTPUT:B.LST U4$
None

MIX.CLD/OUTPUT:C.LST UK$

```
11   U4/KE   ....... UK
```

MIX.CLD/OUTPUT:D.LST KE$
None

MIX.CLD/OUTPUT:E.LST G1$

```
11   U1/G2   ....... G1
11   G2/LO   ....... G1
11   G3/GR   ....... G1
11   G3/LO   ....... G1
11   VT/LO   ....... G1
11   DZ/LO   ....... G1
11   LL/LO   ....... G1
11   MS/LO   ....... G1
11   GR/LO   ....... G1
11  2U1/VT   ....... G1
11  2G2/LO   ....... G1
11  2MS/LO   ....... G1
11  2GR/G2   ....... G1
11  2LO/G2   ....... G1
11  2GR/G3   ....... G1
11  2LO/G3   ....... G1
11  2GR/VT   ....... G1
11  2LO/VT   ....... G1
11  2GR/DZ   ....... G1
11  2LO/LL   ....... G1
11  2LO/MS   ....... G1
11  3LO/G2   ....... G1
11  3GR/G3   ....... G1
11  3LO/G3   ....... G1
11  3GR/VT   ....... G1
11  3LO/VT   ....... G1
11  3LO/LL   ....... G1
11  3LO/MS   ....... G1
```

MIX.CLD/OUTPUT:F.LST G2$

```
11   G1/VT   ....... G2
11   VT/GR   ....... G2
```

MIX.CLD/OUTPUT:G.LST G3$

```
11   LL/MS   ....... G3
11  2LL/LO   ....... G3
11  2LL/KE   ....... G3
11  3LL/LO   ....... G3
11  3LL/KE   ....... G3
```

MIX.CLD/OUTPUT:H.LST VT$
None

MIX.CLD/OUTPUT:I.LST DZ$

```
11   U1/G3   ....... DZ
11   U1/VT   ....... DZ
11   U4/G1   ....... DZ
11   U4/G2   ....... DZ
11   U4/G3   ....... DZ
11   U4/LL   ....... DZ
11   U4/MS   ....... DZ
11   UK/LL   ....... DZ
11   UK/MS   ....... DZ
11  2UK/LL   ....... DZ
11  2G2/U4   ....... DZ
11  2G3/U4   ....... DZ
11  2LL/U4   ....... DZ
11  2MS/U4   ....... DZ
11  2LL/UK   ....... DZ
11  2MS/UK   ....... DZ
11  3G3/U4   ....... DZ
11  3LL/U4   ....... DZ
11  3MS/U4   ....... DZ
11  3LL/UK   ....... DZ
```

MIX.CLD/OUTPUT:J.LST LL$
None

MIX.CLD/OUTPUT:K.LST MS$

```
11   KE/LL   ....... MS
11  2KE/LL   ....... MS
```

MIX.CLD/OUTPUT:L.LST GR$
None

MIX.CLD/OUTPUT:M.LST LO$
None

b) Minor component identified

```
11  2LO/U1   ....... U1
11  3LO/U1   ....... U1

11  2LO/G1   ....... G1

10  2LO/GR   ....... GR
10  3LO/GR   ....... GR
```

Figure 55. Summary of results from identification scheme of artificial mixing of average soil compositions.

The only exception to above is the mixing of two parts lower gabbro with one part lherzolitic peridotite.

The lower gabbro is most frequently produced when one of the components is the loess or Crousa gravel. In both instances the other component is usually another part of the gabbro which exists higher in the differentiation sequence. Additionally the lower Landewednack hornblende schists and Old Lizard Head Series (mica schists) are sometimes involved. Other cases when the lower gabbro is identified involve the mixing of harzburgitic peridotite with the upper gabbro or the Trelan gabbro.

The identification of members of the deformation zone group (DZ) always involves an ultrabasic component. The second group may include any other group except the Crousa gravel or the Kennack gneiss. These two groups were recognized in the reclustering exercise of Chapter 6.4.1 as not being involved in the deformation which it was suggested produced this group. It should be remembered that this group is considered to be the result of mixing of two other groups.

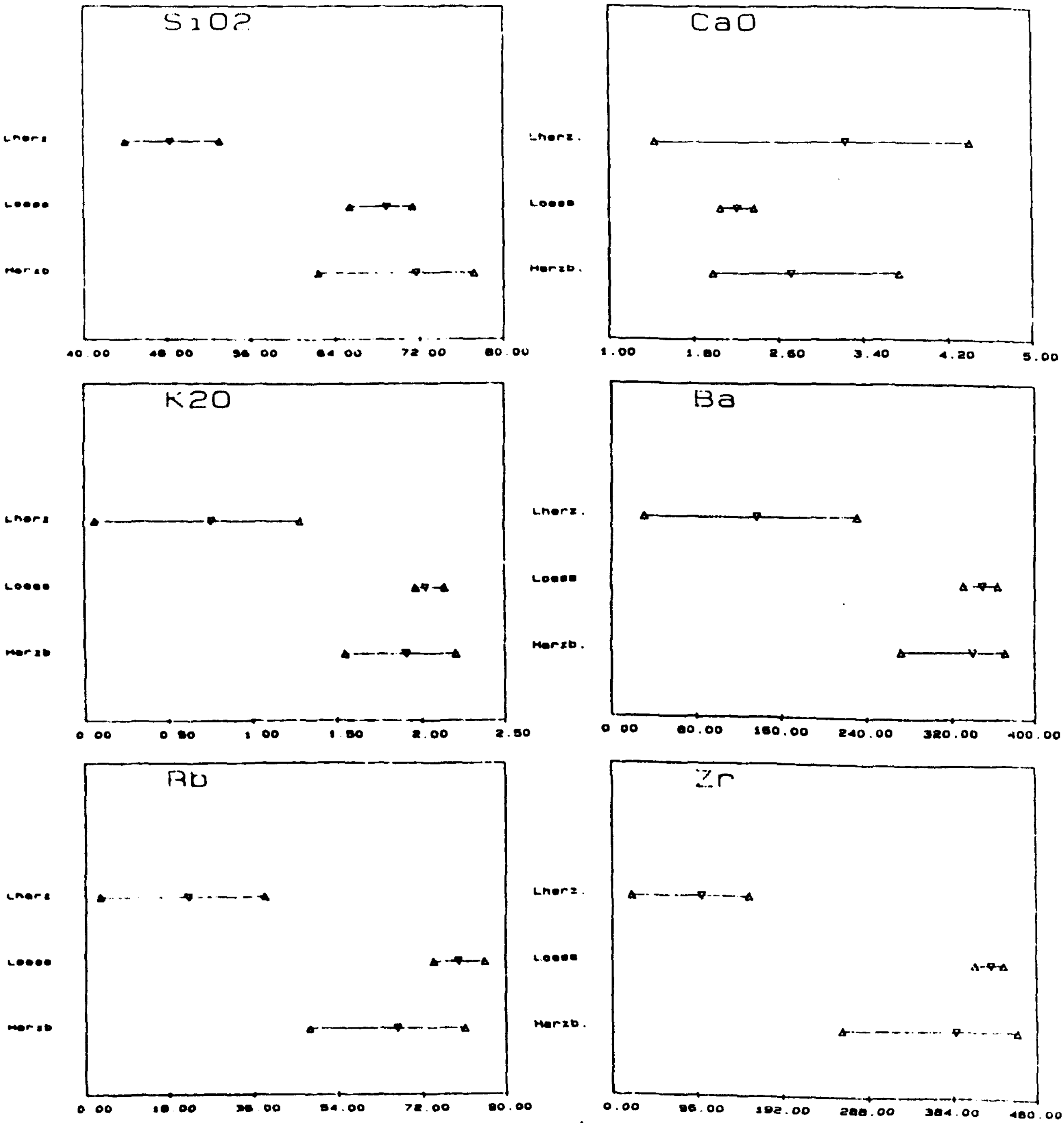
The higher level gabbroic groups (upper gabbro and upper Landewednack schists) may also be produced by the mixing of two other components. The upper gabbro requires the combination of the Trelan gabbro and either the lower gabbro or the Crousa gravel. The identification of the upper Landewednack hornblende schist, however, requires one of the groups to be derived from the lower Landewednack schists. This is considered to be extremely unlikely to occur particularly as the other components would have to be from the Kennack gneiss, mica schist or loess.

The ultrabasic (+ Kennack gneiss component) could only be produced by the mixing of the lherzolitic peridotite and the Kennack gneiss. This, however, is the manner suggested earlier by which this group was formed. Finally the Old Lizard Head Series may be synthesized by the combination of the Kennack gneiss and the lower Landewednack schists (either in equal proportions or 2 parts to one). The remaining units (lherzolitic peridotite, Kennack gneiss, Trelan gabbro, lower Landewednack schists, Crousa gravels and loess) could not be isolated using any combinations of groups.

It should be noted that the loess and Crousa gravels are potentially the most important units for mixing. The lithological units are considered to be relatively unimportant as along a traverse line sampled at 50 metre intervals it would be only at or very close to the contact between the two units that a single anomalous identification may be made. The superficial material in comparison may be spread over a large area. The Trelan gabbro and the Kennack gneiss are the only likely exceptions. The latter has already been discussed and is responsible for the ultrabasic (+ Kennack gneiss group) and little is known about the factors controlling the former.

A major feature that may be seen from this work is considered to be the mixing effect of loess with the lherzolitic peridotite. This mixture consistently results in the identification of the harzburgitic peridotite. If the original concept of separate lherzoltic and harzburgitic peridotites is rejected it is considered that the problem may be resolved relatively easily.

The main difference between the lherzolitic and harzburgitic varieties of ultrabasic rock is the absence of clinopyroxene in the latter. In a whole rock analysis this results in decreased Al_2O_3, CaO and Na_2O concentrations in the harzburgitic peridotite (Fig.18). No such decrease is however seen for Al_2O_3 or Na_2O in the residual soils developed over the harzburgitic peridotite described in the orientation survey (Fig.44) or after the reclustering of the ultrabasic data in the latter stages (Fig.49). An alternative view and one that is now considered to be the most likely is that the "harzburgitic" group actually represents a mixture of the "lherzolitic" peridotite and the loess. By studying Figure 56 it will be seen that the principal elements used in distinguishing the two ultrabasic units could also be used to produce the "harzburgitic" variety from the mixing of loess with the "lherzolitic" component. In each case it can be shown that the mixing of varying proportions of loess with the "lherzolitic" peridotite will result in the development of the "harzburgitic" variety. Further support to this suggestion is also given by Staines (in press) who mapped the occurrence of loess on the Lizard peninsula (Fig.57) . The presence of loess noted as being in excess of 80cm thick lie very close to those areas where traverse line samples have been identified as "harzburgitic" peridotite.



Lherz Lherzolitic peridotite

Harzb Harzburgitic peridotite

Figure 56. Single element graphs for several elements from the "lherzolitic" peridotite, "harzburgitic" peridotite" and loess.

▲ .. min/max ▽ mean oxide data in wt%, else ppm.

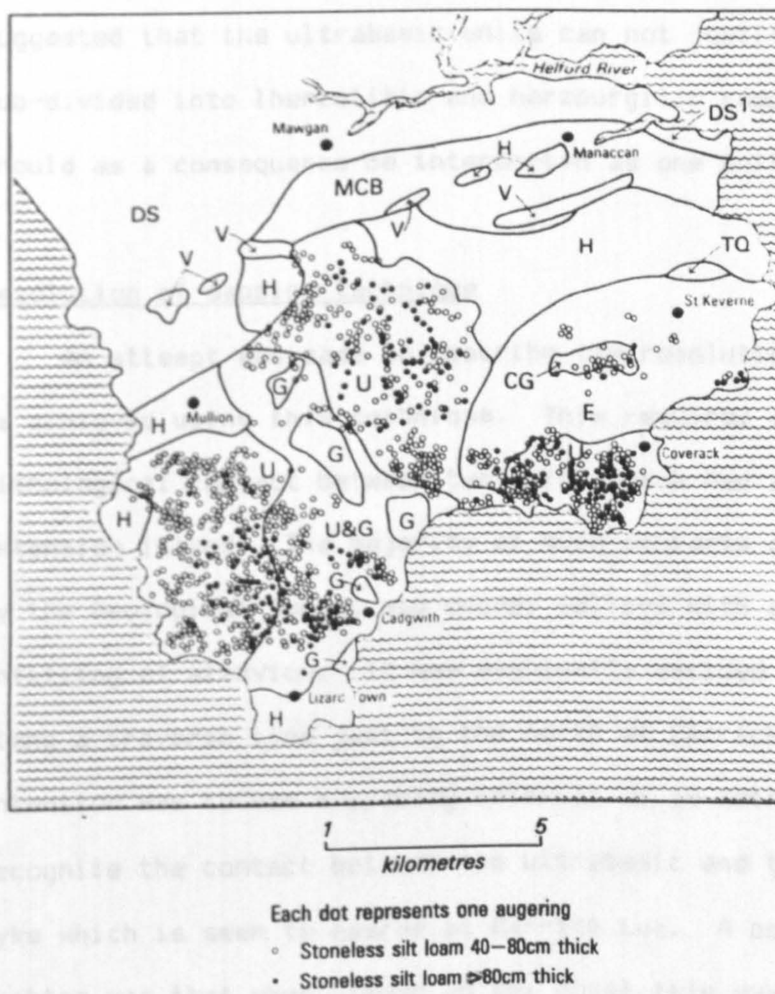


Figure 57. Loess distribution on the Lizard Peninsula. (After Staines, in press).

In the light of the above information it is therefore suggested that the ultrabasic units can not justifiably be sub-divided into lherzolitic and harzburgitic components and should as a consequence be interpreted as one unit only.

6.5.2 Resolution of mapping technique

An attempt was made to describe the resolution which may be achieved using this technique. This required a lithological contact between two units which had a proven extension inland. The majority of such contacts described by the Geological Survey map occupy valleys with a significant infilling of alluvium. It was eventually decided to sample along a traverse line just to the north of Carrick Luz. The intention was to use a spacing interval of 10 metres to recognize the contact between the ultrabasic and the gabbroic dyke which is seen to emerge at Carrick Luz. A potential problem was that when viewed on the coast this dyke is seen to be intensely deformed and in places incorporate lenses of ultrabasic material.

In total 21 samples were collected along a line running east to west (NAS199). The early samples and the final few samples both contained small fragments of ultrabasic material. Following the analysis of these samples the single element geochemistry of the traverse was studied. Some of the graphs from this exercise are shown in Figure 58. An interpretation of the geology (based on the results from the second identification scheme) is also provided. The contact of the

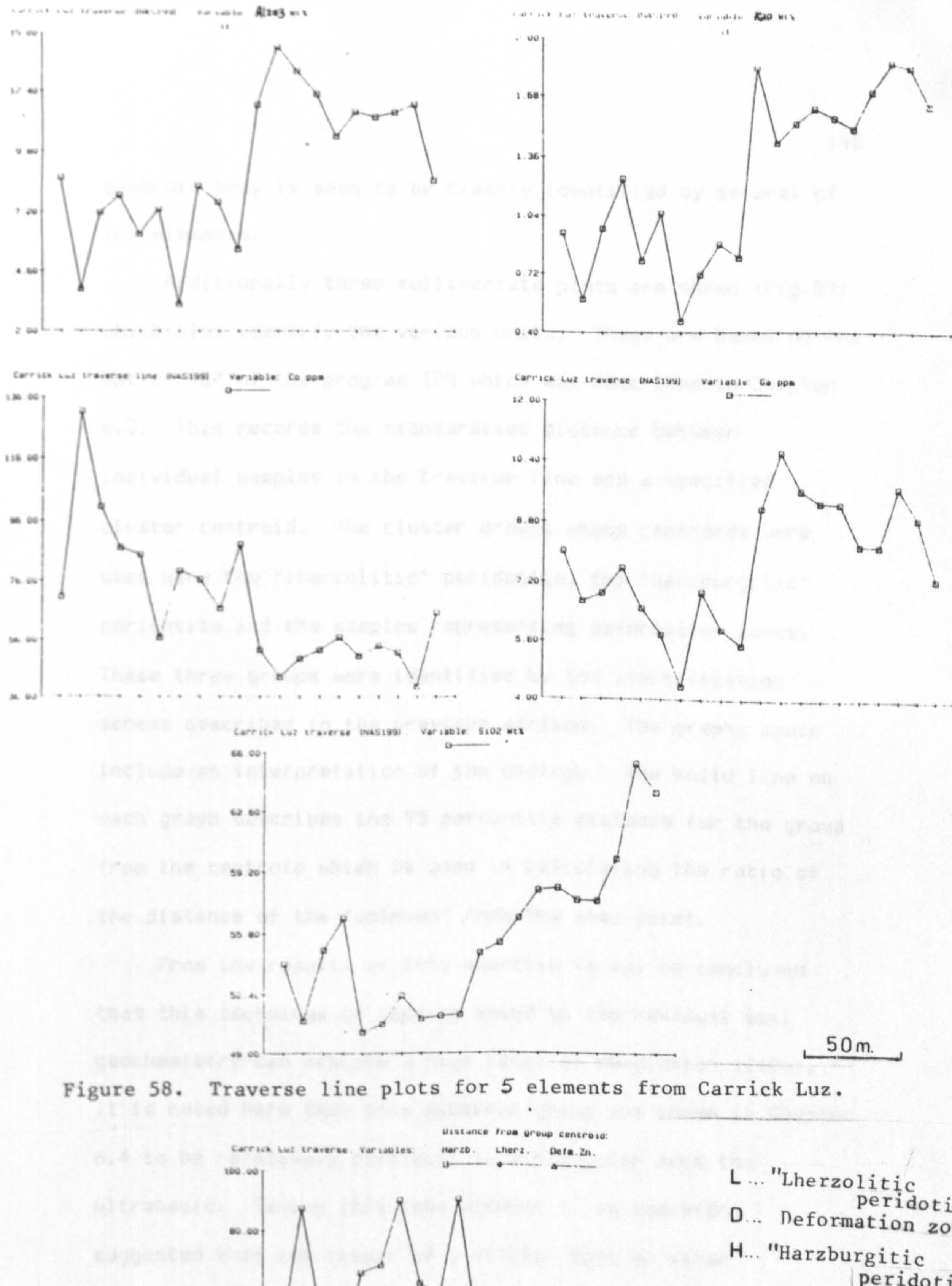


Figure 58. Traverse line plots for 5 elements from Carrick Luz.

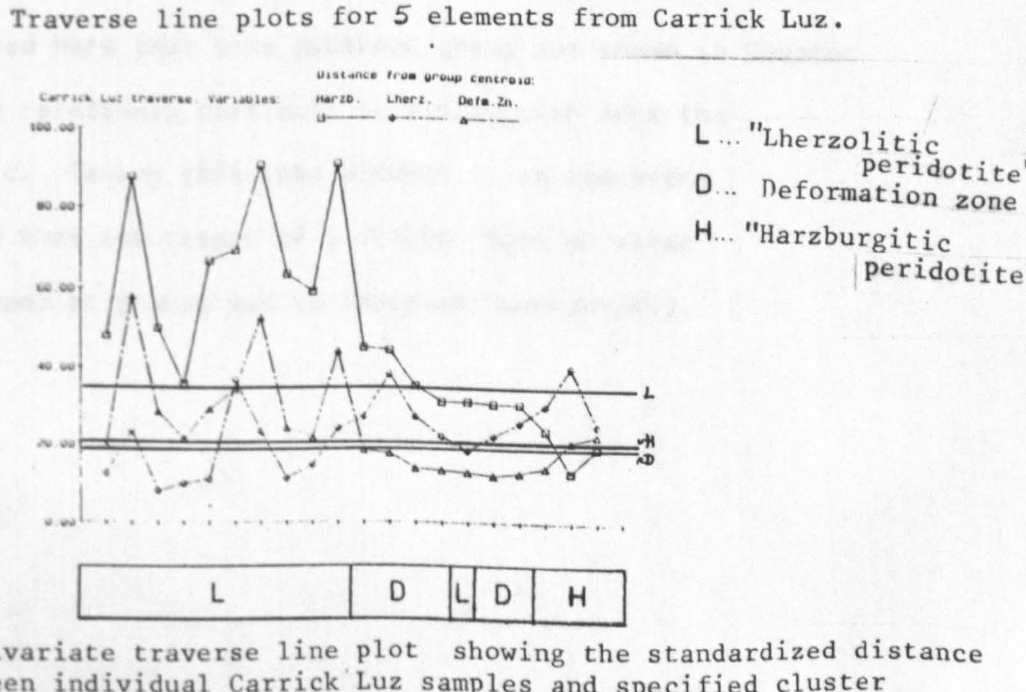


Figure 59. Multivariate traverse line plot showing the standardized distance between individual Carrick Luz samples and specified cluster centroids from the identification scheme (Model 2).

gabbroic body is seen to be clearly identified by several of the elements.

Additionally three multivariate plots are shown (Fig.59) which also identify the various units. These are based on the option "D" of the program IDN which was described in Chapter 6.3. This records the standardized distance between individual samples in the traverse line and a specified cluster centroid. The cluster groups whose centroids were used were the "lherzolitic" peridotite, the "harzburgitic" peridotite and the samples representing deformation zones. These three groups were identified by the identification scheme described in the previous section. The graphs again include an interpretation of the geology. The solid line on each graph describes the 95 percentile distance for the group from the centroid which is used in calculating the ratio of the distance of the "unknown" from the seed point.

From the results of this exercise it may be concluded that this technique of mapping based on the residual soil geochemistry can achieve a high level of resolution (<10m). It is noted here that this gabbroic group was shown in Chapter 6.4 to be relatively difficult to distinguish from the ultrabasic. Taking this into account it is therefore suggested that the result of a similar test on other combinations of groups may be improved considerably.

CHAPTER 7

GEOLOGICAL RE-INTERPRETATION

7.1 Introduction

7.2 Oceanic diapir

7.2.1 Peridotite

7.2.2 Cumulate zone

7.2.3 Upper Landewednack hornblende schist

7.3 Gabbroic intrusions

7.3.1 Crousa gabbro

7.3.2 Trelan gabbro

7.3.3 Basaltic dykes

7.4 Obduction

7.4.1 Basal units

7.4.2 Deformation

7.4.3 Kennack gneiss

7.5 Ophiolite vs. Oceanic diapir

7.6 Tertiary events

7.6.1 Crousa gravels

7.1 Introduction

It is the intention of this chapter to provide a re-interpretation of the geology of the Lizard Complex based primarily upon the geochemistry of the residual soils of the area. The results arising from the application of the identification scheme to these data are shown in Figure 54 (Chapter 6.4.2). The revised interpretation of the overall geology of the area presented is, however, no longer constrained by the paucity of geological knowledge regarding the interior of the Complex.

A revised map for the eastern part of the Lizard Complex is shown in Figure 61. For comparison the original map (Flett, 1946) is shown in Figure 60. It shows an igneous complex ranging from peridotite through a cumulate zone to a deformed and metamorphosed gabbroic body (upper Landewednack hornblende schist). No sheeted dyke or volcanic complex is recognized. The upper Landewednack schists are considered to cover a larger area than portrayed on the existing geological map, extending to the south of St.Keverne. The Crousa gabbro is shown to have a more limited outcrop inland and it is suggested that it is a late-stage intrusion into the igneous complex. Another intrusive body, the Trelan gabbro, is also described. The occurrence of Kennack gneiss inland is confirmed although not to the extent of that suggested by the previously accepted geological map (Fig.3; Chapter 2.3). A schematic section showing the various relationships of the units of the Complex is shown in Figure 62. The Kennack

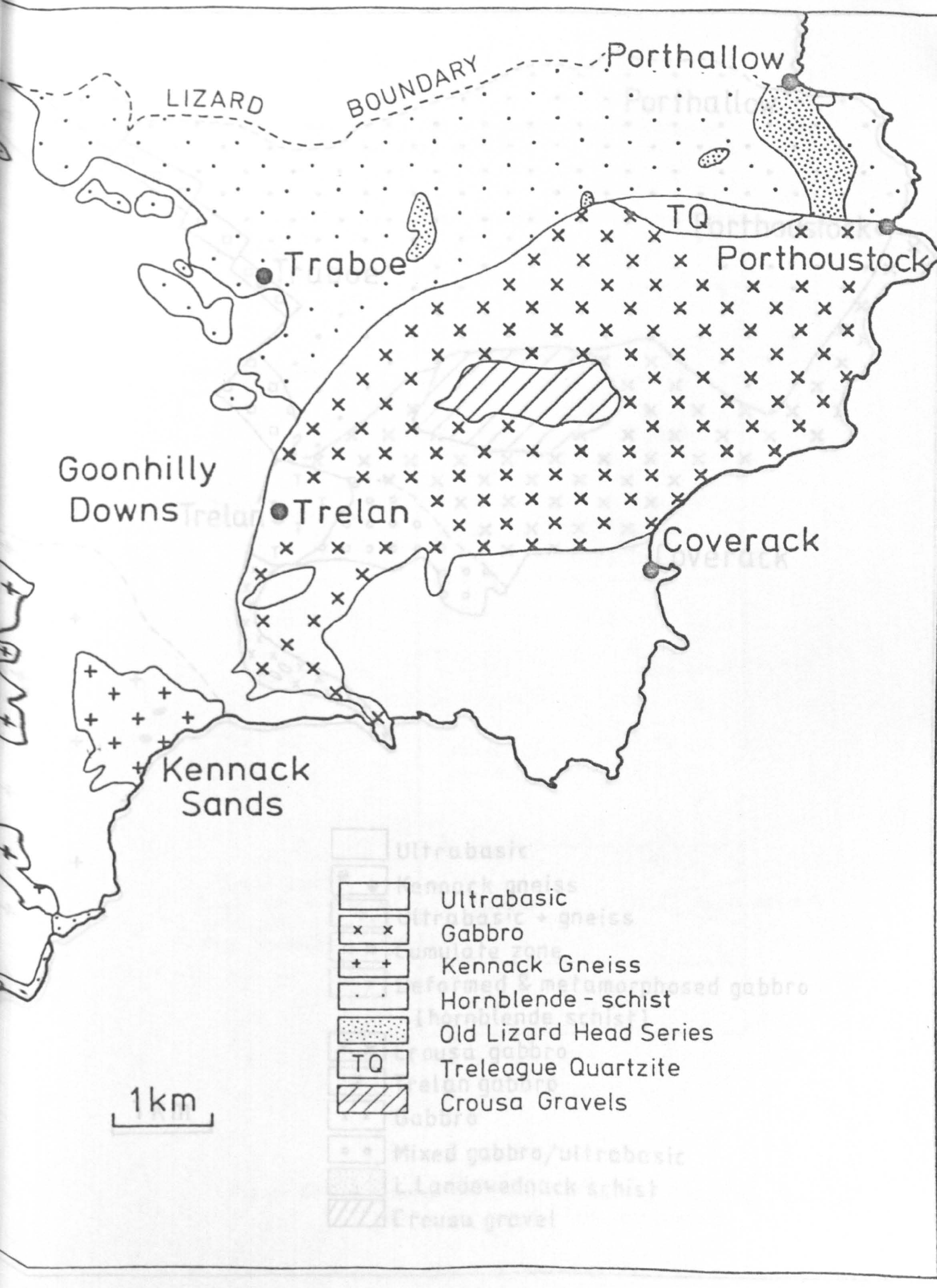


Figure 60. Geological map of the Lizard Complex as previously recognized.

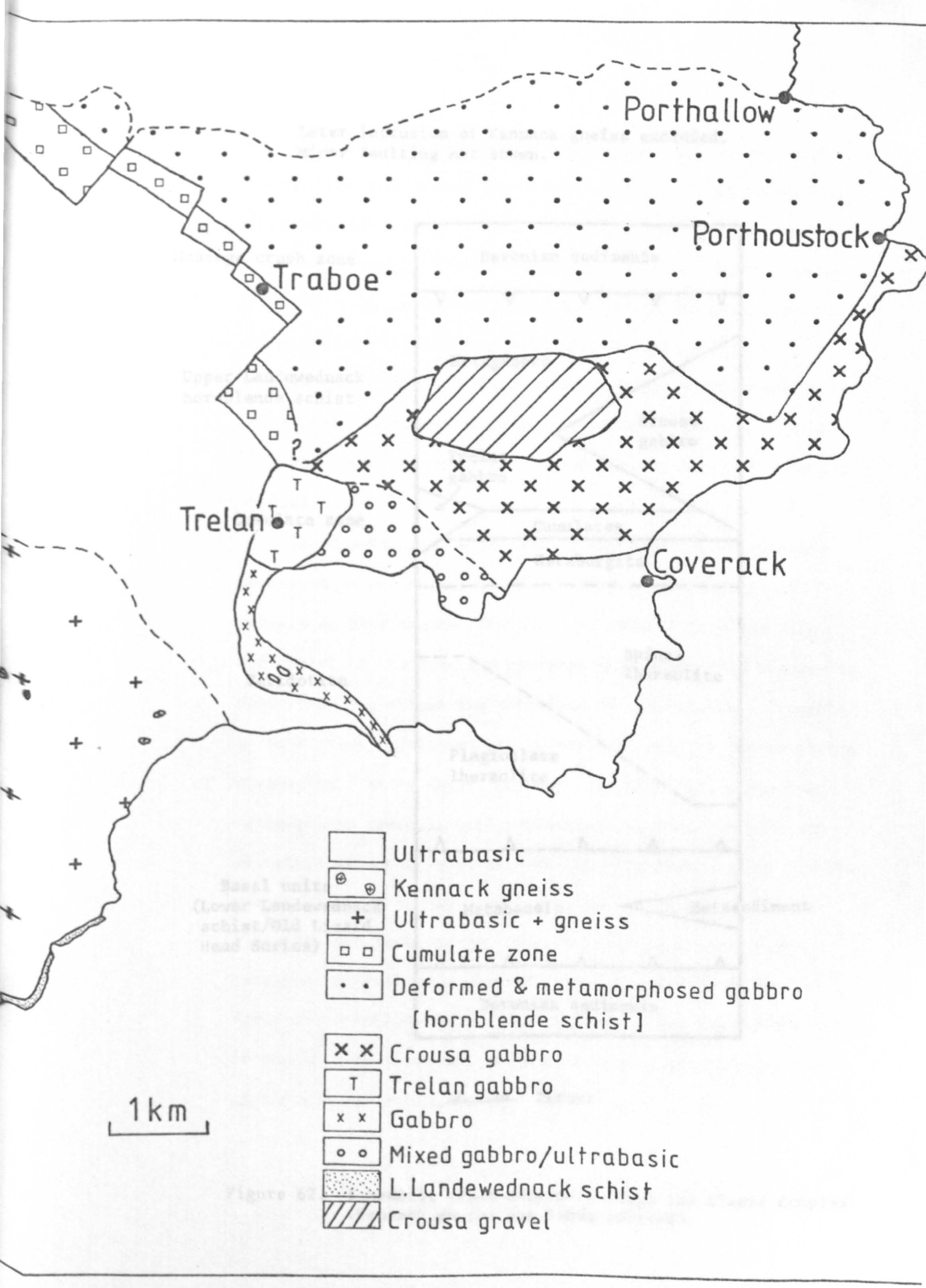


Figure 61. Revised geological map of the Lizard Complex.

Later intrusion of Kennack gneiss excluded.
Minor faulting not shown.

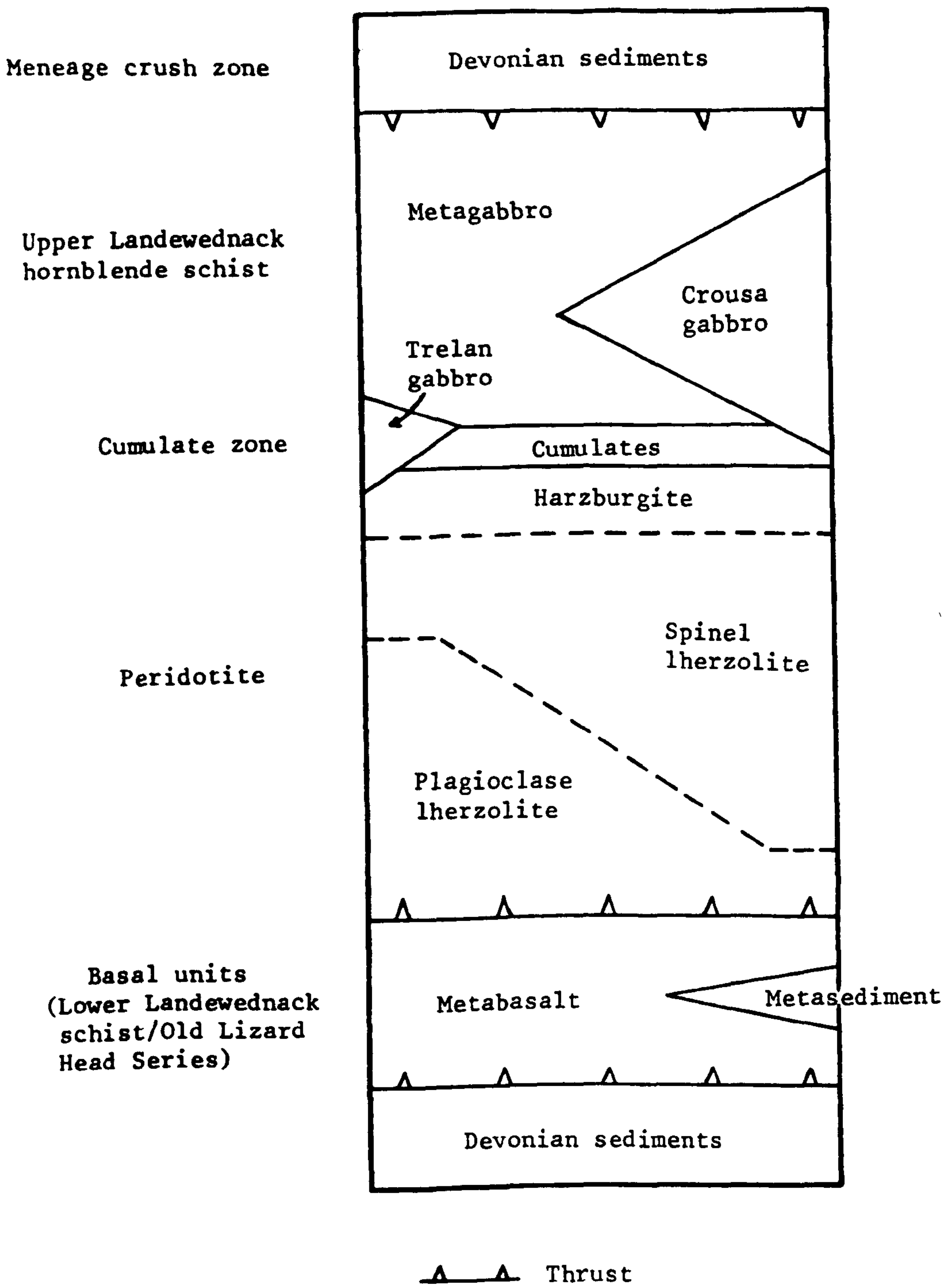


Figure 62. Schematic cross-section through the Lizard Complex (Kennack gneiss and loess omitted).

gneiss, which is omitted from the section, is concentrated towards the base of the peridotite although it is recognized as being intrusive into most of the units of the Complex.

The Crousa gravels are shown to cover a slightly larger area than previously recognized by Flett (1946) and some downslope movement is suggested on the basis of the soil geochemistry. Although individual samples of loess and loess-contaminated soils were identified during the soil mapping, these are not shown on the revised map of the Complex (Fig.61).

The events which gave rise to the above succession are described in chronological order together with additional details as they become relevant. Aspects of both the diapir and ophiolite theories are reviewed throughout this chapter in describing the origin and evolution of the Complex. Elements of both these hypotheses are accepted during the course of the discussion. It is noted, however, at this early stage that although the residual soil geochemistry can be a simple and effective alternative in an area where outcrop mapping is not possible, it is not an ideal solution in areas which have a discontinuous cover of exotic material. Selection of the sampling interval to be used also has a major effect on the scale of variation that can be detected. Borehole information is required to substantiate many of the interpretations made as a result of this work.

7.2 Oceanic diapir

This forms the major part of the Complex and includes the peridotite, the cumulate zone as first recognized by Leake and Styles (1984) and the upper Landewednack hornblende schists. The term "oceanic diapir" is used here to describe a suite of magmatic rocks of oceanic affinity which have risen and evolved from a common source in the upper mantle. It is not intended to be more than a term by which a particular suite of rocks be grouped. This unit is considered to be the oldest intrusive part of the Complex.

The source of magma for generation of the cumulate zone and the gabbro in ophiolites is unknown. It is considered by most ophiolite workers to be a partial melt derived from the underlying peridotite. It is noted, however, that no obvious feeders have yet been recognized.

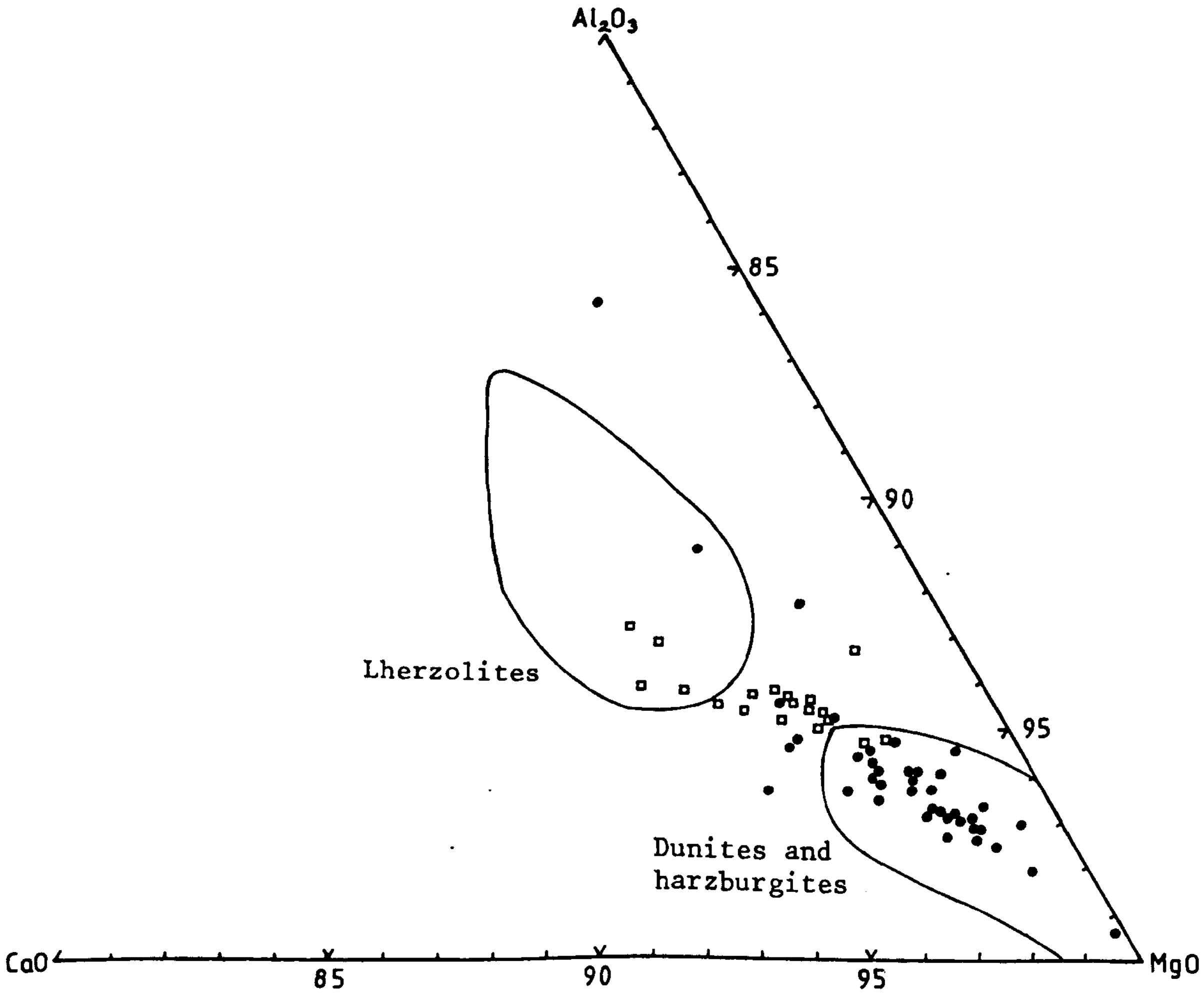
7.2.1 Peridotite

The peridotite could not be sub-divided into lherzolitic and harzburgitic components on the basis of the residual soil mapping. Therefore few comments can be made as to the spatial distribution of the different varieties.

Nicolas and Jackson (1972) subdivided peridotites into harzburgitic and lherzolitic sub-types. The lherzolitic variety was recognized as showing high concentrations of Al_2O_3, CaO and alkalis together with high temperature metamorphic aureole. They were described as representing undepleted mantle material which was associated with mantle diapirs or deep fundamental faults. The harzburgitic sub-type was recognized by Coleman (1977) as being the dominant lithology occupying the basal part of the ophiolite sequence. Coleman (op.cit) also used the term "metamorphic peridotite" to describe ultrabasic material exhibiting the tectonite fabrics which are commonly found in ophiolites. In the Lizard Complex, where recrystallization has been intense, this has given rise locally to a well-defined foliation.

The hypothesis first put forward by Kirby (1978a) that the harzburgitic variety is dominant between Carrick Luz and Coverack is supported on the basis of the chemistry of the chip samples which were collected during the orientation survey (NAS106 and NAS115). These showed depleted levels of Al_2O_3, CaO and Na_2O when compared with the samples collected from Kynance Cove (NAS111). This relationship is shown plotted in Figure 63 as a $MgO-CaO-Al_2O_3$ diagram (Nicolas and Jackson, 1972). The field boundaries from that work are shown to delimit the lherzolitic and harzburgitic varieties.

This confirmation cannot, however, be extended to the inland areas owing to admixture with loess as described in Chapter 6.5.1. An exception to this is the ultrabasic material to the southeast of Trelan. This is considered to be lherzolitic in composition. The residual soils show extremely high levels of Co, Cr and Ni together with moderately high levels of Al_2O_3, CaO and Na_2O. This suggests a primitive undepleted origin as opposed to the depleted upper mantle



- Samples collected between Carrick Luz and Coverack (Harzburgitic peridotite, NAS106 & NAS115)
- Samples collected from Kynance Cove (Lherzolitic peridotite, NAS111)
- Peridotite field boundaries from Nicolas and Jackson (1972)

Figure 63. Peridotites from the Lizard Complex plotted on the Al_2O_3-MgO-CaO diagram. (oxide data in wt %).

origin required for the harzburgitic variety. Complimentary to this is the recognition by Green (1964a) of an olive-green spinel lherzolite just south of Trelan near to Gwenter.

The remainder of the ultrabasic body is accepted as being dominantly lherzolitic in composition. It has been noted by many workers that the dominance of lherzolitic peridotite is not consistent with the description of the ultrabasic portion of an ophiolite provided earlier. As a result of this it is suggested here for the first time (this point will be returned to frequently throughout this Chapter) that the Complex does not represent a typical ophiolite. Although it shows many similarities with other recognized ophiolites, there are many inconsistencies. Chapter 7.5 provides the definition of a typical ophiolite and discusses the possible evolutionary history of the the Lizard Complex.

The lherzolitic component is considered by several other workers to be a mantle residue which has undergone minor depletion of its gabbroic magma. This depletion of magma gave rise first to the cumulate complex trending NW-SE around Traboe and then to a gabbroic mass to the northeast. The peridotite was described by Rothstein (1977) as showing evidence for sub-solidus recrystallization at high temperatures and pressures. Such a mechanism is only attainable within the mantle. This is consistent with the view of Frey (1969) who on the basis of the rare earth element distribution patterns interpreted the ultrabasic unit of Goonhilly Downs to be either a residue left after partial melting or possibly a mantle accumulate. The REE analyses described by Frey (op.cit) showed a marked depletion in the light REE's. In an extension of this work Davies (1984) suggested that this depletion of the spinel lherzolites, which comprise the majority of the Lizard peridotite, "reflects multiple, small percentage (<10%), melt extraction while in the garnet stability field".

The Fo content (Mg/Mg+Fe) of olivines in metamorphic peridotites associated with ophiolites are generally acknowledged to show remarkably consistent values (88.5-94.5% Fo; Coleman, 1977). The pyroxenes show a similar composition range to that of olivine. Analyses by Green (1964a) show ratios of olivine and pyroxene of 90.1±2.0%. Rothstein(1981) describes the Fo content of olivines as being 90±1%. Similar ranges (0.87-0.93 Mg/(Mg+Fe)) were noted for analyses of olivines, pyroxenes and amphiboles from the study of the Traboe boreholes (Leake and Styles, 1984).

Rollin (in press) by modelling residual gravity anomalies has provided an indication of the overall thickness of the peridotite sheet. In the west it is considered to be generally greater than 400 metres thick. It is also suggested that the sheet thins to the northwest towards Mullion. A similar conclusion was made by Tombs (1977) who, following a detailed gravity survey, suggested that the small peridotite mass at Meaver near Mullion was an isolated remnant 30 metres thick rather than part of a diapiric intrusion.

A major period of faulting and rapid uplift is also required to explain both the presence of relatively well-preserved plagioclase lherzolite (depth of origin about 24km) and spinel lherzolite in close proximity to the cumulate zone.

7.2.2 Cumulate zone

Within the zone identified as underlain by the cumulate zone, soil samples were found to be extremely variable (Figure 54) and have been classified within the following groups; the "harzburgitic" and "lherzolitic" peridotites, the upper Landewednack hornblende schists, the upper and lower gabbro, and samples representing deformation zones (DZ). This variation, over distances in excess of 300 metres, is taken to be a function of the extreme variety of lithologies which were noted by Leake and Styles (1984) and described in Chapter 2.3.4.

The cumulate complex is shown in Figure 61 as giving way to the upper Landewednack hornblende schists to the northeast. Aeromagnetic surveys (Rollin, in press) have suggested that the magnetic cumulate zone underlies the hornblende schist to the northeast and is adjacent to the less magnetic serpentinized peridotite to the southwest. The boundary between these two units is considered to be gradational, although it is defined here as the first consistent occurrence of the latter group after the cumulate zone. It is considered that the zone may extend across the valley that emerges at Kennack Towans. Samples collected along the traverse line one half kilometre to the northeast of Trelan (NAS155/56) were identified as belonging to two different lithologies (the upper Landewednack schist and the Trelan gabbro). A notable feature of this traverse was the large proportion of samples (8/27) which could not be identified. For this reason the interpretation of the geology of this area is considered to be uncertain.

The three boreholes drilled at Traboe (Leake and Styles, 1984) are considered to represent only a partial section through the cumulate zone. On the basis of drilling the thickness of the complex was estimated to be between 200 and 500 metres. This zone cannot be recognized in full in coastal sections. At some localities, rocks with a similar appearance may be found (eg.Godrevy Cove and Porthkerris Cove) although they show only a restricted range. The relationship of these minor outcrops to the cumulate zone around Traboe is however yet to be established. No correlation of the Traboe cumulates with the peridotite/gabbro contact at Coverack is considered likely owing to the extreme difference in lithologies between the two areas.

The cumulate rocks analyzed by Leake and Styles (1984) show similar whole rock Mg/(Mg+Fe) ratios to those described by other workers as representing typical ultramafic and mafic cumulates in an ophiolite sequence.

Discrete grains of magnetite and ilmenite (as found in the cumulate zone around Traboe and on the coast between Porthallow and Porthoustock in the upper Landwednack schists respectively) are considered by Coleman (1977) to be rare as cumulus or post-cumulus phases in ophiolites. If the Lizard Complex is to be considered as an ophiolite showing a succession from upper mantle to volcanic extrusives, the presence of these minerals in considerable quantities in some areas must be explained.

No further work was carried out in this area. The reason for this was partly due to the fact that the BGS boreholes have thrown much light on the complicated geology of the area. Additionally a very short sampling interval would have been required to adequately map the surface geology of this area using soil geochemistry.

7.2.3 Upper Landewednack hornblende schists

The area identified as consisting of upper Landewednack schists are considered to have originally been a gabbroic body. After formation it must then have undergone extensive deformation and metamorphism in order to become the hornblende schist unit which is currently recognized. It can be seen in the Crousa gabbro that local deformation and retrogression of the gabbro in small shear zones results in the formation of a hornblende schist.

Very little differentiation has occurred within this unit as the geochemistry of the soils collected close to the boundary with the cumulate zone does not change appreciably when compared with those from other traverse lines to the northeast. Figure 64 shows three x-y plots for a variety of elements. Samples from three traverse lines were selected

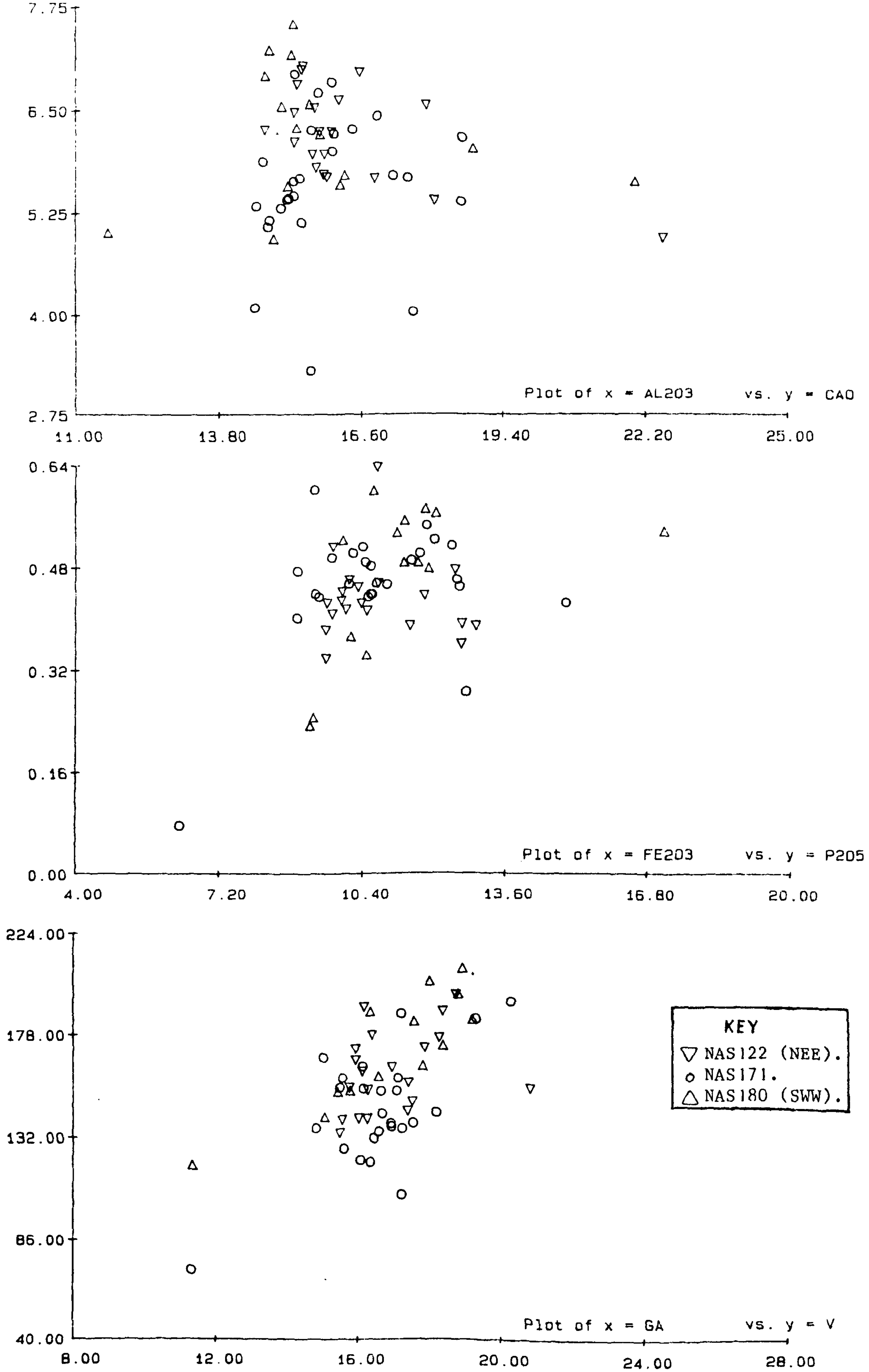


Figure 64. Three x-y plots showing the poorly differentiated nature of the upper Landewednack hornblende schist.

which are well-separated from each other. Each group is also considered to be at a different level within the deformed gabbroic body. The first traverse (NAS180) was taken near to Traboe just to the northeast of the cumulate zone; the third traverse (NAS122) comes from the coast just south of Porthkerris Cove. The second traverse line (NAS171) lies approximately halfway between the previous two lines. It can be seen from the graphs that there is no consistent trend. This absence of a well-defined differentiation trend should be compared to that shown by the Crousa gabbro (Fig.65; Chapter 7.3.1).

A few moderately high levels of TiO_2 and V (upto 2.12 Wt% and 195 ppm respectively) are seen on the coast between Porthoustock and Porthallow. These may be accounted for by the suggestion that no basaltic portion ever developed and therefore the TiO_2 and V was retained by the gabbroic portion.

7.3 Gabbroic intrusions

This section includes discussions relating to the lower and upper gabbro which outcrops on the coast between Coverack and Porthoustock, together with the Trelan gabbro. Very little evidence is presented as to the order in which these two gabbros were intruded.

7.3.1 Crousa gabbro

This unit is for several reasons regarded as intrusive into the oceanic diapir described previously:

a) Although chemically the gabbro and the upper Landewednack hornblende schist have a gabbroic composition, they are mineralogically and texturally distinct. The latter are considered to represent the deformed gabbro above the cumulate zone (Chapter 7.2.3).

b) On the southern margin of the Crousa gabbro intrusive relationships may be seen with the ultrabasic. Some of the evidence for this was described in Chapter 4.4 and is recognized by the soil mapping as repeated interlayering of gabbroic and ultrabasic rocks. This zone is shown separately in Figure 61 for simplicity of drawing and has also been recognized by Rollin (in press) between Trelan and Polcoverack in a ground magnetic survey of the area. Soil mapping suggests that the area around the contact is faulted. As well as the obvious non-alignment of the lithological units in Figure 61, several samples from this area were identified as members of the group representing Deformation Zones (Fig.54).

c) To the north the gabbro shows a discordant relationship with the hornblende schist. It is unlikely that this is a faulted lithological contact over its entire length as suggested by Bromley (1975) and others. It is probable, however, that the valley which runs in a near-continuous arc between a point at the eastern end of Kennack Towans and Porthoustock is a major fault zone. The southern part of the fault around Trelan and

Gwenter is a geological as well as a tectonic contact. Although samples were collected from the northern part of this fault, no lithological contact was identified by the soil mapping. Several samples, however, gave identifications belonging to the group characterizing Deformation Zones.

d) The main gabbro is highly differentiated with its base to the south. The three x-y plots in Figure 65 show show a distinct differentiation trend with Al_2O_3, CaO, Fe_2O_3, P_2O_5, Ga and V all increasing towards the top of the gabbro. The three groups of samples used in these graphs were taken during the orientation survey and represent the succession from the lower to upper part of the Crousa gabbro (NAS119, NAS129, NAS118 from north of Coverack, near Dean Quarry and south of Porthoustock respectively). The presence of this differentiated sequence implies that the Crousa gabbro had a significantly different cooling history from the upper Landewednack schist.

e) Two xenoliths of ultrabasic material several metres across may be found just to the north of Dean Point. Randomly orientated xenoliths of peridotite may also be found in the gabbro at Coverack.

f) Occurrences of gabbro may also be found elsewhere in the Complex. These include areas near to Poltesco in the peridotite; at Polbarrow between Cadgwith and Landewednack Church Cove; on the west coast in the Traboe schist; at Porthkerris Cove on the east coast in the Traboe schist; towards the base of the Kennack Sands borehole; and towards

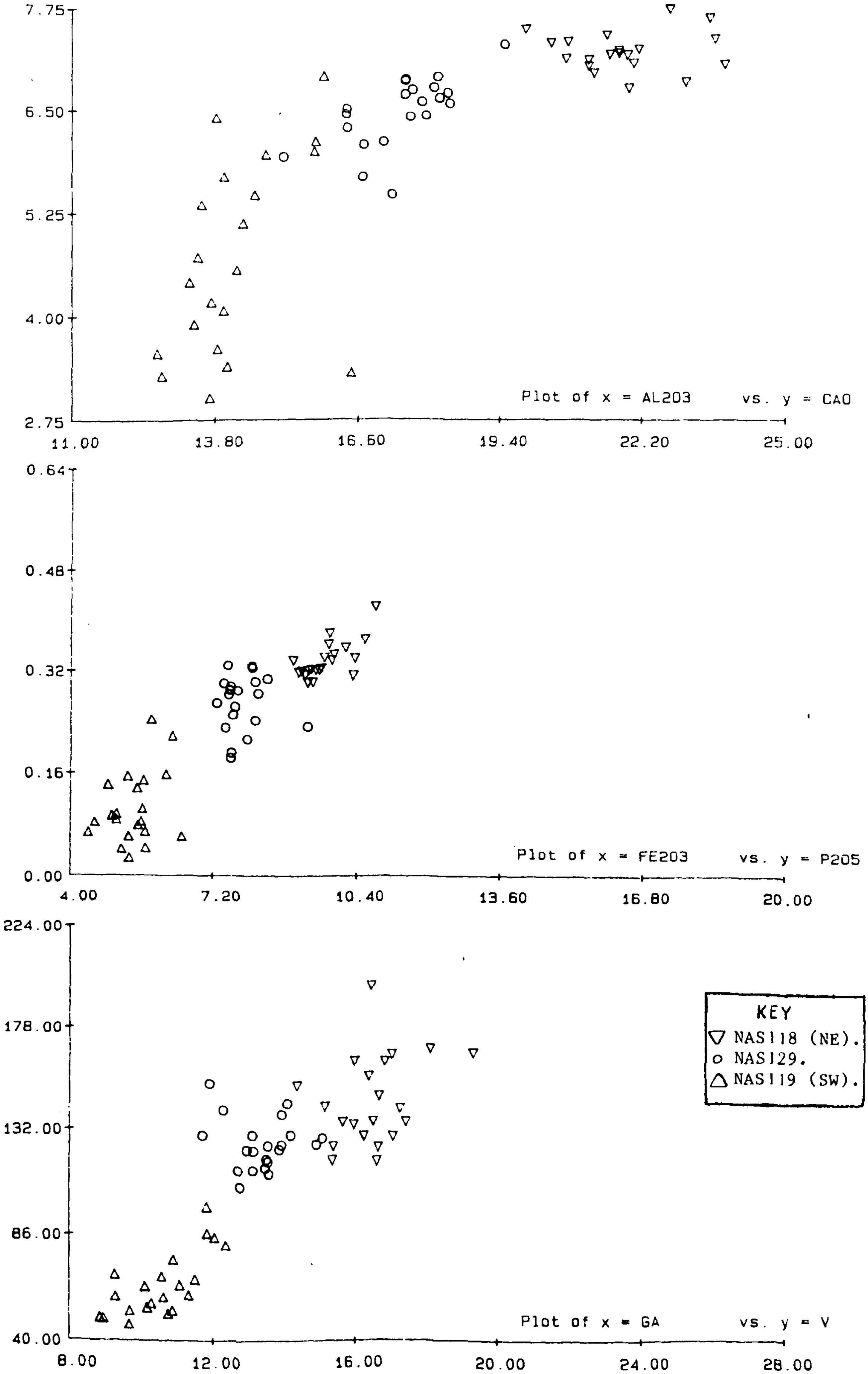


Figure 65. Three x-y plots showing the highly differentiated nature of the intrusive Crousa gabbro.

the top of the Traboe borehole number 1 in the cumulate complex. In the latter occurrence it was noted by Leake and Styles (1984) that gabbro rotated the amphibolite in some places. This clearly indicates that some of the gabbroic magmatism does, in part at least, post-date the formation of the rocks of the oceanic diapir. No gabbroic material has been found in the lower Landewednack hornblende schist or the Old Lizard Head Series to the south of the Complex.

g) Several generations of gabbroic pegmatite may be recognized. Although some of these are deformed, the latest postdates the deformation which has affected the gabbro and the area to the northern end of Portherris Cove (Vearncombe, 1979).

It is suggested that the gabbro may have formed as a result of the remelting of a part of the cumulate zone which could possibly explain the lateral extension of the cumulate zone into the lower members of the gabbro. This would also explain the continuation of the aeromagnetic anomaly trending to the southeast from the Traboe area towards the Crousa gabbro (Rollin, 1978). Additionally, if it were the product of partial melting of the original oceanic diapir it would account for the cogenetic relationship first noted by Thayer (1967) to exist between the gabbro and the ultrabasic at Coverack.

At Dean Quarry several samples were collected for possible Rb/Sr age determinations (samples were also collected from Coverack and Porthoustock). Although the samples did not produce a good isochron, one of the eight samples collected

(ISO-4) showed highly anomalous concentrations of TiO_2, Fe_2O_3, P_2O_5, Ga, Nb, V, Y and Zr. Two other samples from this area also showed moderately enriched levels of these elements (ISO-5 and ISO-6). These samples also showed extremely low concentrations of SiO_2, MgO, CaO, Cr and Ni. Figure 66 shows a 3-dimensional plot of P_2O_5 vs Y vs Zr (size of symbol proportional to concentration). From this and similar plots two distinct trends of fractional crystallization can be seen.

The analyses for these samples together with the analyses from ISO-2 (Porthoustock) and ISO-3 (Dean Quarry) and ISO-8 (Coverack) may be found in Appendix I. The latter three samples are considered to be more representative of the Crousa gabbro.

The high concentrations of P_2O_5 and TiO_2 are due to the presence of abundant apatite and ilmenite respectively. Apatite has been reported occurring as small fine needles in this area by other workers. Kirby (1978a) concluded, however, that they were only a very minor phase and showed chemical analyses with low P_2O_5 concentrations. He concluded on the basis of the immobile trace element geochemistry that the gabbro was of a primitive origin.

The apatite found in ISO-4 formed large euhedral crystals showing distinct hexagonal basal sections (Plate 13). It is likely that these crystals formed as a cumulate phase very early in the paragenetic sequence. They are enclosed by both pyroxene (now mostly uralitized) and feldspar. The samples ISO-5 and ISO-6 also show cumulate textures. Although apatite

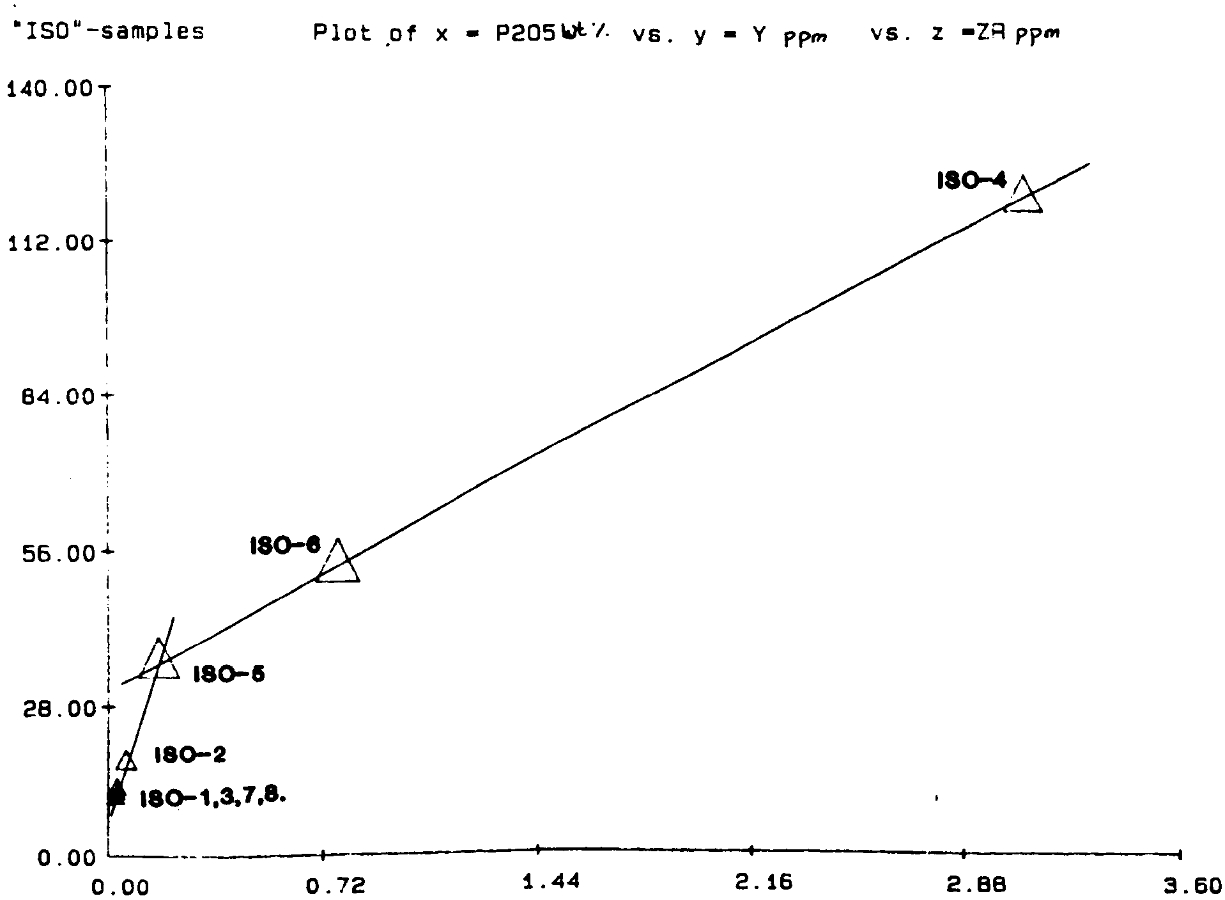


Figure 66. Plot of P_2O_5 vs. Y vs. Zr showing two separate trends of differentiation in the Crousa gabbro.

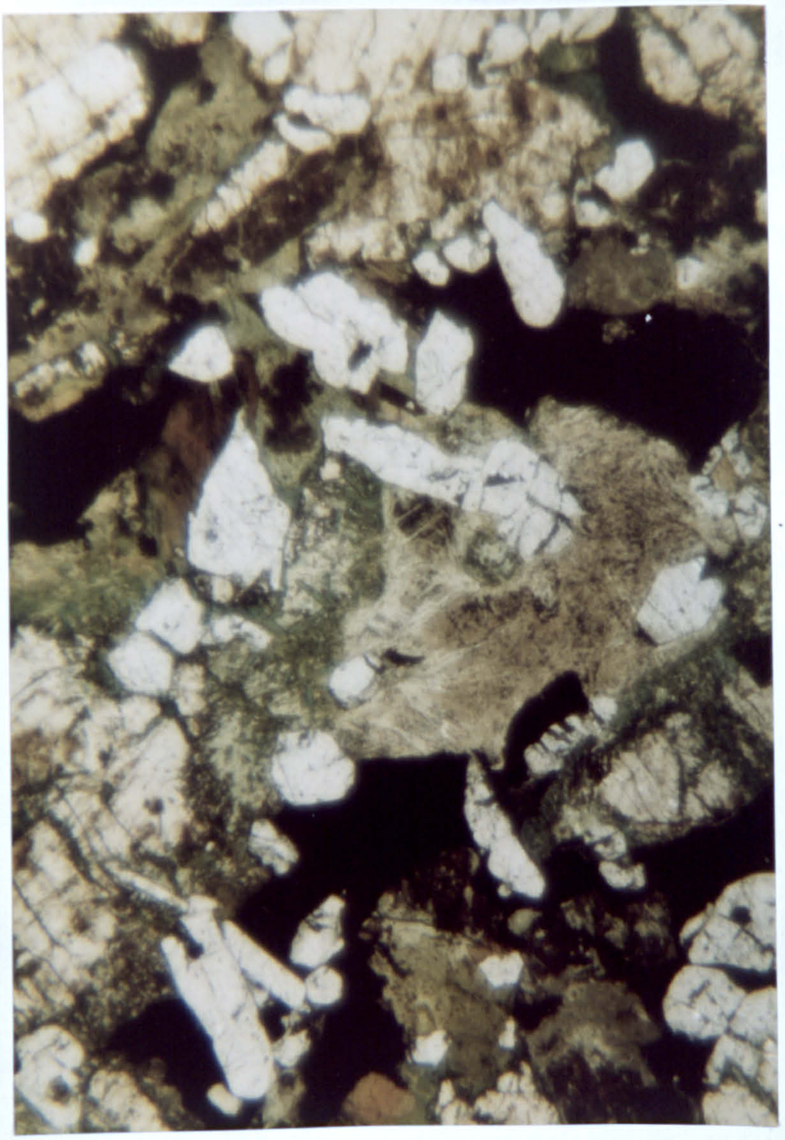


Plate 13. Thin section of the apatite-rich gabbro found in Dean Quarry. Euhedral,colourless apatite showing a high relief with colourless, variably altered plagioclase, greenish-grey clinopyroxene altering to a green amphibole, and large opaque ilmenite crystals. (Plane polarized light; magnification X4).

crystals are rarely seen as a cumulate phase, it is generally recognized that they may crystallize in basic bodies under conditions of intense iron enrichment (Wedepohl, 1969-78). This view is supported by the presence of small (generally less than 0.5 metres) anorthositic bodies within the Crousa gabbro. On the available evidence it is suggested that the Crousa gabbro developed localized cumulates where and when conditions permitted. Olivine, plagioclase and rare pyroxene cumulate layers have been recognized by Kirby (1978a,b) in the area around Dean Point and Lowland Point.

During the soil mapping no samples were collected which showed the anomalous levels of the various elements described above.

7.3.2 Trelan gabbro

This was first described by Smith and Leake (1984) and the extent of this localized intrusive body has been further delineated as a result of the power auger programme and the later soil mapping programme. The southern boundary, however, of the body towards Carrick Luz is unclear. Figure 54b shows that the traverse line to the south of Gwenter (NAS185) identified only some of the gabbroic samples as being members of this group. Further to the south the traverse line trending to the southwest towards Kennack Towans (NAS191) showed no Ti/V enrichment. The Carrick Luz traverse line showed a similar lack of samples from this group.

During the power auger programme a second, basal sample was collected at each sampling site. These bulk samples were sieved using a 5mm mesh sieve to remove any larger fragments and then panned to remove the clay fraction. After chemical analyses of the basal samples were completed several samples which showed relatively high concentrations of TiO_2 and V were selected for further work. A second criterion for the selection of these samples was that there should be a good spatial distribution of samples. Fragments containing obvious opaque material were then separated using a combination of a hand-held electromagnet and a binocular microscope. These fragments were then set in thermoplastic and made into polished ore mounts. Three samples were made into polished thin sections for electron microprobe analysis (EMPA) in the Geology Department at Manchester University.

Under the ore microscope the opaque mineralogy was found to comprise ilmenite and magnetite. Two textures were noted; a granular intergrowth of ilmenite and magnetite (Plate 14), and secondly, an intergrowth between the two minerals. This consisted of ilmenite lamellae elongated parallel to their (0001) direction and orientated in the (111) direction of the magnetite (Plate 15). At high temperatures Ti can enter into solid solution with magnetite. In rapidly cooled basaltic lavas the Ti remains in solid solution giving titanomagnetite. With slower cooling, this solid solution undergoes a very rapid and complete unmixing. This results in the lamellae intergrowth texture or in the granular texture, both of which are described above. The granular intergrowth is seen by

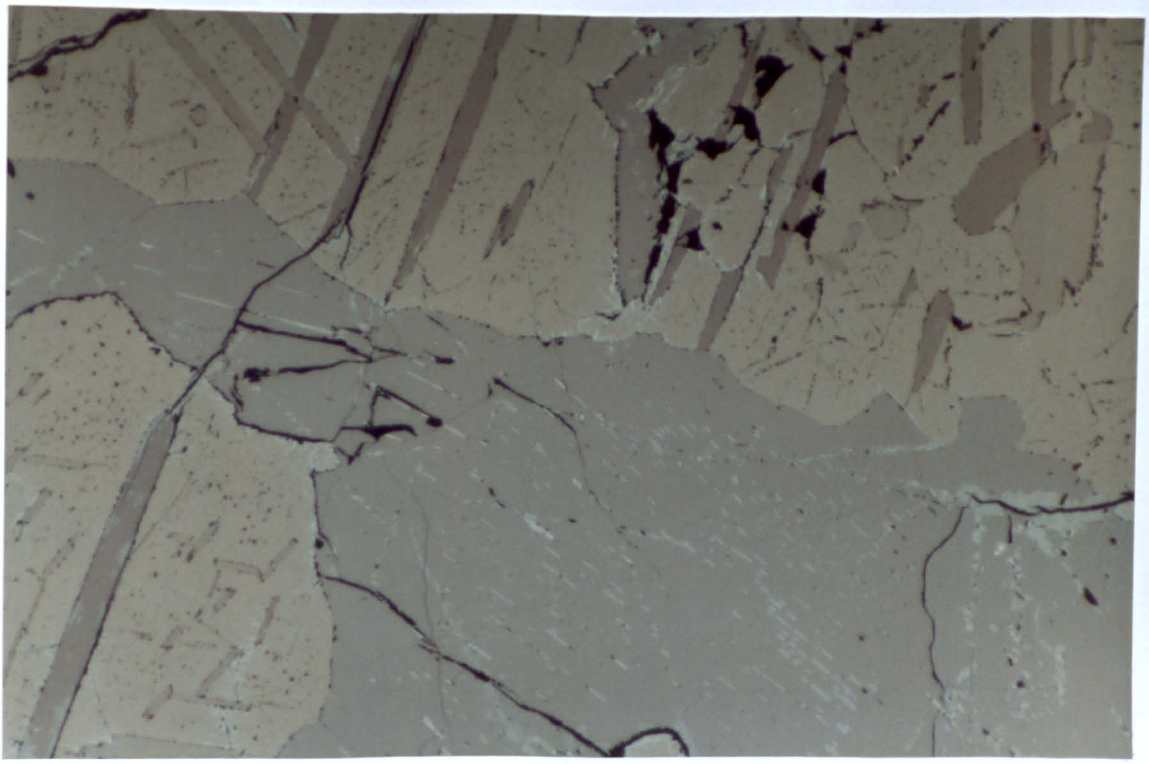


Plate 14. Large granular intergrowth of ilmenite (darker) and magnetite from the Trelan gabbro with some minor lamellae of ilmenite also present. Seriate arrangement of minute haematite exsolution laths (pale blue-grey) visable within the ilmenite. (Partially crossed nicols; magnification X16).

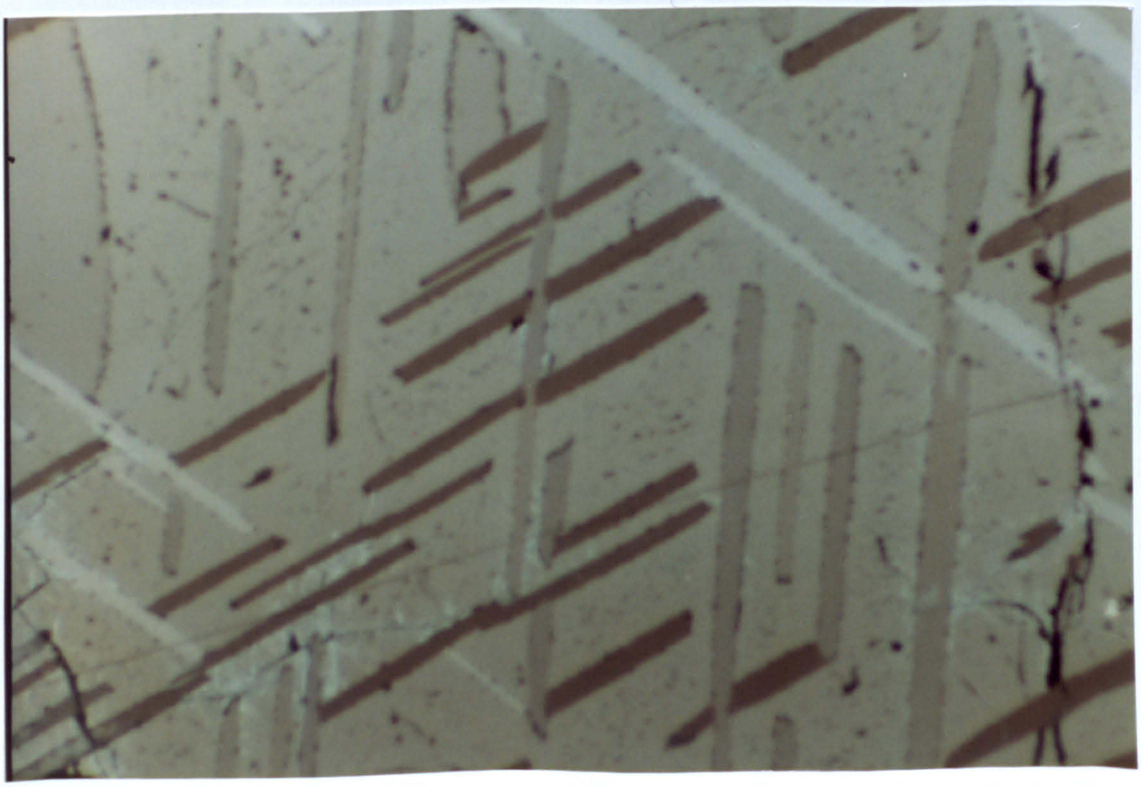


Plate 15. Exsolution intergrowth of ilmenite lamellae in the (111) planes of magnetite from the Trelan gabbro. (Partially crossed nicols; magnification X16).

Edwards (1974) as a response to high diffusion rates at elevated temperatures when cooling is slow. This in turn results in the ilmenite lamellae tending to diffuse to the margins of the magnetite crystals forming irregular to rounded grains. The ilmenite may also be seen to show a further example of unmixing. In Plate 14 minute hematite laths can be seen showing a seriate or ordered arrangement lying in the (0001) direction of the granular ilmenite host.

Extensive hematization was also seen on many of the fragments collected during the power auger programme. When studied under the binocular microscope the hematite was seen to form coatings on the surfaces of a variety of minerals. This is considered to be due to later hydrothermal activity and may possibly be linked to other hydrothermal mineralization which has been described by Seager (1978) in Dean Quarry. This event was considered by Halliday (1975), on the basis of K-Ar dating, to have occurred approximately 215my ago. The other possibility is that it may be connected with the high Fe concentrations of the area, and the effects of the deep sub-tropical weathering which is thought to have occurred during the early Tertiary (Chapter 7.6.1).

Electron microprobe analyses showed that the high levels of V were largely associated with the magnetite rather than the ilmenite. Table 18 shows the summary statistics of the magnetite and ilmenite analyses from the Trelan area. Appendix H provides the data of the analyses carried out on the electron microprobes.

Summary statistics ... Trelan ilmenite analyses (wt%)

... no. variables... 13
... no. samples..... 15

Variable	Average	Median	Min.	Max.
FE2	45.78933	47.87000	44.87000	46.65000
FE3	1.26133	1.35000	0.00000	2.49000
SIO2	0.29987	0.31000	0.00000	0.50600
AL2O3	0.00000	0.00000	0.00000	0.00000
MGO	0.48067	0.37500	0.00000	1.22700
V2O5	0.29189	0.27080	0.00000	0.51990
TIO2	52.16847	52.32300	51.34800	52.91800
NIO	0.02053	0.01100	0.00000	0.07000
COO	0.00000	0.00000	0.00000	0.00000
CR2O3	0.01067	0.00000	0.00000	0.05500
MNO	0.96613	0.98900	0.54000	1.46000
CAO	0.00000	0.00000	0.00000	0.00000

Summary statistics ... Trelan magnetite analyses (wt%)

... no. variables... 13
... no. samples..... 35

Variable	Average	Median	Min.	Max.
FE2	36.66143	36.36000	34.92000	39.99000
FE3	57.53601	58.76000	45.17000	61.01000
SIO2	0.61634	0.40000	0.24000	4.05500
AL2O3	1.49369	1.09900	0.32700	4.54000
MGO	0.13626	0.00000	0.00000	1.15600
V2O5	2.19909	2.09390	1.77470	3.58550
TIO2	1.33571	1.20400	0.38900	4.37100
NIO	0.02360	0.02100	0.00000	0.07300
COO	0.00000	0.00000	0.00000	0.00000
CR2O3	0.07817	0.04900	0.00000	0.45600
MNO	0.00000	0.00000	0.00000	0.00000
CAO	0.00649	0.00000	0.00000	0.22700

Table 18. Summary statistics for the ilmenite and magnetite analyses from the Trelan area.

The recalculation of the Fe_{2+} and Fe_{3+} concentrations was carried out after the data from the EPMA were rekeyed into the computer system at Nottingham. (Details of the recalculation may be found in Appendix B). This used the program MPC (Appendix A) to recalculate the proportions of Fe_{2+} and Fe_{3+} where necessary and calculates cation proportions and other additional useful parameters for a wide range of minerals (eg.pyroxene, amphibole, olivine, feldspar, hematite and ilmenite).

The magnetites analyzed from the Trelan area do not have compositions corresponding to the true end member magnetite of the spinel solid solution group. Together with FeO (34.92-39.99 wt%), Fe_2O_3 (45.17-61.01 wt%) and the concentrations of V previously described, small quantities of Ti, Al, Si, Cr and Ni can be seen. The small amounts of Ti^{4+} are easily contained within the magnetite structure as there is a solid solution series between magnetite and the ulvospinel molecule (Fe_2TiO_4). The Al^{3+} ion can substitute for the Fe^{3+} ions and similarly small proportions of Mn and Mg can substitute for Fe^{2+}. Partial substitution of Cr and V for Fe^{3+} and of Ni for Fe^{2+} are also recognized by Deer et al (1966). The presence of Si in the analyses cannot be explained, although it is noted that Frietsch (1970) also recognized the presence of small quantities of SiO_2 in trace element analyses of magnetite mainly from northern Sweden. The view that these levels of silica are due to contamination is, however, rejected owing to the small volume ($<2\mu^3$) analyzed by the electron microprobe.

The ilmenites analyzed from the Trelan area show, as would be expected high levels of FeO and TiO_2 (44.87-46.65 wt% and 51.35-52.92 wt% respectively). They also contain trace quantities of Fe_2O_3, MnO, MgO, V_2O_5 and SiO_2. Low concentrations of Cr and Ni are also occasionally present. Mn and Mg are commonly recognized in ilmenite where they both substitute for Fe^{2+}.

The Trelan gabbro is considered to be separate from the main body of the Crousa gabbro for a number of reasons:

a) It is located at the base of the Crousa gabbro where it is in contact with the ultrabasic. TiO2 and V are, however, both elements which are generally considered to be most enriched in the upper parts of differentiated sequences. This is best shown in the Crousa gabbro to the south of Porthoustock where large crystals and stringer veins of ilmenite may be found.

b) The plagioclase compositions in the Trelan gabbro (BXA3079 and BXA4055; An_{34-44}) are lower than those from the Crousa gabbro at Coverack (ISO-8; An_{50-54}). They are, however, most similar to the plagioclase in the anomalous Crousa gabbro at Dean Quarry (ISO-4, 5 and 6; An_{32-35}).

c) Magnetite compositions from the coastal section of the Crousa gabbro (ISO-4 and ISO-8) show significantly lower concentrations of Fe_{2+} and higher levels of Fe_{3+} and TiO_2 than the analyses from the Trelan area (Fig.67).

It is probable that the Trelan gabbro is intrusive into the Crousa gabbro and is therefore a later intrusion into the

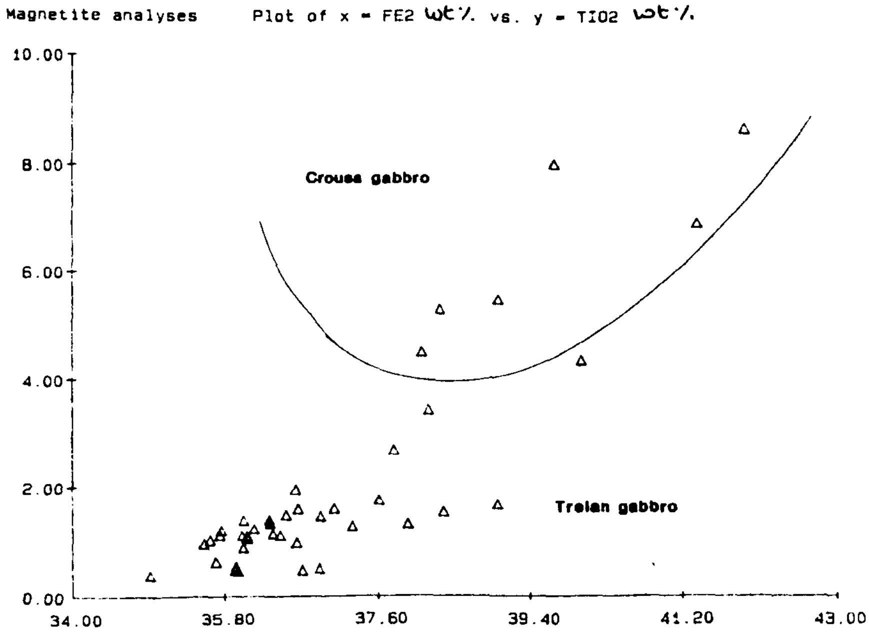


Figure 67. Plot of TiO_2 vs. FeO showing difference in magnetite compositions between Crousa gabbro and Trelan gabbro.

oceanic diapir. Additionally it may be significant that the Trelan gabbro lies approximately along strike to the cumulate zone although further work is required.

The levels of TiO_2 and V recorded in this area show a wide range of concentrations (2-7 Wt% and 150-850 ppm) with occasional zones of enrichment over an area of approximately $1km^2$. Magnetic anomalies are also associated with these zones (Rollin, in press). Ground magnetic traverses show a discontinuous zone of strong magnetic structure between Trelan and Polcoverack (3km to the east). The area around Polcoverack was not sampled during the soil mapping programme due to problems of access. These discontinuous zones identified by both the soil mapping and the geophysical surveys are considered to reflect the amounts of magnetite and ilmenite.

Ophiolites are often hosts to mineralization, particularly massive sulphide deposits and chromite. Deposits formed by secondary processes include laterites and asbestos. The massive sulphide deposits are generally restricted to the extrusive volcanic portion of ophiolites. Examples of these may be found at Troodos, Cyprus (Gass and Smewing, 1973); on the Bay of Islands, Newfoundland (Upadhyay and Strong, 1973); and in the Oman (Bailey and Coleman, 1975). During the soil mapping occasional samples showed moderately high concentrations of Ba, Cu, Pb and Zn. Most of the occurrences of minor base-metal mineralization in the area have been attributed to late-stage processes, and they are largely associated with the peridotite. Chromite deposits associated with ophiolites are generally podiform bodies (Thayer, 1964). They tend to be closely associated with either dunite pods within the metamorphic peridotite or to contact zone between the layered gabbro and peridotite in the ophiolite sequence. No anomalous concentrations of Co, Cr or Ni were found during the sampling of these areas within the Complex. The enrichment of Fe_2O_3, TiO_2 and V referred to previously in the Trelan gabbro is the only indication of possible mineralization which were found during the project.

In a review of the known iron deposits of Europe and adjacent areas, Zitzmann (1977) refers to the ilmenite-magnetite ores as liquid magmatic ore deposits. They are considered to have accumulated during early recrystallization of basic plutonic rocks mainly by gravitational differentiation in the magma. It is suggested that the main iron mineral of the liquid magmatic phase is titanomagnetite. During regional metamorphism this may be recrystallized into magnetite and ilmenite. Most work on this type of deposit has been carried out in the USSR where four types of deposit are recognized:

i) Ti-poor magnetite ores in gabbro-pyroxenite-dunite formations.

ii) Titanomagnetite-ilmenite ores in gabbro and gabbro-amphibolite intrusives.

iii) Ti-rich titanomagnetite ores in gabbro and gabbro-diabase intrusives.

iv) Perovskite-titanomagnetite and apatite-magnetite ores in

alkaline ultrabasic intrusives within carbonatites (eg. Kola Peninsula, USSR).
Most of these occur in areas of pre-Cambrian shield, although the second most important time period is connected with the Variscan orogeny. Two-thirds of the Variscan iron ore province is in the Ural Mountains of the USSR. Less important areas recognized are the Iberian Peninsula, western Europe and Central Europe.

Ilmenite-magnetite rich bodies are rarely reported in ophiolites. In an extensive search of the available literature only one reference could be found to such a body. Zuffardi (1977) in a brief review of deposits related to the Mesozoic ophioltes of Italy referred to Ti in cumulitic gabbros. These occur at Val di Vara in Western Liguria to the west of Genoa. They are described as gravitative accumulations of ilmenite and magnetite occurring in the lower sections of the ophiolitic sequence and appear to be superficially similar to the Lizard Complex. As well as the enrichment in the TiO_2, the ultrabasic portion appears to be dominated by lherzolitic peridotite.

In conclusion, whilst this unit has been recognized for the first time as a part of the Lizard Complex and its surface extent mapped, no further insight into its nature or composition is possible without borehole investigation.

7.3.3 Basaltic dykes

No extension of the dyke swarms from the coast between Godrevy Cove and Porthoustock and to the north of Coverack could be proven by the soil mapping. Whilst several generations of dykes have been recognized on the basis of field evidence (Bromley, 1973) and geochemistry (Kirby, 1984), it is considered that they play no significant role in the evolution of the Complex. Whilst the existence of the two concentrations around Porthoustock and Coverack is accepted, it is noted that basaltic dykes may be found within most of the lithological units of the Lizard Peninsula. The dykes on the west coast were described by Styles and Kirby (1979) on the basis of their chemical composition as indistinguishable from the "later" dykes on the east coast.

Other generations of basaltic dykes to have been recognized include:

a) Between Landewednack Church Cove and Kennack Sands. These are commonly found intruding into the late-stage Kennack gneiss
b) In the peridotite, notably between Coverack and Poldowrian, although also elsewhere around the coast.
c) Deformed dykes which are associated with the Old Lizard Head Series and the Traboe schists at Porthkerris Cove.

Within the typical ophiolite model the sheeted dyke complex is generally recognized as occurring as a transitional phase between the top of the gabbroic complex and the commonly pillowed basaltic complex. It has previously been argued that no extrusive material exists in the main part of the igneous complex and that the Crousa gabbro represents a late stage intrusion. It therefore follows that the concept of a sheeted dyke complex is rejected.

7.4 Obduction

Around 369my (Styles and Rundle, 1984) the igneous complex of basic and ultrabasic intrusives was thrust over a series of basaltic volcanics and metasediments (lower Landewednack hornblende schists and Old Lizard Head Series). These were then obducted from the south or southeast over what is currently recognized as the Gramscatho shales. Badham and Halls (1976)in a paper discussing the effects of microplate tectonics in southwest England suggested that oblique westwards obduction occurred in late Devonian times. Obduction was considered by Barnes and Andrews (1984) to have occurred at 250-350°C and at several kilobars pressure.

Offshore geophysical investigations (Curry et al, 1970) consider the Complex to be a small exotic block. It is thought to be approximately twice the size of the area exposed on the land. Devonian-Carboniferous sediments are thought to occur to the east and west offshore, with Permo-trias sediments to the south. The Devonian sediments of the Meneage Crush Zone to the north is not considered to be associated with the Lizard Complex in any way (Barnes, 1984). In reaching these conclusions he found that the clastic debris is not derived from the Complex and the view that it is an ophiolitic melange was rejected. It is suggested later in this section that the area between Porthkerris and Porthallow may represent a melange.

The events surrounding the obduction of the Lizard Complex are best separated into three distinct sub-sections; the basal units; the deformation associated with the early thrusting and obduction; and the formation of the Kennack gneiss.

7.4.1 Basal units

This consists of both the lower Landewednack hornblende schists and the Old Lizard Head Series which were described in Chapter 2.3. They are concentrated primarily in the southern part of the Complex where they are considered to be of related origin. Three short traverse lines between Cadgwith and Gwavas (NAS186, NAS187, NAS188) failed to identify conclusively the extension along the coast mapped by the Geological Survey (Flett, 1946) which runs towards Kennack Sands.

The traverse to the north of Cadgwith (NAS186) is considered to have intersected a lithological (?) contact. Although the majority of the samples were identified as ultrabasic in composition (S.968 showed a Kennack gneiss component), the three samples at the southern end of the line nearest to the coast gave identifications belonging to the group representing deformation zones. It is suggested that these may represent lower Landewednack material which underwent deformation during the early thrusting. It should also be noted that the deformation group has a significantly higher variance than those of the basal unit. (This is assumed, however, to be partly a function of the limited number of samples collected from these groups).

The traverse near to Gwavas Farm (NAS187) gave identifications over most of its length corresponding to the "hazburgitic" peridotite group. This group is now interpreted as being ultrabasic in composition but possessing a significant loessial component. It should also be noted that this is the area whose name has been given by the Soil Survey of England and Wales to describe one of the loess-rich soils (Staines, in press). Of additional interest is the observation that the loess content on the basis of the Zr content appears to be increasing towards the inland area. The second sample in the traverse line (S.975) is, however, identified as belonging to the lower gabbro unit. This identification may be explained by the mixing of the soils of the lower Landewednack schists with the loess (Chapter 6.5.1; Fig.55).

Finally the traverse line taken near to Prazegooth again shows some significantly high loess levels with the sample S.989 being identified as loess by the identification procedure. Several samples, however, showed very little mixing with the loess. Additionally the first two samples nearest to the coast show relatively enriched levels of Sr which would suggest the presence of Kennack gneiss close to the surface. This is, however, only speculative as the group representing this situation (UK) is not identified.

A limited amount of sampling was carried out on the west coast near Predannack Head and to the north of Mullion Cove. These were interpreted by Smith and Leake (1984) as being part of the lower Landewednack hornblende schist. Both of the traverse lines show that the soils developed in these areas are not geochemically similar to the lower Landewednack schists. Although they are interpreted as gabbroic in composition they resemble more closely the upper portion of the Crousa gabbro than the upper Landewednack hornblende schist. From field evidence this would appear to be unlikely as texturally they appear very different from the Crousa gabbro. An association with the upper Landewednack hornblende schist is only acceptable if a lateral variation within the original magma chamber could be proved. This, however, seem unlikely as the west coast hornblende schists have been noted by other workers to be complexly interfolded with the peridotite.

Although only relatively little sampling has been carried out in this area two possible solutions may be provided:

a) The rocks of this area are related to the upper Landewednack hornblende schists and their geochemical signatures are different due to lateral variation in the original magma chamber. The interfolding may in this case be a local effect. This in turn suggests that the rocks originate close to the cumulate zone in order to allow for the inclusion of the ultrabasics.

b) This unit represents another gabbroic intrusion which predates both the intrusion of the Crousa gabbro and the period of deformation which caused the formation of the upper Landewednack schists.

The presence of a considerable volume of rock from the Old Lizard Head Series within the upper Landewednack schists to the north is discounted. The traverse lines NAS171, NAS176 and NAS177 were all designed to pass over areas which were mapped by Flett (1946) as consisting of the Old Lizard Head Series. From these it is recognized that isolated samples from this area have given identifications corresponding to this group (NAS176; S.768 and S.771). Whilst it is not disputed that these observations are correct, it is felt that they represent only very small isolated bodies of this unit. This would then account for the limited number of samples identified as belonging to this group. Outcrops of this unit have also been recognized in the field by Dr.M.Styles (pers.comm.) of the British Geological Survey. They are reported as showing relatively well-preserved sedimentary structures.

Finally, the Treleague quartzite although not shown on the revised geological map of the Lizard (Fig.61), is recognized both by this work and by other workers (Chapter 2.3.7). The extent of its outcrop is, however, considered to be far less than is shown by the early geological map of the Complex (Fig.3). Whilst this unit was not sampled during the orientation survey, the soil geochemistry from this lithology was expected to be extremely anomalous. No samples from this unit were recognized as a result of the soil mapping. However, from Figure 54 several samples from the traverse lines NAS139 and NAS190, which crossed the supposed outcrop of this unit, were identified as members of the group representing deformation zones. It is suggested, partly on the basis of this, that this unit forms a very narrow zone which has been extensively deformed. This geochemical signature is considered to be the result of the mixing of fault gouge derived from the upper Landewednack schists and the Treleague quartzite. The presence of this unit, even in small quantities, still suggests that the igneous body was generated close to the continental margin (Bromley, 1979).

7.4.2 Deformation

Deformational events are considered to have played a very important aspect in the development of the Lizard Complex. Several important periods of deformation have already been referred to in varying degrees of detail in the earlier parts of the chapter. These have included the rapid uplift of the plagioclase lherzolite and the formation of the upper Landewednack hornblende schists from the original gabbroic part of the diapir. The other major events cover an early phase of high temperature thrusting which is considered to be responsible for the formation of the Kennack gneiss, and the deformation associated with obduction.

Borehole investigation has shown that considerable faulting has occurred throughout the Complex. Although Traboe boreholes 1 and 3 were sited only 75 metres apart, Leake and Styles (1984) could make no exact correlation between them due to tectonic activity. A similar situation was noted in the Predannack Downs borehole (IGS report, 1978) in which several substantial shear zones were noted in the peridotite. Faulting has also been recognized particularly in the cumulate zone and the southern contact of the Crousa gabbro from the soil geochemistry (Fig.61).

The Complex was considered by Bromley (1979) to consist of a series of separate thrust bounded units. Three units were recognized and an attempt was made to explain them as three separate ophiolite units. This conclusion, like all previous work, was based largely on coastal exposure and is in turn rejected on the basis of the inland mapping carried out during this project. The uniform almandine-amphibolite facies metamorphic assemblage found throughout the Landewednack schists was attributed by Bromley (op.cit) as the result of the stacking of a series of thrust slices in the oceanic environment.

The coastal zone between the northern end of the Porthkerris Cove and Porthallow shows an extreme variation in lithology. Most of the lithological units found within the Lizard Complex are found along this narrow strip of land. They include the peridotite, Landewednack hornblende schists, Traboe schists (similar to much of that found around Traboe in the cumulate zone), gabbro, basaltic dykes and the Kennack gneiss. The other notable feature is that the area has undergone intense deformation. The geology of this area has been extensively described by several workers including Green (1964b) and Bromley (1979). Green (op.cit) concluded that the geology showed the effects of small "highs" on the roof of a larger peridotite body which had been intruded vertically into the hornblende schist. A similar hypothesis was also suggested for the small peridotite body at Meaver, near Mullion, which was rejected earlier on the basis of a detailed gravity study (Tombs, 1977). This view has been rejected by all recent workers in the area. The area was considered by Bromley (1979) to be part of an intensely deformed and retrogressed peridotite/gabbro/sheeted dyke assemblage.

Two traverse lines took samples from the Porthkerris area. The Tregaminion Farm traverse (NAS176) was designed to cross the supposed outcrop of the mica schist and stopped near to the coast just south of Porthallow. The final five soil samples taken from the eastern end of the Tregaminion Farm traverse were identified as members of the group representing deformation zones (DZ). The previous three samples showed geochemical characteristics which could not be identified. The remainder of the line comprised largely of samples representing the upper Landewednack hornblende schists.

The second line (NAS172) took samples from along the coast path between Porthkerris and Porthallow. These provided similarly anomalous identifications to those from the eastern end of Tregaminion Farm traverse. In total 13 samples were taken along this short traverse. Two samples were assigned as "Not Identified"; four samples were recognized as being ultrabasic in composition; three as representing deformation zones; and four samples were noted to be mineralized. The mineralized samples were variously enriched in Ba(max=648ppm), Cu(140ppm), Pb(132ppm) and Zn(389ppm). Another notable feature of the samples from this traverse was the presence of high concentrations of Sn in some of the samples (mean=15.67; max=73ppm). Although no reason can be given for these anomalous concentrations, it is noted that no occurence of gravels has been recognized in this area either by previous workers or on the basis of this work. It is possible that both the anomalous concentrations of base metals and Sn could be the result of hydrothermal activity.

It is tentatively suggested here that the area might represent an ophiolitic melange which is preserved as a thin wedge at the front of the ophiolite. It is considered that this zone does not extend inland for any great distance (400 metres maximum) as the soil geochemistry is only anomalous for the most easterly samples in the area.

The wide range of lithologies is considered to be the result of a series of small thrust sheets being stacked on each other along the sole thrust of the ophiolite. This thrust has incorporated ultrabasic material, cumulate zone rocks very similar to much of that seen at Traboe, the upper Landewednack hornblende schists and the later gabbroic intrusives. In some places along the coast the peridotite appears to form an imbricated structure with distinct "beds" of ultrabasic material bounded against tectonic contacts with the Traboe schist. This stacking of thrust slices also implies that the base is very close to the surface in this area.

There has been fairly extensive secondary alteration in this zone between Porthkerris and Porthallow. Epidote may be found in the gabbro, both in fine fractures and as more massive units in excess of 50cm in width. Asbestos, talc and serpentine minerals may be found in fractures and at tectonic contacts in the peridotite. A weakly mineralized gossan was recognized by the BGS during some mapping work in the area (Dr.R.C.Leake, pers.comm.).

Much of the deformation which has affected the area at the northern end of the Porthkerris Cove appears to have taken place at elevated temperatures. This has resulted in the local development of distinct segregation of mafic and felsic minerals. The grain size of the gabbroic material shows a large degree of variation ranging from a mylonitic hornblende schist through to pegmatitic gabbro. The hornblende schist often shows augen of uralitized pyroxenes. Plate 16 shows a typical example of the deformed gabbro with a variable grain size.

Finally, the reason for the presence of the isolated bodies of the Old Lizard Head Series referred to earlier in the earlier section remains a mystery. It is considered that the only reasonable explanation for the inclusion of these

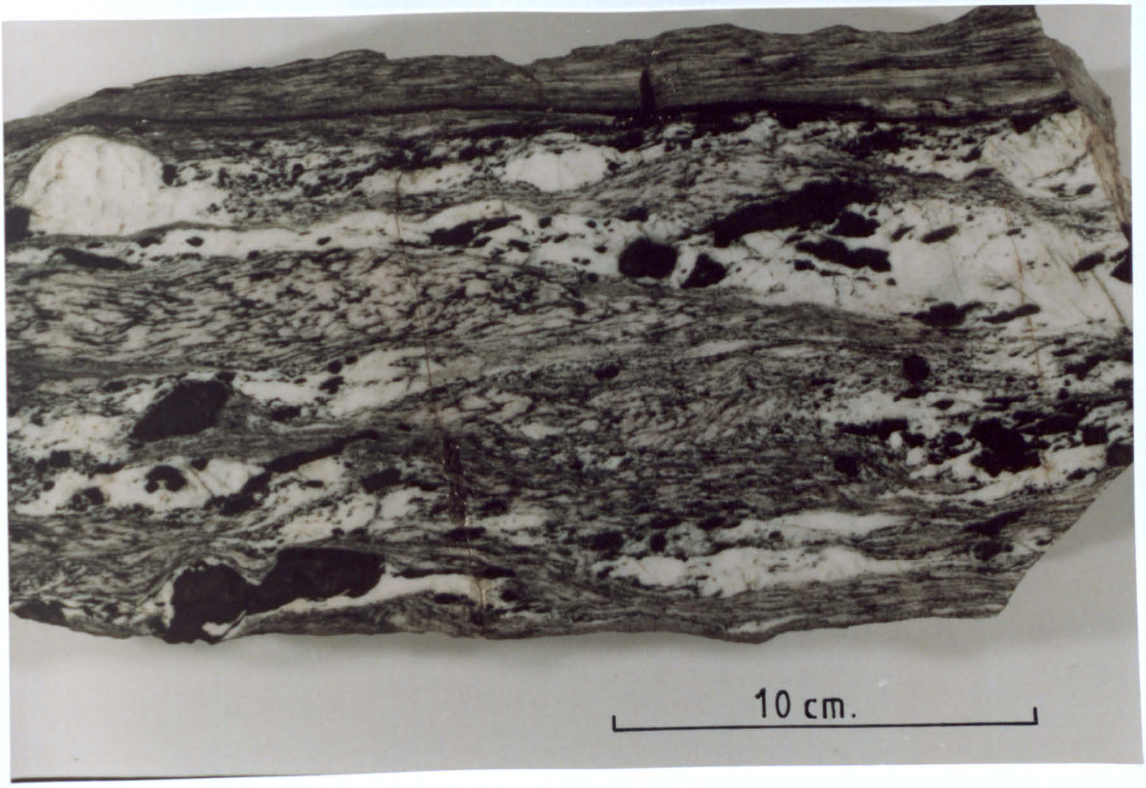


Plate 16. Typical example of the deformed gabbro found to the north end of Porthkerris Cove showing variation from hornblende schist to pegmatitic gabbro.

bodies in the upper Landewednack schists is if they were incorporated in some way with the schists during deformational movement.

7.4.3 Kennack gneiss

The early geological map of the Complex (Fig.3) showed that the Kennack gneiss may be found at the surface over a large area of the main ultrabasic outcrop. The results of the limited soil sampling carried out here, however, suggest that the unit has a very poor surface exposure. Three traverse lines were specifically sampled over "known" outcrops of Kennack gneiss (NAS130, NAS131, NAS133). Additionally the three coastal traverses to the southeast between Cadgwith and Gwavas (NAS186, NAS187, NAS188) were expected to show indications of Kennack gneiss. None of the coastal traverses identified the gneiss, although two of the samples showed moderately high Sr concentrations. Figure 54c shows that only 6 samples collected from the inland localities were identified as representing the Kennack gneiss. A larger number of samples (27) were identified as showing a significant Kennack gneiss component (group "UK"). This group was described earlier in Chapter 6.4.1 and is considered to represent areas where the Kennack gneiss may be found close to the surface, although in the absence of borehole information the depth below surface of the gneiss is unknown.

Although in situ gneiss has never been found on the elevated platform of the Complex, it is accepted that it may be found inland towards the base of the steep-sided valleys on the southeastern part of the area. It may also be found at a number of other localities around the coast:

a) In the peridotite at Kynance, Gew Graze and Vellan Head.

b) In the gabbro at Pen Voose Cove.

c) In the Traboe schist on the west coast at George's Cove and at Porthkerris Cove on the east coast.

On the basis of its known outcrop and on the results from the soil geochemistry it is suggested that the Kennack gneiss represents a large, late-stage granitic intrusion. The basic portion of the gneiss is considered to be derived from the lower Landewednack hornblende schists. This may explain its limited presence at depth in the Kennack Sands borehole, and also why it is not reported inland at higher elevations. The amphibolite occurs in a variety of forms ranging from a blocky xenolithic character (in its least deformed state) to a "flow-banded" gneiss. The latter type is considered to represent a situation in which the basic material has undergone high temperature deformation.

A migmatitic origin as a result of high temperature deformation is considered to be unlikely. It is suggested that the generation of 150+ metres of gneissic material can not be adequately explained by such a mechanism. The gravity survey carried out by the BGS (Rollin, in press) has suggested that the peridotite and gneiss are at least 400 metres thick northwest of Kennack Sands. At Ruan Major to the southwest it is considered to be approximately 150 metres thick. It again seems unlikely that this variation in thickness is the product of anatexis of the underlying lavas and metasediments in zones of high temperature thrusting prior to emplacement.

An intrusive origin would account most easily for the large quantities; for its presence in inland areas where the peridotite is believed to be at least 150 metres thick (Rollin, in press); and also for its apparently intrusive relationship into the peridotite. The latter point includes the dykes of Kennack gneiss intruding into the peridotite at Kennack Sands, and the xenoliths of peridotite in the Kennack gneiss at the same location.

The interlayering of the peridotite and Kennack gneiss described by Styles and Kirby (1979) towards the base of the Kennack Sands borehole may be similarly explained by an intrusive mechanism. The borehole has also shown that the contact between the peridotite and the Kennack gneiss is far more complex and wider than the well defined contact between the hornblende schist and the peridotite seen in the Predannack Downs borehole and on the southeast coast of the Complex. The latter two contacts also show considerable evidence indicating that they represent a major thrust zone with an inverted metamorphic aureole.

If the Kennack gneiss is associated with the sole thrust of the Complex as suggested by Styles and Kirby (1979) then an adequate explanation must be provided as to why the gneiss is not found anywhere else along the coast in large quantities. This is particularly pertinent to the areas around the north of the Complex where it thins.

Geophysical techniques have not been particularly successful in identifying the extent of the outcrop of this unit. Gravity surveys were described by Rollin (in press) as being of little use as a mapping tool in distinguishing the peridotite and gneiss as they have similar densities. Similarly, modelling of the data and its interpretation requires a good knowledge of the variations in lithology at depth.

Aeromagnetic surveys appear to have had limited success as the zones of highest magnetic relief in the western peridotite appear to be coincident with areas containing small outcrops of gneissic rocks. A point made by Rollin (in press) in discussing the application of the aeromagnetic technique, and the effect of stable remnant magnetization (NRM) on the rocks of the Lizard Complex, is considered to be pertinent here:

> "different rocks types on the Lizard might have ... different resultant magnetization vectors. This seriously limits the reliability of quantitative modelling."

Additionally it is suggested here that another important factor should be taken into consideration regarding the application of many geophysical techniques in the area. The peridotite which is the dominant unit in the area has been noted by several workers to have undergone varying degrees of serpentinization. The water content of the rock is considerably increased by this process and would be expected to alter the geophysical properties of the rock. With respect to the application of magnetic surveys over variably serpentinized peridotite it is also noted that magnetite is one of the products of the process.

7.5 Ophiolite vs. Oceanic diapir

Two basic interpretations to account for the origin of much of the Lizard Complex have been developed in the last 25 years:

a) It is a high temperature intrusive diapir.

b) It is a segment of oceanic lithosphere.

The possibility that it represents an *in situ* diapir has been discounted by most workers. The Predannack Downs borehole (IGS report, 1978) shows the peridotite has a sheet-like structure. Gravity surveys (Rollin, in press) and seismic refraction surveys (Brooks et al, 1984) have both shown that the Complex has a limited vertical thickness.

Floyd (1976) considered that "The two interpretations (described above) may not be mutually exclusive as tectonically emplaced peridotites may form part of the oceanic crust". This view is supported on the basis of the results of this work. The answer must lie in the combination of the two interpretations. There is no reason with the available information to deny a diapiric mass which has undergone rapid uplift into the upper levels of the oceanic crust with subsequent emplacement onto the continent.

The term ophiolite is currently used to describe an assemblage of basic and ultrabasic rocks. Its present day usage was defined by the Geological Society of America's Penrose Conference (Anon., 1972). It was proposed that the term ophiolite

> "refers to a distinct assemblage of mafic to ultramafic rocks. It should not be used as a rock name or a lithological unit in mapping. In a completely developed ophiolite the rock types occur in the following sequence, starting from the bottom and working up:
>
> -Ultramafic complex
>
> consisting of variable proportions of harzburgite, lherzolite and dunite usually with a metamorphic fabric (more or less serpentinized).
>
> -Gabbroic complex
>
> ordinarily with cumulus textures commonly containing cumulus peridotites and pyroxenites and usually less deformed than the ultramafic complex.
>
> -Mafic sheeted dyke complex.
>
> -Mafic volcanic complex, commonly pillowed.
>
> Associated rock types include (1) an overlying sedimentary section typically including ribbon cherts, thin shale interbeds and minor limestones (2) podiform bodies of chromite generally associated with dunite (3) sodic felsic intrusive and extrusive rocks.
>
> Faulted contacts between mappable units are common. Whole sections may be missing. An ophiolite may be incomplete, dismembered, or metamorphosed ophiolite."

Under these criteria the term "incomplete ophiolite" should be applied to the Lizard Complex. The succession of ultramafic through cumulate complex to gabbro as described by the GSA Penrose Conference is present. No sheeted dyke and volcanic complexes are identified and the associated sedimentary sequence is also absent (Barnes, 1984).

Although a diapiric mechanism is favoured for generation of the ultrabasic and early gabbroic rocks, rather than one associated with a spreading ridge, it is noted elsewhere in the definition of the term "ophiolite" that although the term "is interpreted to be oceanic crust and upper mantle the use of the term should be independent of its supposed origin".

The short time period between the formation of the Crousa gabbro and the Kennack gneiss (assuming that these dates closely approximate to the primary igneous cooling and emplacement respectively) is not unusual. Coleman (1977) in a survey of several ophiolites and the time period between formation and obduction observed that the time span was generally between 5 and 35my.

The two remaining problems are the presence of a large proportion of lherzolitic peridotite and the presence of later extrusive bodies. The former may only be successfully explained by a mantle diapir model and/or by the action of deep fundamental faults. Finally, there is no reference in the definition of the term ophiolite provided by the Penrose Conference to describe the presence of later intrusive bodies. It is noted, however, that late-stage gabbroic intrusions of oceanic compositions have been described by Smewing (1980) intruding into the cumulate complex of the Oman ophiolite.

7.6 Tertiary events

Three events of major significance to both the history of the Complex and also the application of the mapping technique to this area occurred during this period. Chronologically these include the effects of intensive weathering on the Complex together with the deposition of the Crousa gravels and the development of the loess sheets. The most important of these to the application of the mapping technique was the extensive sub-tropical weathering which occurred during this time (Bristow, 1977). This caused the unusual depths of soils which developed in the area. It is suggested, however, that there must have been at least two periods of relatively intensive weathering. The most extreme occurring prior to the deposition of the Crousa gravels. The power auger programme showed the development of a substantial thickness of residual soil beneath the gravels.

Figure 68 shows the geochemistry for several elements down a particular profile (BX_3181). The first 5 metres of the profile are interpreted as being part of the Crousa gravel. At approximately 6 metres the geochemistry indicates the presence of a residual gabbroic soil. This extends to the base of the profile at 10 metres.

The second period of relatively intensive weathering accounts for the extensive translocation of clays in the soils

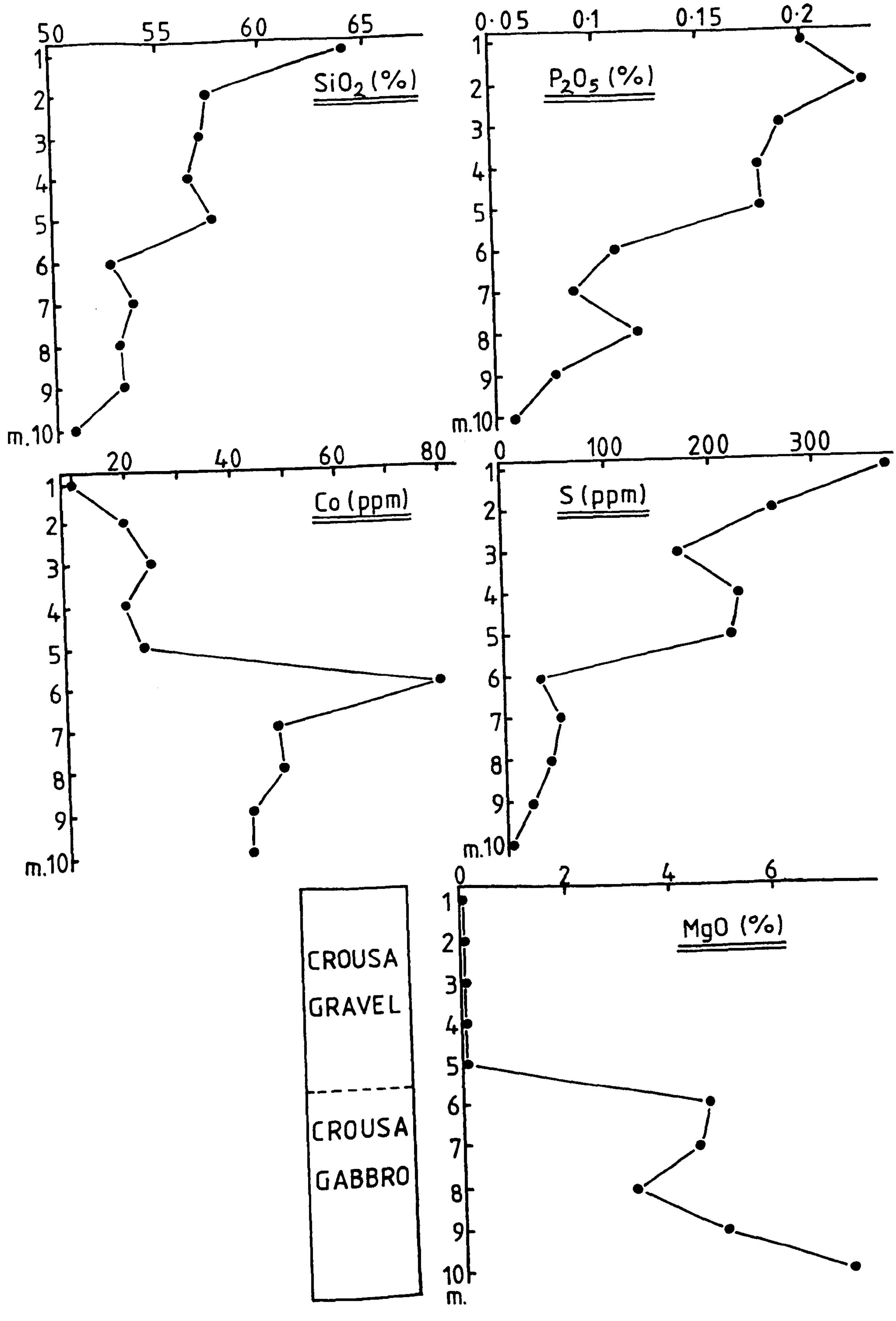


Figure 68. Profile through Crousa gravel showing a substantial thickness of gabbroic soils developed below the gravels. (BX_3181)

over the Crousa gravels which has been noted by the Soil Survey of England and Wales (Staines, in press).

A final point connected with the influences of weathering on the current form of the Complex concerns the early Pliocene or Miocene wave-cut platform which was described by Flett (1946). This date was largely based on observations made by Reid (1890), who first suggested the Pliocene origin for the platform. Its development was related to the recognition of the fossiliferous St.Erth Beds of south Cornwall. It is suggested here that if the form of the Complex is to be attributed to marine action, the wave-cut platform must have developed earlier in the Tertiary than has previously been suggested. This would then allow for a substantial thickness of soil to develop prior to the deposition of the gravels.

The development of the loess sheets represents the final stage in the evolution of the area. Its deposition occurred in the Devensian (Wintle, 1981) and resulted in a veneer of loessial material being spread over the areas of the Complex which exhibit a low relief. These particularly included the Goonhilly Downs, the area inland of Gwavas and Arrowan Common inland from Black Head. It is also responsible for causing the most serious problems to the mapping programme.

7.6.1 Crousa gravels

Although the overall extent of this unit is now better known there remain many problems in understanding its origin. The Crousa gravels were described by Flett (1946) as being

Pliocene in age and having a marine origin. They were compared in the Memoir to the high level gravels found at Polcrebo which have been described by Hill and MacAlister (1906). Other deposits which may also be found include those around St.Agnes (Reid and Scrivenor, 1906), at Hele near Barnstaple and on the Scilly Isles (Mitchell, 1960). None of these deposits, however, are fossiliferous and only their relationship to the "Pliocene platform" discussed earlier links them to a dateable deposit. Kidson and Wood (1974) demonstrated that the Hele gravels are not of marine origin but are glacial outwash deposits.

During the latter stages of this work an attempt was made to use pollen dating techniques. A number of bulk samples were collected from the gravels which were dried and then dissolved in hydrofluoric acid by Dr.D.Holyoak of the Geography Department at Nottingham University. The resulting pollen, which is insoluble, was found to be too oxidized to be of any further use. A similar attempt was made by Dr.J.Scourse of the Godwin Laboratory at Cambridge University with similar results. Some pollen of possible early Tertiary age were recognized but were too oxidized to be fully described (Dr.J.Scourse, pers.comm.).

During the geochemical analysis of the Crousa gravels collected by the Minuteman power auger moderately high levels of Sn together with minor W were discovered. The maximum concentration of Sn analyzed from the gravels was 198 ppm (BXS3181g). The overall mean concentrations of Sn and W were

42 ppm and 10 ppm respectively. In sampling at one metre intervals down the profile varying levels of Sn were recognized. Insufficient samples were, however, collected to allow for correlations to be made between different holes. The response to periglacial activity which was noted by Flett (1946) and also by Staines (in press) would have seriously affected any attempt at stratigraphic correlations.

The above levels of Sn and W together with the recognition of vein-quartz similar to that found in the killas to the north, and the prescence of tourmaline and mica in the washed portion of the gravels suggests the origin of much of the finer material was from the north. It is therefore reasonable to suggest that they were deposited after transportation (by an unknown medium) from this direction. The other major components found in the washed gravels were fragments of gabbroic material and fine ilmenite sand, both of which are considered to be locally derived.

The presence of the large gabbro boulders (some of which are in excess of 30 tonnes in weight) are, however, extremely difficult to explain. They are not considered to be _in situ_ as was suggested by Flett (1946). In many localities where they have not been moved by farming they are underlain by gravels which frequently exceed 10 metres in thickness.

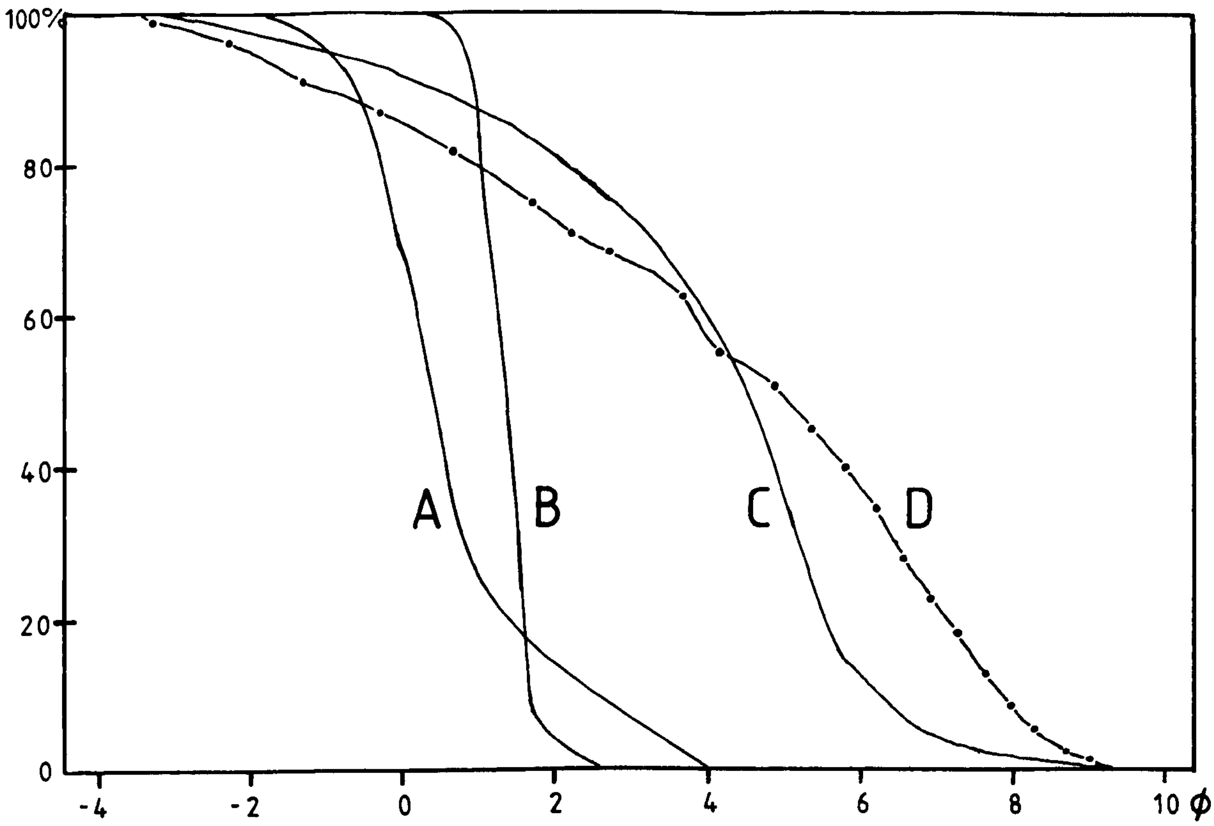
A source of these boulders is therefore one of the first questions that must be answered prior to any explanation of a mechanism which would be capable of moving these boulders. Figure 61 shows that the northern limit of the Crousa gabbro coincides with the outcrop of the gravels, and therefore it seems unlikely that they originate from the same direction as most of the finer material. Additionally they are also noted as occurring over the upper Landewednack hornblende schists to the north of the gabbro although in lesser quantities. Geophysical evidence (Curry et al,1970; Rollin, in press) suggests that the gabbro does not extend to the east offshore for any great distance.

The boulders must have originated from a relatively narrow coastal strip. Although no geochemical analyses of the boulders were made this suggestion is supported by several other points. The boulders have relatively well-rounded edges and show very little indication of weathering. Similar boulders and promontories may be found on the coast and are considered to be the result not of atmospheric or sub-areal erosion but marine erosion. It is believed that only the sea is capable of causing the smoothing which is found on all the inland gabbro boulders. They are too strong and resistant to weathering to be eroded by any other mechanism. They originate from a narrow coastal strip between a point just north of North Corner near Coverack and Dean Point. In a visual survey of many of the boulders around Crousa Common, Crousa Down and to the east towards Dean Point, no boulders could be found that included either the ultrabasic or the basaltic dykes. A second direction of transport from the southeast must be recognized to account for these boulders.

An overall solution allowing for an explanation of the gravels and the associated boulders is extremely difficult, and is probably best left to workers more familiar with the history of the Tertiary. A number of comments and suggestions, however, are made below:

The two logical routes to follow are that either the deposition of the gravels and the boulders are related or that they are not related and occurred at different times. A major difficulty if they were deposited at the same time is their almost opposite directions of origin and also their size difference. A fluvial origin remains the most acceptable explanation for the gravels. This would explain the horizontal stratification which was described by Flett (1946). The minor folding described in the top 3 metres is easily attributed to periglacial activity. The wide range of particle sizes, however, still causes some problems. Figure 69 shows the particle size distribution for a sample of Crousa gravel. It describes both extremely coarse material ($<-3\Phi$) together with extremely fine clay. The small jump in the curve at approximately 3.7 phi is due to a change in the sizing technique. The larger fragments were sized using traditional wet-screening techniques whilst the finer material was sized using a Malvern 2600/3600 laser particle sizer.

Under fluvial conditions it is difficult to envisage conditions where both coarse and fine grained material would be deposited together. Although some of the clays could have originated as a result of translocation during the soil-forming process, it is unlikely that the answer lies entirely



A. Typical poorly-sorted stream gravel

B. Typical well-sorted beach gravel

C. Typical glacial boulder clay

D. Crousa gravel sample

(A,B,C from Greensmith, 1978)

Figure 69. Comparison between the particle size distribution curve for the Crousa gravel and other selected sediments.

with this mechanism. The curve does, however, show a good similarity with that one from a boulder clay.

It seems unlikely that the gabbro boulders were transported by fluvial processes. Although marine action may move these boulders short distances during heavy storms, it is not considered to be feasible that they should have been moved over 2 kilometres to a position 110 metres OD. It is suggested that glacial activity is the only plausible explanation which could achieve this degree of movement.

An ice-rafting mechanism is considered to be one possible solution although why the boulders should be concentrated at a topographic high is uncertain. The presence of the finer grained gabbroic fragments may also be explained by this theory. A second mechanism would, however, still be required for the northerly derived material.

Another possible glacial mechanism would require the resurrection of an idea first put forward by Kellaway (1971) and Kellaway et al (1975). This proposed that two major ice sheets reached the English Channel, as an extension of the Irish Sea ice sheet during the Anglian (274,000 years) or Wolstonian (161,000 years) glaciations. This would provide a method of transportation for the boulders and finer material. A reason for the lack of killas material derived from the north must, however, be explained before the gravels are reinterpreted as a glacial till.

If such an ice sheet did once extend from the Irish Sea onto the mainland of southwest England and if it extended as far as the Lizard Peninsula both the boulders and the finer fragments could have been deposited as the ice retreated. This hypothesis could also account for erratics such as the Giant's Rock near Porthleven. This is a 50 tonne boulder of microcline gneiss of unknown origin. A major problem with this is to explain why the residual soils were not removed by the action of the ice.

A final alternative might be an ice-dam which trapped both the gravels and boulders. Although initially derived from the north, the gravels could then have been washed by rivers and the sea to a position off the east coast of the Lizard Complex. If this dam was subsequently breached the trapped material and the large boulders could have then been transported northwards. In this instance the boulders would be expected to be deposited very quickly whilst the fragments were scattered over large areas of southern Cornwall.

CHAPTER 8

CONCLUSIONS

Conclusions

The conclusions arising from this work may be sub-divided into two separate disciplines; statistics and geology:

a) Statistics

It was realized at a very early stage in the work that the task of mapping the inland geology of the Complex could most easily be accomplished by the use of a wide variety of univariate and multivariate statistical techniques. These had numerous applications which included geochemical analysis together with sample classification and identification. A summary of a selection of these is provided below:

It has been shown that improved analyses of pressed powder pellets by X-ray fluorescence spectrometry may be obtained if a multiple linear regression approach is used. It is also suggested that the regression coefficients should be re-calculated for each analytical run. It is considered that periodically a stepwise procedure for selecting the most effective variables for a pre-determined set of standards should be used.

A powerful non-hierarchical clustering technique has been described. The K-means algorithm has many distinct advantages over some of the other multivariate statistical techniques currently being used; there is no requirement for any population distribution, it is simple to use, it can handle very large amounts of data without the serious storage problems encountered by hierarchical cluster algorithms and it is very rapid in its operation.

A versatile identification procedure has been described. This uses a variety of statistical techniques, the selection of which reflects the degree of difficulty in recognising any particular unit. The most powerful of these techniques employs a modified version of the K-means algorithm. In this form the technique becomes an identification tool and is capable of taking the variances of groups into account prior to the assignment of an identity to an unknown.

Although the classificatory and identificatory procedures described have been used here as effective tools in the classification and delineation of lithologies in areas of very poor exposure, it is stressed that they could be applied to the classification and subsequent identification of any other geochemical data set.

b) Geology

The original aim of this work was to attempt to map the inland geology of the Lizard Complex. This was to be achieved using the geochemistry of the residual soils of the area. Following the interpretation of the geochemical data a revised map is presented. This in many instances confirms the geology as interpreted by previous workers. It does, however, also allow for several major revisions to be made to the established map of geological the Complex:

i) Rocks of gabbroic composition have been found to be far more abundant, complex and variable than was previously recognized. The Crousa gabbro is considered to be a late-stage intrusion. This shows a discordant contact with the upper Landewednack hornblende schist to the north, and has resulted in a zone of alternating ultrabasic and basic rocks on its southern contact. The Upper Landewednack schists are considered to cover a large area to the south of its currently accepted boundary. Additionally the full extent of the Trelan gabbro has been mapped.

ii) The Crousa gravels have been shown to cover a slightly larger area than previously thought. It has also been shown that it has been affected by significant downslope movement. This is particularly noticeable in a broad arc from the southwest to the east of the known outcrop, although it has also affected other areas towards the north.

iii) It is now considered that the the Kennack gneiss is not as widespread inland as reported by the geological map of 1946. It is, however, suggested on the basis of the soil geochemistry that it may be found very close to the surface in many of the inland areas. It is also accepted from field evidence that it can be found outcropping in many valley bottoms.

iv) Although samples representing the Old Lizard Head Series have been identified within the upper Landewednack hornblende schist it has been shown not to be as widespread as indicated by the established geological map.

v) It has been found that it is possible to identify zones within which deformation has occurred using the residual soil geochemistry. On the basis of this it is suggested that given more intensive sampling, a full picture of the deformational events which occurred during the evolution of the Complex could be described.

vi) Loess has been shown to be widespread over much of the inland areas of the Complex. It has been a particularly serious problem over areas of low relief such as Goonhilly Downs and Arrowan Common. This low relief is principally developed over the ultrabasic rocks and to a lesser extent the downslope areas of the Crousa gravels. Severe difficulties have in turn been caused in the recognition of different varieties of the ultrabasic.

On the basis of the revised geological map it has been possible to re-interpret the evolutionary history of the Lizard Complex. A major conclusion is that although obduction of the Complex onto the continent is considered to be the most plausible process by which emplacement could occur, it is suggested that the gabbroic and ultrabasic material formed as an oceanic diapir. This never resulted in the formation of extrusive or hyperbyssal basalts and occurred in several stages. The ultrabasic, a cumulate zone and a gabbroic body which after deformation became the upper Landewednack hornblende schists were formed first. Subsequently the Crousa gabbro and the Trelan gabbro were intruded. This occurred at a later stage in the evolution of the Complex when different conditions existed. This could explain the presence of the highly differentiated igneous succession which is seen on the coast. It would also allow for the generation of ilmenite and magnetite-rich gabbro around Trelan and cumulate apatite as found in Dean Quarry.

The Kennack gneiss is considered to have formed as a response to the early thrusting which occurred prior to obduction. This would then account for the late stage at which formation took place and also for a cold emplacement of the ophiolite slab. Finally a glacial origin is suggested as responsible for the development of the Crousa gravels.

It is considered that future work in the area should include the drilling of a series of short drillholes. These would best be able to recognize the complexity of the geology of this area. In the likely event that this is not possible, more detailed sampling of the residual soils would also provide much additional information. It is felt that any further soil sampling should concentrate on the inland extent of the Kennack gneiss and on the variation in the ultrabasic body. The nature and origin of the gneiss, in particular, remains perhaps the most controversial and enigmatic question to be answered. It is further suggested that any further samples should be taken from a greater depth than 70cm. This may then possibly avoid the many problems that arose as a result of the intermixing of exotic material, especially on the elevated platform of the Complex.

APPENDICES

A. <u>Computer programs and subroutines</u>

This Appendix is divided into two parts and includes listing of many of the programs and subroutines which were written for use during this project. Whilst all the programs referred to in the text are described briefly below, not all of them are listed. Only those programs representing new or important approaches associated with this work have detailed listings. The programs which are not listed are generally concerned with data handling tasks or use numerical methods which are well documented elsewhere. The listings of these are available if required for a specific purpose.

The first section contains program listings. These are listed in the order in which they were referred to in the main body of the text.

XRFA .. XRF data processing program.

<u>Option 1.</u> Creates a RAW-file equivalent which comprises composition details of standards (read in from a Standards File) and Count Ratios of each element analysed. File subsequently used by program MLR to calculate the regression coefficients needed by the second option.

<u>Option 2.</u> Uses regression coefficients computed by MLR to calculate the major element compositions of individual sample after XRF analysis.

MLR .. Multiple regression program.

Regression may be carried out in conjunction with RAW-file created by XRFA or separate RAW-file. Dependant variable selected by user.

INVAL .. Program to insert/remove data into/from a VAL-file produced by XRF analysis. (No listing provided).

Option 1. To overwrite the original VAL-file with ten major element values calculated using the multiple regression approach.

Option 2. To insert/remove up to 12 elements into/from a VAL-file.

CVAL .. Short program to alter the value of one element in a VAL-file by simple regression of the form; $Y = mX + c$.

(No listing provided).

ERR1 .. Fixed ANOVA calculation. (No listing provided).

ERR2 .. Random ANOVA calculation. (No listing provided).

OEG .. Program to produce one element graphs for upto 20 groups.

Program to be used on VT240 series terminals only.

Graphs may be written to file for plotting on HP7475A plotter.

(No listing provided).

GRA .. Program producing graphs from RAW-files.

Option 1. Traverse line plots. May read up to 8 equal length files for simultaneous plotting.

Option 2. XY-plots. May read up to 8 files (groups) for simultaneous plotting.

(No listing provided).

MAV .. Program to perform a moving averages calculation on traverse line data. (No listing provided).

STA .. Basic statistics program. (No listing provided).

Options:
- 0....Basic statistics only.
- 1....Basic statistics and correlation coefficients.
- 2....Basic statistics and histograms.
- 3....Basic statistics,correlation coefficients and histograms.
- 4....Histogram only.

KMN .. Non-hierarchical k-means clustering program.

Initial seed point may be selected in a variety of ways:

First file to be read assumed to contain seed points;

Best seed points selected using FSEED subroutine;

Optimum number of clusters selected using FSEED & GRAPH subroutines.

Other options include assessment of relative importance of variables.

Program also includes the modified version of the k-means algorithm used by identification procedure (IDN) with the following options.

Assign each sample to nearest seed point (one pass only);

Record distance of unknown from selected seed centroid.

Calculate distances between seed centroids;

DSC .. Program to calculate the linear discriminant function between two sets of data held in RAW-files.

IED .. Editor for direct access files xxx.IDN required by program IDN. Editor will create, list, alter or copy file into a formatted sequential file.

IDN .. Identification program using direct access files xxx.IDN created by editor IED.

Program takes one sample at a time from a RAW-file & attempts to make an identification. Results sent to screen or file.

Options include:

Default ... Uses all xxx.IDN to identifying "unknown";

C .... Uses clustering option only (ignores rest);

D .... Records distance from specified seed centroid in file DREF.RAW.

MIX .. Program to combine seed centroids of various groups.

50/50, 66/33, 33/66, 75/25, 25/75 calculated.

Results sent to MIX.RAW for later use with IDN.

MPC .. Program to carry out microprobe calculations.

Reads in wt% oxides held in .RAW-file. (Fe must be in form FeO)

Calculates Fe^{2+}/Fe^{3+} proportions from electron microprobe analyses where necessary.

Calculates cation proportions & additional useful parameters.

User must specify mineral group sample belongs to.

(No listing provided).

There is considerable documentation within each program listing. This is an aid both to other users and also to the original programmer who two years after writing the program tends to forget the logic involved in the program.

The second part of this Appendix lists, in alphabetical order, the subroutines and functions used by the programs which are listed and were described above.

```
      PROGRAM SETD
C     XRF data processing.
C     Program to read in data from a specified IPF & REQ file.
C     Two options;
C         Option S creates a file fred.RDT which consists of
C         composition details of each element analysed in the
C         standards (eg. Fe%) read in from the Standards File
C         by GETSTD,followed by details of the Count Ratios
C         of each element analysed in the standards (eg. FeC).
C         This can then be used in the program MLR to calculate the
C         regression coefficients needed for Option P.
C         RDT-file is an early version of the RAW-file used in other
C         programs.
C
C         Option P used with the regression coefficients computed
C         in MLR to calculate the major element compositions of
C         each sample. Program ensures,if required,that the values
C         calculated from the regression coeffs fall within the
C         range of the standards values read in from a previously
C         constructed file MINMAX.NAS. A warning is posted if they
C         fall more than 25% under or 5% over...as this could make
C         the regression unstable.
C
C     Subroutines used:   CEXTEN  GETSTD
C
C     ****************************************************************
      LOGICAL *1 FILE(30),CMD,XTITLE(80),FBUF(80),QFILE(30),XNAME(10),
     1    STD(30),XELEM(8),IO(282),AFILE(30),ORR(10)
C
      INTEGER TT,DK1,DK2,IADD(50),SN1(282),NM1(282)
C
      REAL *4 NAME,SPAC
      REAL *8 ELEM(30),SN2(282),NM2(282),SMP,HADDR(11)
C
      DIMENSION CR(282,20),CONC(10),B(10,11),PCR(10),VALS(10),CMIN(10),
     1    CMAX(10),XMIN(10),XMAX(10)
C
      EQUIVALENCE (PCR,CONC),(CR(1,11),CMAX),(CR(1,12),B),
     1    (CR(1,13),XMIN),(CR(1,15),XMAX),(CR(1,16),CMIN)
C
      DATA TT,DK1,DK2,KX,LEN,LVAL,MLEN/5,1,2,0,2*50,30/
      DATA STD/'R','E','F','S','T','D','.','S','T','D',20*'0/
      DATA FBUF/'(','B','F','1','5',',','6',')',72*'0/
      DATA SPAC/' ar '/
C     ****************************************************************
C
C     Which option required
  149 WRITE (TT,98)
      READ (TT,99)CMD                          !Type 'S','P' or <ret>
C
      IF (CMD.EQ.' ') GOTO 500
      IF(CMD.EQ.'P') GOTO 150
      IF(CMD.EQ.'S') GOTO 150
      GOTO 149
C
C     Open and read .IPF-file & .REQ-file
  150  WRITE (TT,100)
      READ (TT,101) NF,FILE
      IF (NF.EQ.0) GOTO 500               !If <ret> pressed...leave program
C                                          without reading .IPF-file
      NQ=NF
      NA=NF
C
      DO 155 I=1,30
C     Receives name of .REQ-file
      QFILE(I)=FILE(I)
      IF(CMD.NE.'P') GOTO 155
C     Receives name of .RES-file
      AFILE(I)=FILE(I)
  155 CONTINUE
C
C     Call extension check subroutine
      CALL CEXTEN(FILE,NF,MLEN,'I','P','F')
      OPEN (UNIT=DK1,TYPE='OLD',NAME=FILE,ERR=400)
C
C     Open .REQ-file & read in sample names.
C     Name of file already given when .IPF-file name was requested(re.FILE)
      CALL CEXTEN(QFILE,NQ,MLEN,'R','E','Q')
      OPEN(UNIT=DK2,TYPE='OLD',NAME=QFILE,ERR=407)
C
      IF(CMD.NE.'S') GOTO 160
C     ...............................................................
C
C     Inputing all other filenames needed to run prog under option 'P'
C
C     Asks for name of standards file --s.RDT
      WRITE(TT,110)
      READ(TT,101) NX,FILE
      IF (NX.EQ.0) GOTO 500               !If <ret> pressed...leave program
C                                  without entering info into .RDT
```

```
C     XRFA continued.
C     Asks for title of file.KD1
      WRITE (TT,112)
      READ(TT,113)(XTITLE(I),I=1,80)
C     ..............................................................
C
C     Extracting sample names from .REQ-file.
  160 READ(DK2,126) NAME
C
      IF(NAME.NE.'NOTT') GOTO 160
      NELEM=0
C
  165 NELEM=NELEM+1
      READ(DK2,128) NAME
      IF (NELEM.NE.10) GOTO 165
      GOTO 171
C
  170 READ(DK2,126) NAME          !Dummy read to skip element names
C
  171 IF(NAME.NE.'SAMP') GOTO 170
      KT=0
C
  180 READ(DK2,127) NAME,(NM1(KT+I),NM2(KT+I),I=1,6)
      IF(NAME.EQ.'END ') GOTO 192
      KT=KT+6
      GOTO 180
C
  192 CLOSE(UNIT=DK2)
C     ..............................................................
C
C     Section used by options 'S' & 'P'
C     Zero variables
      KN=0
      KS=0
C
C     Look at each sample in .IPF-file in turn
C     Read in header info
      READ (DK1,102) NEL
      DO 193 I=1,NEL
  193 READ (DK1,104) ELEM(I)
      GOTO 196
C
  194 DO 195 I=1,NEL
  195 READ (DK1,106)              !Dummy read to skip monitor
C
C     Read in tray name
  196 READ (DK1,104) SMP
      IF(SMP.EQ.'****    ') GOTO 235
      IF(SMP.EQ.'MONITOR ') GOTO 194
C
  205 KS=KS+1
      IF(NM1(KS).EQ.'. ') GOTO 205              !Empty position in tray
C                                               -- No .IPF-data
C     Read in data provisionally
      DO 197 I=1,NELEM
  197 READ(DK1,106) PCR(I)
      IF(NELEM.EQ.NEL) GOTO 206
      DO 198 I=1,(NEL-NELEM)
  198 READ(DK1,106)               !Dummy read to skip trace element data
C
C     Encode field name of sample
  206 ENCODE(2,99,XNAME) NM1(KS)
C
C     Decide whether info in XNAME is required or not
      IF(CMD.EQ.'S'.AND.XNAME(1).NE.':') GOTO 234
C
C     Info in XNAME is required
      KN=KN+1
C     Set address of NM1(KS) & NM2(KS) for later use
      SN1(KN)=NM1(KS)
      SN2(KN)=NM2(KS)
C
C     Read in count ratio data from PCR
      DO 215 I=1,NELEM
  215 CR(KN,I)=PCR(I)
C     Where CR(KN,I) equals CR(Field no.,Element id.)
C
C     Return for new tray name.
  234 GOTO 196
C
C
  235 CLOSE(UNIT=DK1)
C
      IF((KT/6).LE.47) GOTO 236
      WRITE(TT,1142)
 1142 FORMAT(/' Exit ... Too many trays (>47)')
      GOTO 500
C
  236 WRITE(TT,1132) KN,NELEM
 1132 FORMAT(/' Total no.of samples in .IPF-file; 'I3,/
     1      ' Total no.of elements in .IPF-file; 'I2/)
```

```
C       XRFA continued.
C
        IF (CMD.EQ.'P') GOTO 286
C       ..............................................................
C
C       Section used by option 'S' only
C       Read STD-file
        OPEN (UNIT=DK2,NAME=STD,TYPE='OLD',FORM='UNFORMATTED',ERR=405)
C
        DO 255 I=1,KN
        ENCODE(10,111,XNAME) SN1(I),SN2(I)
C
C       Identify no.of active letters in XNAME...Needed in GETSTD
        DO 240 J=1,10
    240 IF(XNAME(J).EQ.' ') GOTO 245
C
    245 NC=J-1
C
        CALL GETSTD(DK2,STD,ELEM,IADD,NELEM,NC,LEN,XNAME,VALS,LVAL,KX)
C
        IF(KX.NE.1) GOTO 250          !If std.not found don't print values
    250 NJ=NELEM
C
C       Insert further Element headings & Compositions of stds.
        DO 255 J=1,NELEM
        ENCODE(8,103,XELEM) ELEM(J)
        DO 251 IE=1,8
    251 IF(XELEM(IE).EQ.' ') GOTO 252
    252 NE=IE-1
        DO 253 IE=NE,1,-1
    253 XELEM(IE+1)=XELEM(IE)
        XELEM(1)='C'
        DECODE(8,103,XELEM) ELEM(NJ+J)
    255 CR(I,(NJ+J))=VALS(J)
C
        NELEM=2*NELEM
        CLOSE(UNIT=DK2,ERR=402)
C       ..............................................................
C
C       Open .RDT-file
C
C       Check if extension present
        CALL CEXTEN(FILE,NX,MLEN,'R','D','T')
C       Open file to insert info. required
        OPEN (UNIT=DK2,TYPE='NEW',NAME=FILE,ERR=401)
C
C       Read in all info required in ---S.RDT-file
        WRITE (DK2,113) (XTITLE(I),I=1,80)
        WRITE (DK2,113) (FBUF(I),I=1,80)
        WRITE (DK2,114) NELEM,KN
        WRITE (DK2,109) (ELEM(I),I=1,NELEM)
        DO 270 I=1,KN
        WRITE(DK2,108) SN1(I),SN2(I)
    270 WRITE (DK2,FBUF) (CR(I,J),J=1,NELEM)
C
C       Closing .RDT-file
        CLOSE (UNIT=DK2,ERR=402)
C
        GOTO 500                 !EXIT ... Option 'S'
C
C       File .RDT is preserved & all details of standards can now
C       be used in program MLR.This program will calculate the
C       regression coeffs to be used in option 'P' of this program.
C       ..............................................................
C
C       Read .RCF-file (FOR OPTION 'P' ONLY)
C       Use this segment to calculate the compositions of each sample
C       Read Regression Coeffs File created in program MLR
C       Check if extension present
    286 OPEN(UNIT=DK2,TYPE='OLD',NAME='DM2:[5,50]NAS.RCF',ERR=404)
C
        DO 300 IV=1,NELEM
        READ(DK2,115)(HADDR(I),I=1,(NELEM+1))
    300 READ(DK2,122) (B(IV,J),J=1,(NELEM+1))
        CLOSE(UNIT=DK2)
C
C       Open file .RES in which to store results
C       Check if extension present
        CALL CEXTEN(AFILE,NA,MLEN,'R','E','S')
C
        OPEN(UNIT=DK2,TYPE='NEW',NAME=AFILE,ERR=408)
C
C       Finding the min.and max.values of the standards.
C       Read values from file created manually after MLR was run
        OPEN(UNIT=DK1,TYPE='OLD',NAME='DM2:[5,50]MINMAX.NAS')
C
        READ(DK1,113)
        READ(DK1,113) (FBUF(I),I=1,80)
        READ(DK1,114) NO,NOM
        READ(DK1,109)
```

```
C       XRFA continued.
        DO 322 I=1,NOM
        READ(DK1,108)
   322  READ(DK1,FBUF) (XMIN(I),XMAX(I))
C
C       Write headings to results file .RES
C       Results file to have same format as XRF's .VAL-file in order
C       that values worked out here can be easily inserted into .VAL
C       as using program INVAL.
   324  WRITE(DK2,137) NELEM
        DO 325 LC=1,NELEM
   325  WRITE(DK2,138)ELEM(LC),SPAC
C
C       Computing analyses
        DO 320 IC=1,KN
C
        NM1(IC)=SN1(IC)
        NM2(IC)=SN2(IC)
C
        IZ=IC
        IO(IZ)='0'
        ENCODE(2,99,XNAME) SN1(IZ)
        IF(XNAME(1).NE.':') GOTO 305
        IO(IZ)='1'
   305  CONTINUE
C
        DO 315 LC=1,NELEM
        CONC(LC)=0.0
        ORR(LC)=' '
C
        DO 310 KC=1,NELEM
        ZX=0.0
C
   310  CONC(LC)=CONC(LC)+B(LC,KC+1)*CR(IC,KC)
        CONC(LC)=CONC(LC)+B(LC,1)
        ZX=CONC(LC)
        IF(ZX.LT.0.0) CONC(LC)=0.0
        IF(ZX.LT.0.0) ZX=0.0
C
        ZZ=ZX+0.25*ZX
        ZY=ZX-0.05*ZX
        IF(ZZ.LT.XMIN(LC)) ORR(LC)='b'
        IF(ZY.GT.XMAX(LC)) ORR(LC)='b'
C
   315  CONTINUE
C
C       Finding the min.& max.values of the 'unknowns'
        DO 318 LC=1,NELEM
        IF(IC.NE.1) GOTO 316
        CMIN(LC)=1.0E10
        CMAX(LC)=-1.0E10
C       Don't look at standards
   316  IF(IO(IC).EQ.'1') GOTO 318
        IF(CONC(LC).LT.CMIN(LC)) CMIN(LC)=CONC(LC)
        IF(CONC(LC).GT.CMAX(LC)) CMAX(LC)=CONC(LC)
   318  CONTINUE
C
C       Write results of analyses
C       CONC(LC)     where LC=element id.
C
C       Write data to .RES-file
   319  WRITE(DK2,123) NM1(IC),NM2(IC),'/','/'
        DO 330 LC=1,NELEM
   330  WRITE(DK2,125) CONC(LC),ORR(LC)
C
   320  CONTINUE
C
        WRITE(DK2,123) '**','**        '
C
C       Checking that the 'unknowns'values fall inside the range of the
C       standards values....Post warning if not
        WRITE(DK2,134)
        WRITE(DK2,131)
C
        DO 323 I=1,NELEM
        ZZ=CMIN(I)+0.25*CMIN(I)
        ZY=CMAX(I)-0.05*CMAX(I)
        IF(ZZ.LT.XMIN(I)) WRITE(DK2,132) ELEM(I),XMIN(I),CMIN(I)
        IF(ZY.GT.XMAX(I)) WRITE(DK2,133) ELEM(I),XMAX(I),CMAX(I)
   323  CONTINUE
C
        GOTO 500
C       ..............................................................
C       Error messages
   400  ERR=1.0
        GOTO 403
   401  ERR=2.0
   403  WRITE (TT,140) ERR
        GOTO 500
   402  WRITE (TT,141)
        GOTO 500
```

```
C      XRFA continued.
  404 ERR=3.0
      GOTO 403
  405 ERR=4.0
      GOTO 403
  407 ERR=5.0
      GOTO 403
  408 ERR=6.0
      GOTO 403
C
  500 STOP
C
C      ++++++++++++++++++ formats +++++++++++++++++++++++++++++++++++
C
   98 FORMAT (' Options;'/
     1  ' "S" to create a file .RDT containing compsn details & count'/
     2  '  ratios for standards for use with MLR.'/
     3    ' "P" to calculate 10 major element compsns of samples.'/
     4  ' Max of 282 samples (47 trays) including stds.'/
     5    '$<ret> to exit from program.    ')
   99 FORMAT (A1)
  100 FORMAT ('$IPF-file name; ')
  101 FORMAT (Q,30A1)
  102 FORMAT (1X,I5)
  103 FORMAT(A8)
  104 FORMAT (1X,A8)
  106 FORMAT (18X,F15.6)
  108 FORMAT (X,A2,A8)
  109 FORMAT (8(X,A8))
  110 FORMAT ('$stds.RDT-file name; ')
  111 FORMAT (A2,A8)
  112 FORMAT ('$Title of .RDT-file./Should have format [_TITLE]')
  113 FORMAT (80A1)
  114 FORMAT (2I6)
  115 FORMAT (8A8)
  122 FORMAT (8F20.4)
  123 FORMAT(X,A2,A8,2A1)
  125 FORMAT(X,F14.3,A1)
  126 FORMAT(X,A4)
  127 FORMAT(X,A4,X,6(2X,A2,A8))
  128 FORMAT(X,A4,18X,A8)
  131 FORMAT(' Outside range of regression!')
  132 FORMAT(5X,A8,5X,'Std.min=',F6.2,5X,'Sample min.=',F6.2)
  133 FORMAT(5X,A8,5X,'Std.max=',F6.2,5X,'Sample max.=',F6.2)
  134 FORMAT(1H0)
  137 FORMAT(X,I5)
  138 FORMAT(X,A8,2X,A4)
  140 FORMAT (' Error in opening file'F2.0)
  141 FORMAT (' Error in closing file')
C      +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
       END


       PROGRAM MLR
C      Multiple regression program.
C      Program to read raw data from a file x.RAW. Then to organize
C      that data such that the dependant variable is inserted into
C      the data matrix A(MNE) first with the independant variables
C      afterwards.
C      This data is then put into the Multiple Regression subroutine.
C                                                             Max size
C      A             Raw data                                      (MNE)
C      HADDR         Variables names                               (MNV)
C      JADD          Variable addresses in HADDR (1=Dependant variable)  (MNV)
C      XDATA         Temporary data array used by scratch file (LDEV)    (MNV)
C
C      N             No of samples in [A]
C      M             No of variables in [A]
C      NVAR          No of variables in scratch file (LDEV)
C
C      TT            Output device     (Terminal/File)
C      KDEV          Scratch file unit no
C      DK1           RAW-file unit no
C      DK2           Output device for regression coefficients (Used in
C                                         conjunction with XRFA)
C      Max no of variables allowed=20
C      Max no of data items allowed=1800
C
C      Subroutines used:   CEXTEN  GTHED   GTREC   SERADD  MATNUL  MREG
C
C      Options
C        CMD       V ... List variable names
C                  A ... Use only in conjunction with XRFA
C                        Program will read in all independant variables from
C                        RAW-file constructed in XRFA. It will read in only
C                        composition details of the standards.
C                  B ... Use all variables. Select dependant variable first
C                  C ... Continue
C
```

```
      C       MLR continued.
      C
      C       JOPT          Run option:     1 .. Summary of results to screen
      C                                     2 .. Full results to screen
      C                                     3 .. Full results to file .RCO
      C                                     4 .. Regression coefficients to file .RCF
      C
      C       ***********************************************************
0002          LOGICAL *1 QFILE(30),NM1(8),TITLE(80),CMD,RFILE(30),INS(6),
             1    TMP(4),LST(11),FBUF(80),LFILE(30),IO(1800),EXIST,FCHECK,OUT
      C
0003          INTEGER TT,DK1,DK2,SN1,KG,ADDRES,BDDRES,JADD(40),KADD(40)
      C
0004          REAL *8 HDG(40),NAME,SN2
      C
0005          EQUIVALENCE (AS(1),YY),(AS(21),XX),(AS(421),W),(AS(821),C),
             1    (AS(841),B),(AS(861),T)
      C
0006          DIMENSION A(1800),AS(1800),X(190),XDATA(40),AMEAN(20),SD(20),
             1    C(20),B(20),YY(20),W(20,20),T(20),XX(20,20)
      C
0007          DATA TT,DK1,DK2,NNN,LLL,IEOF,IERR,MLEN,MNE,MNV,KDEV/5,2,5*0,
             1    30,1800,40,4/,
             2  LST/'G','D','C','I','J','R','N','S','V','E','L'/,
             3    JOPT,N,NV,MNY,SMALL/2,0,20,190,-9998.0/
      C       ***********************************************************
      C
0008          XXX=FLOAT(MNE)*0.9
      C
0009          WRITE(TT,2000)
      C
      C       Open .RAW-file
0010      170 WRITE(TT,100)
0011          READ(TT,101) NF,QFILE
      C
0012          IF(NF.EQ.0) GOTO 350
      C
0014          DO 199 I=1,30
0015      199 LFILE(I)=QFILE(I)
      C
      C       Call extension check subroutine
0016          CALL CEXTEN(QFILE,NF,MLEN,'R','A','W',IERR)
0017          IF(IERR.GT.0) GOTO 350
      C
      C       Check .RAW-file exists
0019          EXIST=FCHECK(DK1,QFILE)
0020          IF(.NOT.EXIST) GOTO 170
0022      201 OPEN(UNIT=DK1,TYPE='OLD',NAME=QFILE,ERR=340)
      C
      C
      C       Read in data & insert into scratch file
0023          OPEN(UNIT=KDEV,TYPE='SCRATCH',FORM='UNFORMATTED',
             1NAME='SY0:Z1.SCR')
      C
      C       Read in header information
0024          CALL GTHED(NVAR,NSMP,HDG,MNV,TITLE,FBUF,DK1,IERR)
0025          IF(IERR.NE.1) GOTO 258
0027          WRITE(TT,141)
0028          GOTO 170
      C
0029      258 IF(IERR.NE.2) GOTO 297
0031          WRITE(TT,620)IERR,(QFILE(I),I=1,30)
0032          GOTO 170
      C       ...........................................................
      C
      C       Which option required
0033      297 WRITE(TT,95)
0034          READ(TT,99) NX,CMD
      C
0035          IF(CMD.EQ.'A'.OR.CMD.EQ.'B'.OR.CMD.EQ.'C') GOTO 298
0037          IF(CMD.EQ.'V') GOTO 296
0039          IF(CMD.EQ.'E') GOTO 350
0041          IF(CMD.EQ.' ') GOTO 509
0043          WRITE(TT,50)
0044      509 WRITE(TT,96)
0045          GOTO 297
      C
0046      296 WRITE(TT,51)(II,HDG(II),II=1,NVAR)
0047          WRITE(TT,52)
0048          GOTO 297
      C       ...........................................................
      C
0049      298 CALL GTREC(DK1,NVAR,SN1,SN2,XDATA,MNV,FBUF,KG,IEOF,IERR)
0050          IF(IERR.GT.0) WRITE(TT,137)(QFILE(I),I=1,30)
0052          IF(IEOF.EQ.1) GOTO 2050
      C
      C       Write data to scratch file on unit=KDEV
0054      301 WRITE(KDEV) SN1,SN2,KG,(XDATA(I),I=1,NVAR)
0055          N=N+1
0056          GOTO 298    !Next record
```

```
C       MFR continued.
C
C       Place dependant & independant variables in column 1 of [A]
   2050 IADD=0
    220 IF(IADD.EQ.0) WRITE (TT,107)                  !Asks for dep.var.name
        IF(IADD.GE.1.AND.CMD.EQ.'B') GOTO 506
        IF(IADD.GE.1.AND.CMD.NE.'B') WRITE (TT,110)!Asks for indep.var.name
        IF(IADD.GE.1.AND.CMD.EQ.'A') GOTO 233
C
        READ (TT,105) NX,NM1
        IF(IADD.EQ.0.AND.NX.EQ.0) GOTO 350   !Exit
        IF (NX.EQ.0) GOTO 223               !If <ret> pressed...leave loop
C
        DECODE(8,112,NM1) NAME
C
C       Search for element address
        CALL SERADD(I,NAME,HDG,1,1,1,1,NVAR,MNV,TT,IERR)
        IF(IERR.EQ.1) GOTO 2050
C
        IADD=IADD+1
C
        IF(IADD.LE.MNY) GOTO 404
        WRITE(TT,144)
        GOTO 350
C
    404 IF((N*IADD).LE.MNE) GOTO 302
        WRITE(TT,140)
        GOTO 350
C
    302 IF(FLOAT(N*IADD).GT.XXX) WRITE(TT,143)N*NVAR,MNE    !Warning
C
        JADD(IADD)=I
        KADD(IADD)=I
        GOTO 220
C
C       ****************************************************** CMD='B'
    506 DO 507 L=1,NVAR
        IF(L.EQ.JADD(1)) GOTO 507
C
        IADD=IADD+1
C
        IF(IADD.LE.MNY) GOTO 508
        WRITE(TT,144)
        GOTO 350
    508 IF((N*IADD).LE.MNE) GOTO 510
        WRITE(TT,140)
        GOTO 350
    510 IF(FLOAT(N*IADD).GT.XXX) WRITE(TT,143)N*NVAR,MNE    !Warning
C
        JADD(IADD)=L
        KADD(IADD)=L
C
    507 CONTINUE
C       ******************************************************
C
C       Inserting dep.& indep var.into [A]
    223 DO 224 JJ=1,IADD
        REWIND KDEV
C
        DO 224 J=1,N
        READ(KDEV) SN1,SN2,KG,(XDATA(II),II=1,NVAR)
        ADDRES=IADD*(J-1)+JJ
        BDDRES=JADD(JJ)
        IO(ADDRES)='0'
    224 A(ADDRES)=XDATA(BDDRES)
C
    240 M=IADD               !M=no.of variables in [A]
        GOTO 264
C
C       ****************************************************** CMD='A'
C       Inserts independant data values automatically.Used only
C       in conjunction with standards file from XRFA.
    233 NELEM=NVAR/2
        DO 234 IA=1,NELEM
    234 JADD(IA+1)=IA
        KADD(IA+1)=IA
        DO 235 IB=1,NELEM
        REWIND KDEV
        DO 235 J=1,N
        READ(KDEV) SN1,SN2,KG,(XDATA(II),II=1,NVAR)
        ADDRES=NELEM*(J-1)+IB
        IO(ADDRES)='0'
    235 A(ADDRES)=XDATA(IB)
C
        M=NELEM+1            !M=no.of variables in [A]
C
    264 CONTINUE
D       LL1=0
D       DO 2001 KK=1,N
C
```

```
C       MLR continued.
D       WRITE(5,2004) KK
D       DO 2002 LL=1,M
C
D       LL1=LL1+1
D2002 WRITE(5,2003) IO(LL1)
D2001 CONTINUE
C
D2004 FORMAT(' ***',I3,'***')
D2003 FORMAT(X,A1)
C
C       ++++++++++++++++ Multiple regression loop ++++++++++++++++++++++
        CALL MREG(A,AS,SD,AMEAN,X,N,M,NV,MNE,MNY,TT,DK2,HDG,KDEV,IO,C,
     1     B,YY,W,T,XX,JADD,KADD,XDATA,MNV,NVAR,JOPT)
C       ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
        TT=5
        DK2=0
C
C       Program does a regression on all data first,then asks for
C       further instructions;
  265 WRITE(TT,122)
      READ(TT,123) NCHAR,INS
C
  268 DO 270 L=1,10
  270 IF(LST(L).EQ.INS(1)) GOTO 280
      IF(INS(1).EQ.' ') GOTO 295
      WRITE(TT,50)
      GOTO 265
C
  295 WRITE(TT,126)                 !Type instruction options
      WRITE(TT,127)
      GOTO 265
C
  280 NON=0
      IF(NCHAR.LT.3) GOTO 292
C
C       Address included in instruction....strip it out
      NON=1
      DO 290 J=3,NCHAR
      JK=J-2
  290 TMP(JK)=INS(J)
C
      DECODE(NCHAR-2,125,TMP) MOD
C
C            ..G...D...C...I...J...R...N...S...V...E....
  292 GOTO (264,300,305,310,315,320,330,380,390,345),L
C
C       ..........................................................D
C       Delete sample
  300 IF(NON.EQ.1)GOTO 304
      WRITE(TT,124)
      GOTO 265
  304 IF(MOD.LE.N) GOTO 601
      WRITE(TT,128)
      GOTO 265
  601 DO 603 ID=1,M
      ADDRES=M*(MOD-1)+ID
      IF(A(ADDRES).LE.SMALL) GOTO 603
      IO(ADDRES)='1'
  603 CONTINUE
      GOTO 265
C       ..........................................................C
C       Delete element
  305 IF(NON.EQ.1) GOTO 309
      WRITE(TT,124)
      GOTO 265
  309 IF(MOD.LE.M) GOTO 306
      WRITE(TT,128)
      GOTO 265
  306 DO 308 IC=1,N
      ADDRES=M*(IC-1)+MOD
      IF(A(ADDRES).LE.SMALL) GOTO 308
      IO(ADDRES)='1'
  308 CONTINUE
      GOTO 265
C       ..........................................................I
C       Insert sample
  310 IF(NON.EQ.1) GOTO 314
      WRITE(TT,124)
      GOTO 265
  314 IF(MOD.LE.N) GOTO 311
      WRITE(TT,128)
      GOTO 265
  311 DO 313 II=1,M
      ADDRES=M*(MOD-1)+II
      IF(A(ADDRES).LE.SMALL) GOTO 313
      IO(ADDRES)='0'
  313 CONTINUE
      GOTO 265
```

```
C     MLR continued.
C     ............................................................J
C     Insert element
  315 IF(NON.EQ.1) GOTO 319
      WRITE(TT,124)
      GOTO 265
  319 IF(MOD.LE.M) GOTO 316
      WRITE(TT,128)
      GOTO 265
  316 DO 318 IJ=1,N
      ADDRES=M*(IJ-1)+MOD
      IF(A(ADDRES).LE.SMALL) GOTO 318
      IO(ADDRES)='0'
  318 CONTINUE
      GOTO 265
C     ............................................................R
C     Select run option
  320 IF(NON.EQ.1)GOTO 328                  !Option no included in INS
C
      WRITE(TT,131)
      READ(TT,132) JOPT
      GOTO 329
C
  328 JOPT=MOD
  329 IF(JOPT.GT.4) JOPT=2
C
      GOTO(264,264,323,324) JOPT
C
C     Print results to .RCO ................ JOPT=3
  323 TT=1
      IF(NNN.GT.0) GOTO 326
      NNN=1
C
C     Call extension check subroutine
      CALL CEXTEN(LFILE,NF,MLEN,'R','C','O',IERR)
      IF(IERR.GT.0) GOTO 350
C
      OPEN(UNIT=TT,TYPE='NEW',NAME=LFILE)
C
  326 WRITE(TT,130)
      GOTO 264
C
C
C     Regression coeffs to .RCF file ........ JOPT=4
  324 DK2=3
      IF(LLL.GT.0) GOTO 322
C
  321 WRITE (TT,120)
      READ (TT,121) NR,RFILE
      IF (NR.EQ.0) GOTO 265
C
      LLL=1
C
C     Call extension check subroutine
      CALL CEXTEN(RFILE,NR,MLEN,'R','C','F',IERR)
      IF(IERR.GT.0) GOTO 350
C
      OPEN(UNIT=DK2,TYPE='NEW',NAME=RFILE,ERR=340)
  322 GOTO 264
C
C     ............................................................N
C     Next regression
  330 REWIND DK1
      GOTO 2050
C     ............................................................S
C     List sample names
  380 REWIND KDEV
      WRITE(TT,55)
      DO 381 I=1,N
      OUT=' '
      READ(KDEV) SN1,SN2,KG,(XDATA(II),II=1,NVAR)
      ADDRES=M*(I-1)+1
      IF(A(ADDRES).LT.-9998.0.OR.IO(ADDRES).EQ.'1') OUT='d'
  381 WRITE(TT,54) OUT,I,SN1,SN2
      WRITE(TT,52)
      GOTO 265
C     ............................................................V
C     List variable names
  390 WRITE(TT,56)
      DO 391 I=1,M
      II=0
      OUT=' '
      NX=JADD(I)
      DO 394 J=1,N
      ADDRES=M*(J-1)+I
  394 IF(IO(ADDRES).EQ.'1') II=II+1
      IF(II.EQ.N) OUT='d'
  391 WRITE(TT,57) OUT,I,HDG(NX)
      WRITE(TT,52)
      GOTO 265
```

```
      C     .............................................................E
      C     Exit
        345  IF(LLL.LT.1) GOTO 348
            DK2=3
            CLOSE (UNIT=DK2)
      C
        348 IF(NNN.LT.1) GOTO 350
            TT=1
      C     CLOSE(UNIT=TT)
            GOTO 350
      C
      C     File error message
        340 WRITE (TT,111)
      C
        350 STOP
      C
      C     +++++++++++++++++++ formats ++++++++++++++++++++++++++++++++
       2000 FORMAT(' Multiple regression program.'/)
         95 FORMAT('$CMD> ')
         96 FORMAT(' Valid responses to CMD>'/
           1    ' <ret> ... Obtain a copy of these responses'/
           2  '   V   ... List variable names'/
           3    '   A   ... Use only in conjunction with XRFA'/
           4    '         Program will read in all independant variables'/
           5  '        from RAW-file constructed in XRFA. It will read in'/
           6    '         only composition details of the standards.'/
           7  '   B   ... Use all variables. Select dependant variable first'/
           8  '   C   ... Continue.  User selects variables to be used.'/
           9    '   E   ... Exit')
         99 FORMAT(Q,A1)
        100 FORMAT('$.RAW-file; ')
        101 FORMAT(Q,30A1)
        102 FORMAT(X,A2,A8)
        103 FORMAT(80A1)
        104 FORMAT(2I6)
        105 FORMAT(Q,8A1)
        107 FORMAT('$Dependant variable:')
        108 FORMAT(8(X,A8))
        110 FORMAT('$Independant variable:')
        111 FORMAT(' Error during execution of OPEN statement')
        112 FORMAT(A8)
        117 FORMAT(' IO=1:  Sample no',I2,3X,A8)
        120 FORMAT(/'$Regression Coeff Filename; ')
        121 FORMAT(Q,30A1)
        122 FORMAT(/'$INS> ')
        123 FORMAT(Q,6A1)
        124 FORMAT(' Address not given.....Type instruction again.')
        125 FORMAT(I8)
        126 FORMAT('  Valid responses to INS>'/
           1    ' <ret> Obtain a copy of these responses'/
           2  '   G    GO ... Uses most recent run option (R)'/
           3  '   D    Delete a sample.Form:D=<address> <ret>'/
           4  '   C    Delete an element.Form:C=<address> <ret>'/
           5  '   I    Insert a sample.Form:I=<address> <ret>'/
           6  '   J    Insert an element.Form:J=<address> <ret>'/
           7  '   R    Select run option. Form:R=<option no>'/
           8  '         1 ... Summary of results to screen'/
           9    '         2 ... Full results to screen')
        127 FORMAT(8X,' 3 ... Full results to file .RCO'/
           1    '         4 ... Regression coeffs to file .RCF    '/
           2    '   S    List sample names'/
           3  '   V    List variable names'/
           4    '   N    Do next regression'/
           5    '   E    Exit. Files saved')
        128 FORMAT(' Error...address too large')
        130 FORMAT(1H1)
        131 FORMAT(' Type option required;'/
           1    '                        1 ... Summary of results to screen'/
           2    '                        2 ... Full results to screen'/
           3  '                        3 ... Full results to file .RCO'/
           4    '$                       4 ... Regression coeffs to file .RCF    ')
        132 FORMAT(I3)
        141 FORMAT(' Ignored--exceeded allowed no of variables')
        620 FORMAT(' Error',I2,'in GTHED in',30A1,'File ignored')
        137 FORMAT(' Reading error in GTREC in',30A1)
        144 FORMAT(' Error -- exceeded allowed no of variables')
        140 FORMAT(' Error -- exceeded allowed no of data items')
        143 FORMAT(' Warning .. Approaching max no of data items'/
           1    ,12X,'Now;'I4,'    Max;',I4)
         50 FORMAT(' Not identified ... Try again!')
         52 FORMAT(1H )
         51 FORMAT(4(9X,I2,X,A8))
         55 FORMAT('  s',5X,'Sample name')
         54 FORMAT(2X,A1,X,I3,X,A2,A8)
         56 FORMAT('  s',5X,'Variable')
         57 FORMAT(2X,A1,X,I3,X,A8)
      C     +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      C
            END
```

```
      PROGRAM KMN
C     Program to run MacQueen's k-means method for non-hierachical
C     convergent clustering.
C     NUMBR...No of samples in clusters (MNC)
C     DATA1....1-d data matrix (MNV1 or MNV2)
C     DATA2....1-d data matrix (MNV2)
C     DREF....Distance between cluster & sample seed
C     MAXIT...Max no of iterations (preset at 4)
C     NE......No of entities (data units)
C     NVAR....No of variables
C     MNV1....Max no of variables that may be read from .RAW files
C     MNV2....Max no of variables that may be used in clustering
C     NC......No of clusters              MNC..Max no of clusters
C                                         MCT..(MNV2*MNC)
C     N1DEV...Output device
C     N2DEV...Unformatted scratch file (unstdzd data)
C     N3DEV...Unformatted scratch file holding address of each sample
C     N4DEV...Original .RAW files & unformatted scratch file (stdzd data)
C     N8DEV...Direct Access file for centroids and sum of data values
C     VARNAM..Variable names from .RAW-files (MNV1)
C     VNAM....Variable names (MNV2)
C
C  CMD
C       G ... GO (Switches as set)
C    1  K ... Normal KMEAN clustering algorithm
C    2  A ... Assess relative importance of variables
C    3  P ... Full print out
C             (Only with 'A')
C    4  M ... No of samples misclassified & DELTA sent to
C             MCLD.RAW.
C             (Only with 'A' & 'a priori' knowledge)
C    5  N ... Assign each sample to nearest seed
C             point (one pass only). Used in KMEAN by IDN only.
C    6  S ... Calculate distances between seed centroids
C             (Both 'N' & 'S' require use of an established seed file)
C    7  D ... Record values of DREF in DREF.RAW for further
C             interpretation  Used in KMEAN by IDN only.
C    8  I ... Using incompatible files. Manually ensure they are
C             identical by means of delete option before entering KMEAN
C    9  R ... Remove specified variables
C   10  F ... First file to be read assumed to contain
C             seed points
C   11  C ... Choose best seed points using FSEED
C             subroutine
C   12  O ... Select optimum no of clusters using FSEED
C             & GRAPH subroutines. Runs automatically.
C   13  V ... Results to vdu (1) or file (0)
C       E ... Exit
C
C     [Subroutines]/{functions} used;
C     CHANGE              {FCHECK}           CEXTEN          GTHED
C     GTREC               KSTDZ              FSEED           KMEAN
C     GRAPH               KRSLTS
C
C     **************************************************************
      LOGICAL *1 FILE(30),TIT(80),FMT(80),CMD(13),FCHECK,EXIST,IO(35),
     1    AA,INS(6),LST(9),TMP(4),ORD(2),XSN1(2),LST1(14),C,SYMB(22)
C
      REAL *8 VARNAM(28),VNAM(35),SN2
      REAL MDIST
C
      INTEGER SN1,KG,ULIMIT,CL(15)
C
      EQUIVALENCE (TIT,GRA),(FMT,GRB),(IO,NUMBR),(TMP,ORD)
     1    ,(VNAM(2),BLEG),(VNAM(6),YDIST),(VNAM(14),NUM),
     2    (SD(1),NCOMB),(SD(106),MCOMB),(DATA2,SUM1),(SORT,CDELTM)
C
C     ************************************************************
C     NB. To set full display of workings, must use /DE switch
C         when using compiling KMN & KMEAN;
C
C     Must reduce size of program by altering header block of KMN;
C
C     Change SORT(105),CDELTM(105),NCOMB(105),MCOMB(105),SUM1(105)
C     to (1) & N2 from 105 to 1.
C     Change SM(15,15) to (1,1) & N3 from 15 to 1.
C     Change VDELTM(28),MADD(28) to (1) & N4 from 28 to 1.
C     ************************************************************
C
      DIMENSION NUMBR(15),GRA(15),GRB(15),YDIST(15),NUM(71),BLEG(8),
     1    DATA1(35),DATA2(28),SUM(28),SD(420),KOUNT(15),
     2    NCOMB(105),MCOMB(105),SUM1(105),SORT(105),CDELTM(105),SM(15,15)
     3    ,MADD(28),VDELTM(28)
C
      DATA MLEN,MNC,MNV1,MNV2,MAXIT/30,15,35,28,4/,
     1    N1DEV,N2DEV,N3DEV,N4DEV,N5DEV,N7DEV,N8DEV,N9DEV/5,2,3,4,5,7,8,9/,
     2    ULIMIT,IOPT,IFLAG,N1,N2,N3,N4/2*1,0,420,105,15,28/,
     3    LST/'C','D','R','S','Z','V','A','E','L'/,
     4    LST1/'G','K','A','P','M','S','I','R','F','C','O','V','E','L'/,
```

KMN continued.

```
     5    CMD/'1','0','0','0','0','0','0','0','0','1','0','0','1'/,
     6    SYMB/' ','o','x','+','=','-','@','#','$','2','3','4','5','6','7',
     7    '8','9','*','?','!','|','-'/,ORD/' ',' '/
C         **************************************************************
C
C         Select options
      200 WRITE(N5DEV,100)
          READ(N5DEV,101) NCHAR,AA
C
          IF(NCHAR.EQ.0) GOTO 210
C
          DO 202 L=1,13
      202 IF(AA.EQ.LST1(L)) GOTO 215
C
      209     WRITE(N5DEV,105)
      210 WRITE(N5DEV,102) (CMD(II),II=1,4)
          WRITE(N5DEV,103) CMD(6),(CMD(II),II=8,11)
          WRITE(N5DEV,104) (CMD(II),II=12,13)
          GOTO 200
C
C                 .G...K...A...P...M...S...I...R...F...C...O...V...E..
C                  |   |   |   |   |   |   |   |   |   |   |   |   |
      215 GOTO(240,218,219,220,221,224,226,227,228,229,230,231,999),L
C
C         'K' ... Normal KMEAN clustering algorithm
      218 CALL CHANGE(CMD(1))
          GOTO 200
C
C         'A' ... Assess importance of variables
      219 IF(CMD(1).EQ.'1') CALL CHANGE(CMD(2))
          GOTO 200
C
C         'P' ... Full print out
      220 IF(CMD(2).EQ.'1') CALL CHANGE(CMD(3))
          GOTO 200
C
C         'M' ... Identify no of misclassified samples
      221 IF(CMD(1).EQ.'1') CALL CHANGE(CMD(4))
          GOTO 200
C
C         'S' ... Calculate distances between seed centroids
      224 CALL CHANGE(CMD(6))
C         Zero CMD(1) to CMD(4)
          IF(CMD(1).EQ.'1') CALL CHANGE(CMD(1))
          IF(CMD(2).EQ.'1') CALL CHANGE(CMD(2))
          IF(CMD(3).EQ.'1') CALL CHANGE(CMD(3))
          IF(CMD(4).EQ.'1') CALL CHANGE(CMD(4))
          GOTO 200
C
C         'I' ... Using incompatible files
      226 CALL CHANGE(CMD(8))
          GOTO 200
C
C         'R' ... Remove specified variables
      227 CALL CHANGE(CMD(9))
          GOTO 200
C
C         'F' ... First file to be read assumed to contain seed points
      228 CALL CHANGE(CMD(10))
          IF(CMD(11).EQ.'1') CALL CHANGE(CMD(11))
          IF(CMD(12).EQ.'1') CALL CHANGE(CMD(12))
          GOTO 200
C
C         'C' ... Choose best seed points using FSEED
      229 CALL CHANGE(CMD(11))
          IF(CMD(10).EQ.'1') CALL CHANGE(CMD(10))
          IF(CMD(12).EQ.'1') CALL CHANGE(CMD(12))
          GOTO 200
C
C         'O' ... Select optimum no of clusters
      230 CALL CHANGE(CMD(12))
          IF(CMD(10).EQ.'1') CALL CHANGE(CMD(10))
          IF(CMD(11).EQ.'1') CALL CHANGE(CMD(11))
          GOTO 200
C
C         'V' ...  VDU / File
      231 CALL CHANGE(CMD(13))
          IF(CMD(13).EQ.'1') N1DEV=5
          IF(CMD(13).EQ.'0') N1DEV=1
          GOTO 200
C
C         **************************************************************
C         Open unit for output of results if required
      240 IF(N1DEV.NE.5) OPEN(UNIT=N1DEV,TYPE='NEW',NAME='SY0:Z.KMN')
          IF(N1DEV.NE.5) WRITE(N1DEV,99)
C
          IF(CMD(12).EQ.'1'.OR.CMD(6).EQ.'1') GOTO 241
          WRITE(N5DEV,110)
          READ(N5DEV,111) NC
```

```
C
      IF(NC.LE.0) GOTO 999          !Exit
C
      IF(NC.LE.MNC) GOTO 241
      WRITE(N5DEV,142)
      GOTO 999              !Exit
C
  241 IF(CMD(6).EQ.'1') GOTO 242
C
      WRITE(N5DEV,106)
      READ(N5DEV,107) NXX,MXIT
C
      IF(NXX.EQ.0) GOTO 242
C
      MAXIT=MXIT
C
C     Open scratch file to hold all unstandardised data
  242     OPEN(UNIT=N2DEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1    NAME='SY0:Z1.SCR')
C     Open scratch file to hold membership data
      OPEN(UNIT=N3DEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1    NAME='SY0:Z2.SCR')
C
C     Write file title
      IF(N1DEV.NE.5) WRITE(N1DEV,112)
C
C     Read in all data
      NE=0
      NON=-1
C
  250 WRITE(N5DEV,115)                        !Asks for input
      READ(N5DEV,116) NF,FILE
      IF(NF.EQ.0) GOTO 310                    !Continue
C
C     Check for extension, check .RAW-file exists & open file
      CALL CEXTEN(FILE,NF,MLEN,'R','A','W',IERR)
      IF(IERR.GT.0) GOTO 999                  !Exit
C
      EXIST=FCHECK(N4DEV,FILE)
      IF(.NOT.EXIST) GOTO 250                 !Try again
C
      OPEN(UNIT=N4DEV,TYPE='OLD',NAME=FILE)
C
C     Get all data out of .RAW-file & store in DATA1 temporarily
      CALL GTHED(NVAR1,NSMP,VNAM,MNV1,TIT,FMT,N4DEV,IERR)
      IF(IERR.NE.1) GOTO 258
      WRITE(N5DEV,141)
      GOTO 300                   !Try again
C
  258 IF(IERR.NE.2) GOTO 259
      WRITE(N5DEV,120)IERR,(FILE(I),I=1,30)
      GOTO 300                   !Try again
C
  259 NON=NON+1
C
      IF(CMD(8).EQ.'0'.AND.NON.LT.1.OR.CMD(8).EQ.'1') MVAR=NVAR1
      IF(NON.GE.1.AND.CMD(8).EQ.'0') GOTO 293
C
      DO 260 I=1,NVAR1
  260 IO(I)='0'
C
      IF(CMD(9).EQ.'0'.AND.CMD(8).EQ.'0') GOTO 297
C
      WRITE(N5DEV,124)
      WRITE(N5DEV,125)
      DO 262 I=1,NVAR1
      IF(IO(I).EQ.'0') AA='-'
      IF(IO(I).EQ.'1') AA='d'
      WRITE(N5DEV,126) I,AA,VNAM(I)
  262 CONTINUE
C
  264 WRITE(N5DEV,127)
      READ(N5DEV,128) NCHAR,INS
C
      IF(INS(1).EQ.' ') GOTO 266
C
      DO 265 L=1,8
  265 IF(INS(1).EQ.LST(L)) GOTO 267
      WRITE(N5DEV,105)
      GOTO 264
C
  266 WRITE(N5DEV,129)
      WRITE(N5DEV,133)
      GOTO 264
C
  267 NNN=0
      IF(NCHAR.LT.3) GOTO 272
C
```

```
C     MMN continued.
C     Address included in instruction....strip it out
      NNN=1
      DO 270 J=3,NCHAR
      JK=J-2
  270 TMP(JK)=INS(J)
C
      DECODE(NCHAR-2,130,TMP) MOD
C
C           ..C...D...R...S...Z...V...A...E..
  272 GOTO (293,275,280,285,287,290,304,999),L
C
C     ...........................................................D
C     Delete variable
  275 IF(NNN.EQ.1)GOTO 276
      WRITE(N5DEV,131)
      GOTO 264
  276 IF(MOD.LE.NVAR1) GOTO 277
      WRITE(N5DEV,132)
      GOTO 264
  277 IF(IO(MOD).EQ.'1') GOTO 264
      MVAR=MVAR-1
      IO(MOD)='1'
      GOTO 264
C     ...........................................................R
C     Replace variable
  280 IF(NNN.EQ.1) GOTO 281
      WRITE(N5DEV,131)
      GOTO 264
  281 IF(MOD.LE.NVAR1) GOTO 282
      WRITE(N5DEV,132)
      GOTO 264
  282 IF(IO(MOD).EQ.'0') GOTO 264
      MVAR=MVAR+1
      IO(MOD)='0'
      GOTO 264
C     ...........................................................S
C     Reset switches
  285 MVAR=NVAR1
      DO 286 I=1,NVAR1
  286 IO(I)='0'
      GOTO 264
C     ...........................................................Z
C     Delete all variables
  287 MVAR=0
      DO 288 I=1,NVAR1
  288 IO(I)='1'
      GOTO 264
C     ...........................................................V
C     View current state of I/O switches
  290 WRITE(N5DEV,124)
      WRITE(N5DEV,125)
      DO 291 I=1,NVAR1
      IF(IO(I).EQ.'0') AA='-'
      IF(IO(I).EQ.'1') AA='d'
      WRITE(N5DEV,126) I,AA,VNAM(I)
  291 CONTINUE
      GOTO 264
C     ...........................................................A
C     View original variable names chosen in CMD(8)='1' option
  304    IF(CMD(8).NE.'1') GOTO 264
      WRITE(N5DEV,122)
      DO 307 I=1,NVAR
  307 WRITE(N5DEV,123) I,VARNAM(I)
      GOTO 264
C     ............................................................
C     ............................................................
C
  293 IF(NVAR1.EQ.MVAR) GOTO 297
      MMM=0
C
      DO 294 I=1,NVAR1
      IF(IO(I).EQ.'1') GOTO 294
      MMM=MMM+1
      VNAM(MMM)=VNAM(I)
  294 CONTINUE
C
  297 IF(NON.GE.1) GOTO 295
C
      IF(MVAR.LE.MNV2) GOTO 765
      WRITE(N5DEV,141)
      GOTO 300              !Too many variables, try again
C
  765 NVAR=MVAR
      DO 306 I=1,NVAR
  306 VARNAM(I)=VNAM(I)
      GOTO 305
C
C     Check files are compatible
  295 IF(MVAR.NE.NVAR) WRITE(N5DEV,135)(FILE(I),I=1,30)
      IF(MVAR.NE.NVAR) GOTO 300
```

```
C     KMN continued.
C
      DO 296 I=1,NVAR
      IF(VNAM(I).NE.VARNAM(I)) WRITE(N5DEV,136)(FILE(IA),IA=1,30)
  296     IF(VNAM(I).NE.VARNAM(I)) GOTO 300
C
C     File exists & is compatible...write name to file & continue
  305 IF(N1DEV.NE.5) WRITE(N1DEV,117) (FILE(I),I=1,30)
C
  298 CALL GTREC(N4DEV,NVAR1,SN1,SN2,DATA1,MNV1,FMT,KG,IEOF,IERR)
      IF(IERR.GT.0) WRITE(N5DEV,137)(FILE(I),I=1,30)
      IF(IEOF.EQ.1) GOTO 300
C
      IF(MVAR.EQ.NVAR1) GOTO 301
C
      MMM=0
      DO 299 I=1,NVAR1
      IF(IO(I).EQ.'1') GOTO 299
      MMM=MMM+1
      DATA1(MMM)=DATA1(I)
  299 CONTINUE
C
  301 ENCODE(2,165,XSN1) SN1
      IF(XSN1(1).NE.'*') GOTO 302
      WRITE(N1DEV,168) SN1,SN2,KG
      GOTO 298
C
C     Write data to scratch file on unit=N2DEV
  302     WRITE(N2DEV) SN1,SN2,KG,(DATA1(I),I=1,NVAR)
      NE=NE+1
      GOTO 298
C
  300 CLOSE(UNIT=N4DEV)
C
      IF(CMD(6).NE.'1') GOTO 250
      NC=NE
C
C     Write variable names used
  310 WRITE(N1DEV,144)
C
      DO 311 I=1,NVAR
  311 WRITE(N1DEV,145) VARNAM(I)
C
C     Open  second scratch file for use with KSTDZ
      OPEN(UNIT=N4DEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1    NAME='SY0:Z3.SCR')
C
C     Open direct access file to hold means & std devns
C     (NVAR records, 2 values in each)
      OPEN(UNIT=N9DEV,TYPE='SCRATCH',NAME='SY0:Z9.SCR',
     1    ACCESS='DIRECT',RECORDSIZE=2)
C
C     Standardise data & read new values into N4DEV
      CALL KSTDZ(N2DEV,N4DEV,DATA1,DATA2,SUM,NE,NVAR,MNV2,IOPT,N9DEV)
      CLOSE(UNIT=N2DEV)
C
D     WRITE(N1DEV,189)
D     DO 3010 I=1,NVAR
D     II=I
D     READ(N9DEV'II) AM,STDV
D3010 WRITE(N1DEV,190) VARNAM(I),AM,STDV
C
      DO 316 I=1,3
  316 IF(CMD(9+I).EQ.'1') GOTO 317
C
  317 KOPT=I-1
      GOTO(325,325,322)(KOPT+1)
C
  322 WRITE(N5DEV,161)
      READ(N5DEV,164) MDIST
C
      VNAM(1)='TDIST    '
      GRB(1)=0.0
C
      DO 321 I=1,MNC
  321 GRA(I)=FLOAT(I)
C
      WRITE(N5DEV,160) MNC
      READ(N5DEV,111) ULIMIT
      IF(ULIMIT.GT.MNC) ULIMIT=MNC
C
  325 DO 350 I=2,ULIMIT
      GOTO(332,327,326)(KOPT+1)
  326 NC=I
C     Choose best seed points
  327 CALL FSEED(DATA1,DATA2,NE,NVAR,NC,MNV2,MNC,N5DEV,N4DEV,N2DEV,
     1    N7DEV,KOPT,IFLAG,MDIST,YDIST)
      IF(KOPT.EQ.2) IFLAG=IFLAG+1
      KDEV=N4DEV
      N4DEV=N2DEV
      N2DEV=KDEV
```

```
C     KMN continued.
C
      GOTO(331,332),KOPT
C
  331 WRITE(N1DEV,166)
      REWIND N4DEV
      DO 933 K=1,NC
      READ(N4DEV) SN1,SN2,KG,(DATA1(KK),KK=1,NVAR)
      IF(K.EQ.1) GOTO 933
      WRITE(N1DEV,167) SN1,SN2,KG
  933 CONTINUE
      WRITE(N1DEV,169) YDIST(NC)
C
C     Open direct access file to hold centroids and sum of data values
C     (2 * NC) records, NVAR values in each.
  332 OPEN(UNIT=N8DEV,TYPE='SCRATCH',NAME='SY0:Z8.SCR',
     1    ACCESS='DIRECT',RECORDSIZE=30)
C
      CALL KMEAN(NUMBR,DATA1,DATA2,DUMMY,0,DREF,
     1    MAXIT,NE,NVAR,NC,MNV2,MNC,N5DEV,N4DEV,N1DEV,N2DEV,N3DEV,N7DEV,
     2    N8DEV,VARNAM,CMD,KOPT,IFLAG,GRB,CL,SD,NCOMB,MCOMB,SM,SUM1,
     3    KOUNT,SUM,VDELTM,SORT,CDELTM,MADD,N1,N2,N3,N4)
C
      IF(KOPT.EQ.2) CLOSE(UNIT=N8DEV)
C
  350 CONTINUE
C
      IF(KOPT.NE.2) GOTO 360
C
      ASSIGN 353 TO JUMP
  351 IPR=N5DEV
  352 OPEN(UNIT=N7DEV,TYPE='SCRATCH',NAME='Z7.SCR')
      OPEN(UNIT=N8DEV,TYPE='SCRATCH',NAME='Z8.SCR')
      CALL GRAPH(GRA,GRB,VNAM(1),ULIMIT,ULIMIT,2,MNC,MNC,NDUMMY,
     1    NUM,71,BLEG,8,IPR,0,ORD,1,SYMB,22,70,B,C,1,N7DEV,N8DEV,0)
      CLOSE(UNIT=N7DEV)
      CLOSE(UNIT=N8DEV)
C
      GOTO JUMP
  353 IF(N1DEV.EQ.5) GOTO 354                 !Results to vdu only
      ORD(1)='/'
      ORD(2)='R'
      IPR=N1DEV
      ASSIGN 354 TO JUMP
      GOTO 352
C
  354 WRITE(N5DEV,162)
      READ(N5DEV,163) NNN,ORD
C
      IF(ORD(1).EQ.'/'.AND.ORD(2).EQ.'R') GOTO 351          !Rerun GRAPH
C
  355 WRITE(N5DEV,110)
      READ(N5DEV,111) NC
C
      IF(NC.LE.0) GOTO 368                !Exit
      IF(NC.LE.MNC) GOTO 357
      WRITE(N5DEV,142)
      GOTO 355
C
  357 KOPT=1
      ULIMIT=1
      GOTO 325                !Run thro KMEAN again
C
C     KMEAN subroutine completed
C
  360 CALL KRSLTS(NUMBR,DATA1,NE,NVAR,NC,MNV2,MNC,
     1    N4DEV,N1DEV,N3DEV,N8DEV,N9DEV)
C
      CLOSE(UNIT=N8DEV)
C
      IF(CMD(12).EQ.'1') GOTO 355 !Select another value for
C                                  NC if required.
  368 CLOSE(UNIT=N9DEV)
      IF(N1DEV.NE.5) WRITE(N5DEV,153)
C
  999 STOP
C
C     ................ formats ..............................
   99 FORMAT(' Non-hierachical convergent K-means cluster analysis'/)
  100 FORMAT('$CMD> ')
  101 FORMAT(Q,A1)
  102 FORMAT(' ...... Valid responses to CMD>'/
     1  ' <ret> ... Shows these valid responses'/
     2  '  G    ... GO (Switches as set)'/
     3  '  K',X,A1,X,' ... Normal KMEAN clustering algorithm'/
     4  '  A',X,A1,X,' ... Assess importance of variables.'/
     5  '  P',X,A1,X,' ... Full print out'/
     6  '             (Only with 'A')'/
     7  '  M',X,A1,X,' ... No of samples misclassified & DELTA sent to
     8 MCLD.RAW.')
```

```
C      KMN continued.
  103      FORMAT(11X,'(Only with 'a priori' knowledge)'/
     1        ' S',X,A1,X,' ... Calculate distances between seed centroids'/
     2       ,11X,'(Reads 1 file only ... Must be an established seed file)'/
     3        ' I',X,A1,X,' ... Using incompatible files'/
     4        ' R',X,A1,X,' ... Remove specified variables'/
     5        ' F',X,A1,X,' ... First file to be read assumed to contain
     6 seed points'/
     7        ' C',X,A1,X,' ... Choose best seed points using FSEED
     8 subroutine')
  104 FORMAT('  O',X,A1,X,' ... Select optimum no of clusters using
     1 FSEED'/,
     2     11X,'& GRAPH subroutines. Runs automatically.'/
     3     ' V',X,A1,X,' ... Results to vdu(1) or file(0)'/
     4     ' E      ... Exit')
  127 FORMAT('$INS> ')
  128 FORMAT(Q,6A1)
  129 FORMAT('....... Valid responses to INS>'/
     1  '        <ret> Shows these valid responses'//
     2  '          C   Continue.(Leaves switches as set)'//
     3  '          V   View current state of I/O switches'/
     4  '          A   View original variable names chosen'/
     5  '              Only if using incompatible files option'/
     6  '          D=<address><ret> ... Deletes specified variable'/
     7  '          R=<address><ret> ... Replaces specified variable'//
     8  '          S   Resets switches'/
     9  '          Z   Delete all variables'/)
  133 FORMAT('       E   Exit from program'/)
  105 FORMAT(' Command not identified.....Try again')
  106     FORMAT('$Max number of iterations (d=4) ')
  107 FORMAT(Q,I3)
  110 FORMAT(/'$No of cluster gps; (Type '0' to exit)  ')
  111 FORMAT(I3)
  112 FORMAT(' Files read;')
  115 FORMAT('$.RAW> ')
  116 FORMAT(Q,30A1)
  117 FORMAT(X,30A1)
  120 FORMAT(' Error',I2,'in GTHED in',30A1,'File ignored')
  122 FORMAT(' Original variable names;')
  123 FORMAT(X,I2,3X,A8)
  124 FORMAT(' Current state of I/O switches')
  125 FORMAT('      I/O',3X,'Element')
  126 FORMAT(2X,I2,2X,A1,5X,A8)
  130 FORMAT(I8)
  131 FORMAT(' Address not given.....Type instruction again.')
  132 FORMAT(' Error...address too large')
  135 FORMAT(' ',30A1,' ignored--differing no.of variables')
  136 FORMAT(' ',30A1,' ignored--differing order of variable names')
  137 FORMAT(' Reading error in GTREC in',30A1)
  141 FORMAT(' File ignored--exceeded allowed no of variables')
  142 FORMAT(' Error -- exceeded allowed no of values of clusters')
  144 FORMAT(/' Variables used;')
  145 FORMAT(4(7(X,A8)/))
  153 FORMAT(/' Results stored in SY0:Z.KMN')
  160 FORMAT(/'$Max no of clusters expect to be formed; (max=',I2,')  ')
  162 FORMAT('$Type /R to rerun graph or <ret>  ')
  163 FORMAT(Q,2A1)
  165 FORMAT(A2)
  166 FORMAT(/' Seed points selected by FSEED')
  167 FORMAT(X,A2,A8,A2)
  169 FORMAT(' Min distance between seed points set at',F7.2)
  168 FORMAT(X,A2,A8,A2,' removed')
  179 FORMAT(' .......Try again')
D 189 FORMAT(1H )
D 190 FORMAT(X,A8,3X,'Mean ... ',F7.2,6X,'Std devn ... ',F7.2)
  161 FORMAT('$Start value for min distance between seeds ... ')
  164 FORMAT(F10.0)
C
      END


      PROGRAM DSC
C     Program to perform a linear discriminant analysis between two
C     sample set.
C     Data accessed as RAW-files and held in two scratch files.
C     Selected variables may be removed from calculation.
C
C     Subroutines/functions:        FCHECK  CEXTEN  GTHED   GTREC
C                              XCRMLT  SOLVE
C
C     ***************************************************************
      LOGICAL *1 XDT(30),FMT(80),TIT(80),CH1,CH2,CHAR,IO(50),AA,
     1  INS(6),LST(8),TMP(4),CMD,EXIST,FCHECK
C
      REAL *8 VNAM(50),VARNAM(50),SN2
C
      INTEGER TT,DK1,DK2,DK3,SN1,KG
C
      DIMENSION DATA(50),A1(50),A2(50),B(50),A(50,50),C(2,50)
```

```
C       DSC continued.
C
        DATA KB,TT,DK1,DK2,DK3,NX,NV/2*5,1,2,3,2000,50/
        DATA CH1,CH2,LENFN,IPRINT,IFLAG,NWRONG/' ','*',30,4,2*0/
        DATA NSMP1,NSMP2,IERR,R0,R1,R2,D2/3*0,4*0.0/
        DATA LST/'C','D','R','S','Z','V','E','L'/
C       ****************************************************************
C
        WRITE(TT,95)
C
C       Option to write to VDU
        WRITE(TT,98)
        READ(TT,99) NC,CMD
C
        IF(CMD.EQ.'V') IPRINT=5
        IF(IPRINT.EQ.5) GOTO 459
C
C       Open file for results
        OPEN(UNIT=IPRINT,NAME='SY0:Z.DSC')
C
C       Open scratch file for data
  459   OPEN(UNIT=DK2,TYPE='SCRATCH',FORM='UNFORMATTED',
     1      NAME='SY0:Z1.SCR')
        OPEN(UNIT=DK3,TYPE='SCRATCH',FORM='UNFORMATTED',
     1      NAME='SY0:Z2.SCR')
C
C       Request filenames
        DO 450 KK=1,2
        IF(IPRINT.NE.5) WRITE(IPRINT,96) KK
C
  246   NS=0
C
        WRITE(KB,100) KK
        READ(KB,101) NXDT,XDT
C
        IF(NXDT.EQ.0.AND.((KK.EQ.1.AND.NSMP1.EQ.0).OR.
     1      (KK.EQ.2.AND.NSMP2.EQ.0))) GOTO 900        !Exit
C
        IF(NXDT.EQ.0) GOTO 450                         !Continue
C
C       Add extension,check exists and open file
        CALL CEXTEN(XDT,NXDT,LENFN,'R','A','W',IERR)
C
C       Check .RAW-file exists
        EXIST=FCHECK(DK1,XDT)
        IF(.NOT.EXIST) GOTO 246
C
        OPEN(UNIT=DK1,TYPE='OLD',NAME=XDT,ERR=901)
C
C       Get all data out of .RAW-file & store in DATA temporarily
        CALL GTHED(NVAR1,NSMP,VNAM,NV,TIT,FMT,DK1,IERR)
C
        IF(IERR.NE.1) GOTO 258
        WRITE(TT,141)
        GOTO 300
C
  258   IF(IERR.NE.2) GOTO 259
        WRITE(TT,117)IERR,(XDT(I),I=1,30)
        GOTO 300
C
  259   IF(IFLAG.GT.0) GOTO 296                        !I/O switches already set
C
C       Deletion option
  260   AA='-'
        MVAR=NVAR1
C
        WRITE(TT,124)
        WRITE(TT,125)
        DO 262 I=1,NVAR1
        IO(I)='0'
  262   WRITE(TT,126) I,AA,VNAM(I)
C
C
  264   WRITE(TT,127)
        READ(TT,128) NCHAR,INS
C
        IF(INS(1).EQ.' ') GOTO 266
C
        DO 265 L=1,7
  265   IF(LST(L).EQ.INS(1)) GOTO 267
        WRITE(TT,116)
        GOTO 264
C
  266   WRITE(TT,129)
        WRITE(TT,133)
        GOTO 264
C
  267   NNN=0
        IF(NCHAR.LT.3) GOTO 272
C
```

```
C     PSC continued.
C     Address included in instruction....strip it out
      NNN=1
      DO 270 J=3,NCHAR
      JK=J-2
  270 TMP(JK)=INS(J)
C
      DECODE(NCHAR-2,130,TMP) MOD
C
C         ..C...D...R...S...Z...V...E..
  272 GOTO (296,275,280,285,287,290,900),L
C
C     ..............................................................D
C     Delete variable
  275 IF(NNN.EQ.1)GOTO 276
      WRITE(TT,131)
      GOTO 264
  276 IF(MOD.LE.NVAR1) GOTO 277
      WRITE(TT,132)
      GOTO 264
  277 IF(IO(MOD).EQ.'1') GOTO 264
      MVAR=MVAR-1
      IO(MOD)='1'
      GOTO 264
C     ..............................................................R
C     Replace variable
  280 IF(NNN.EQ.1) GOTO 281
      WRITE(TT,131)
      GOTO 264
  281 IF(MOD.LE.NVAR1) GOTO 282
      WRITE(TT,132)
      GOTO 264
  282 IF(IO(MOD).EQ.'0') GOTO 264
      MVAR=MVAR+1
      IO(MOD)='0'
      GOTO 264
C     ..............................................................S
C     Reset switches
  285 MVAR=NVAR1
      DO 286 I=1,NVAR1
  286 IO(I)='0'
      GOTO 264
C     ..............................................................Z
C     Delete all variables
  287 MVAR=0
      DO 288 I=1,NVAR1
  288 IO(I)='1'
      GOTO 264
C     ..............................................................V
C     View current state of I/O switches
  290 WRITE(TT,124)
      WRITE(TT,125)
      DO 291 I=1,NVAR1
      IF(IO(I).EQ.'0') AA='-'
      IF(IO(I).EQ.'1') AA='d'
      WRITE(TT,126) I,AA,VNAM(I)
  291 CONTINUE
      GOTO 264
C     ...............................................................
C     Command not identified
      WRITE(TT,116)
      GOTO 264
C     ...............................................................
C     ...............................................................
C
  296 IFLAG=IFLAG+1
      IF(NVAR1.EQ.MVAR) GOTO 297
C
      MMM=0
      DO 294 I=1,NVAR1
      IF(IO(I).EQ.'1') GOTO 294
      MMM=MMM+1
      VNAM(MMM)=VNAM(I)
  294 CONTINUE
C
  297 IF(IFLAG.GT.1) GOTO 303
      NVAR=MVAR
      DO 252 I=1,NVAR
  252 VARNAM(I)=VNAM(I)
      GOTO 302
C
C     Check that the variables are the same
  303     IF(MVAR.EQ.NVAR) GOTO 400
      WRITE(KB,107)                    !Different number of variables
      IFLAG=IFLAG-1
      CLOSE(UNIT=DK1)
      GOTO 246
C
```

```
C     DSC continued.
  400 DO 402 I=1,MVAR
      IF (VNAM(I).EQ.VARNAM(I)) GOTO 402
      WRITE(KB,108)                    !Variable name does not match
      IFLAG=IFLAG-1
      CLOSE(UNIT=DK1)
      GOTO 246
  402 CONTINUE
C
C     File exists & is compatible
  302 IF(IPRINT.NE.5) WRITE(IPRINT,97) (XDT(II),II=1,30)
  298 CALL GTREC(DK1,NVAR1,SN1,SN2,DATA,NV,FMT,KG,IEOF,IERR)
      IF(IERR.GT.0) WRITE(TT,137)(XDT(I),I=1,30)
      IF(IERR.GT.0) GOTO 900
      IF(IEOF.EQ.1) GOTO 300
C
      NS=NS+1
      NON=0
C
      DO 299 I=1,NVAR1
      IF(IO(I).EQ.'1') GOTO 299
      NON=NON+1
      DATA(NON)=DATA(I)
  299 CONTINUE
C
C     Write data to scratch file
      GOTO(343,344),KK
  343 WRITE(DK2)SN1,SN2,KG,(DATA(II),II=1,MVAR)
      GOTO 298
  344 WRITE(DK3)SN1,SN2,KG,(DATA(II),II=1,MVAR)
      GOTO 298
C
  300 CLOSE(UNIT=DK1)
C
      GOTO (341,342),KK
  341 NSMP1=NSMP1+NS
      GOTO 246
  342 NSMP2=NSMP2+NS
      GOTO 246
C
  450 CONTINUE
C
C     Variables match...continue
C
C     Get cross products matrices
      CALL XCRMLT(DK2,NSMP1,DK3,NSMP2,C,B,A,DATA,MVAR,NV)
C
      CALL SOLVE(A,B,MVAR,NV,IERR)
      IF (IERR.EQ.1) GOTO 899
C
      AN1=FLOAT(NSMP1)
      AN2=FLOAT(NSMP2)
      AN3=AN1+AN2-2.0
      AVAR=FLOAT(MVAR)
C
      DO 205 I=1,MVAR
      CQ1=C(1,I)/AN1
      A1(I)=CQ1
      CQ2=C(2,I)/AN2
      A2(I)=CQ2
      R0=R0+B(I)*(CQ1+CQ2)/2.0
      R1=R1+B(I)*CQ1
      R2=R2+B(I)*CQ2
  205 D2=D2+B(I)*(CQ1-CQ2)
C
      F=(((AN1+AN2-AVAR-1.0)*AN1*AN2)/(AN3*AVAR*(AN1+AN2)))*D2
      IDF1=MVAR
      IDF2=NSMP1+NSMP2-MVAR-1
      FND4=FLOAT(NSMP1*NSMP2)/FLOAT(NSMP1+NSMP2)
      HOT2=D2*FND4
C
      WRITE(IPRINT,110) R1,R0,R2,D2,HOT2,F,IDF1,IDF2
      WRITE(IPRINT,111)
C
      DO 206 J=1,MVAR
      PCACC=(B(J)*(C(1,J)/AN1-C(2,J)/AN2)/D2)*100.0
      DIFF=A1(J)-A2(J)
  206 WRITE(IPRINT,104) VARNAM(J),B(J),PCACC,A1(J),A2(J),DIFF
C
      REWIND DK2
      REWIND DK3
C
      DO 240 KK=1,2
      WRITE(IPRINT,112) KK
      GOTO(241,242),KK
  241 NSMP=NSMP1
      GOTO 243
  242 NSMP=NSMP2
C
```

```
C     DSC continued.
  243 DO 240 K=1,NSMP
      GOTO(254,257),KK
  254 READ(DK2)SN1,SN2,KG,(DATA(II),II=1,MVAR)
      GOTO 253
  257 READ(DK3)SN1,SN2,KG,(DATA(II),II=1,MVAR)
C
  253 SUM=0
C
      DO 208 L=1,MVAR
      X=DATA(L)
  208     SUM=SUM+B(L)*X
C
      DMIN=SUM-R0
      CHAR=CH1
      IF (DMIN.GT.0.0) CHAR=CH2
      GOTO(237,238),KK
  237 IF (DMIN.LT.0.0) NWRONG=NWRONG+1
      GOTO 240
  238 IF (DMIN.GT.0.0) NWRONG=NWRONG+1
  240 WRITE(IPRINT,106) K,SUM,DMIN,CHAR
C
      PCWR=100.0*NWRONG/(NSMP1+NSMP2)
      WRITE(IPRINT,105) PCWR
C
      IF(IPRINT.EQ.5) GOTO 900
      WRITE(TT,142)
      GOTO 900
C
C     Error in opening first data file
  901 WRITE(KB,120)
      GOTO 900
C
  899 WRITE(KB,103)
C
  900 STOP
C
C     ......................... formats ............................
   95 FORMAT(' Program to perform a linear discriminant analysis'/
     1 ' between two sample sets (may have >1 file per set).'/)
   96 FORMAT(/' Group',I2,' files;')
   97 FORMAT(X,30A1)
   98 FORMAT('$Type "V" to send results to VDU   (d=File)  ')
   99 FORMAT(Q,A1)
  100 FORMAT('$DSC> filename Gp',I2,' or <ret>  ')
  101 FORMAT(Q,30A1)
  103 FORMAT(' * cross-product matrix singular *')
  104 FORMAT(1H ,A8,5F12.4)
  105 FORMAT(1H0 ,'.........% mis-classified...',F6.2/)
  106 FORMAT(1H ,I6,4X,2F12.4,10X,A1)
  107 FORMAT(' * number of variables in each file differ *')
  108 FORMAT(' * variable names do not agree between files *')
  110 FORMAT(1H /
     1 ' Discriminant value Gp.1',F12.4,9X,'Discriminant index',F12.4/
     2 ' Discriminant value Gp.2',F12.4,9X,'Mahalanobis D-sqr ',F12.4/
     3 ' Hotelling T-sqr....... ',F12.4//
     4 ' F-ratio ',F12.4,' with',I4,' and',I4,'  degrees of freedom')
  111 FORMAT(1H0,'Variable    -- A(i) --    -- % acc --  Gp1 means    '
     1 'Gp2 means   diff.'/)
  112 FORMAT(1H0,'   .......Discriminant scores:  Group',I2//
     1 '  Sample no.   Score 1     Score 2     Classification'/)
  120 FORMAT(' * error in opening data file *')
  116 FORMAT(' Command not identified.....Try again')
  117 FORMAT(' Error',I2,'in GTHED in',30A1,'File ignored')
  124 FORMAT(' Current state of I/O switches')
  125 FORMAT('     I/O',3X,'Element')
  126 FORMAT(2X,I2,2X,A1,5X,A8)
  127 FORMAT(/'$INS>')
  128 FORMAT(Q,6A1)
  129 FORMAT('....... Valid responses to INS>'/
     1 '      <ret> Shows these valid responses'//
     2 '      C    Continue.(Leaves switches as set)'//
     3 '      V    View current state of I/O switches'/
     4 '      D=<address><ret> ... Deletes specified variable'/
     5 '      R=<address><ret> ... Replaces specified variable'//
     6 '      S    Resets switches'/
     7 '      Z    Delete all variables'/)
  133 FORMAT('      E    Exit from program'/)
  130 FORMAT(I8)
  131 FORMAT(' Address not given.....Type instruction again.')
  132 FORMAT(' Error...address too large')
  137 FORMAT(' EXIT ... Reading error in GTREC in',30A1)
  141 FORMAT(' Ignored--exceeded allowed no of variables')
  142 FORMAT(/' Results stored in Z.DSC')
C
      END
```

```
      PROGRAM IED
C     Editor for direct access files xxx.IDN required by program IDN.
C     Options include:
C                        0 .... Create file
C                        1 .... List file
C                        2 .... Alter file
C                        4 .... Copy to formatted sequential file  (Z.IDN)
C
C     Function/Subroutines used;  FCHECK  CEXTEN
C
C     *****************************************************************
      LOGICAL *1 AFILE(30),FCHECK,EXIST,XTYPE(2),XNAME(2),CMD(2),
     1    INS,LST(8),IDT(3)
C
      REAL *4    NULL3
      REAL *8 ELEM(5),ELEM1(5),NULL2
C
      INTEGER NM(24),NM1(24),NAME,RO(5),RO1(5),NULL1,ID(24)
C
      DIMENSION VAL(5),VAL1(5),DIST(24),DIST1(24)
C
      DATA IDEV,JJDEV,LDEV,MLEN,IERR,IEOF/5,1,3,30,2*0/
     1    ,NEND,NV,NX/99,50,5000/
     2    ,LST/'C','I','D','E','X','N','R','L'/
     3    ,NULL1,NULL2,NULL3/'  ','        ','    '/
C     *****************************************************************
C
  200 NON=0
      NKOUNT=0
      MKOUNT=0
      JFLAG=0
      JJFLAG=0
      JDEV=1
      KDEV=5
      INS=' '
C
C     Select options
  202 WRITE(IDEV,100)
      READ(IDEV,101)NX,CMD
C
      IF(NX.EQ.0) GOTO 204
      IF(CMD(1).NE.'/') GOTO 216
      IF(CMD(1).EQ.'/') GOTO 206
C
  204 WRITE(IDEV,102)
      GOTO 202
C
  206  IF(CMD(2).NE.'C') GOTO 208
       KOPT=0                               !Create file
       GOTO 218
C
  208 IF(CMD(2).NE.'L') GOTO 210
      KOPT=1                                !List file
      GOTO 218
C
  210 IF(CMD(2).NE.'A') GOTO 212
      KOPT=2                                !Alter file
      GOTO 218
C
  212 IF(CMD(2).NE.'F') GOTO 214
      KOPT=4                                !Copy to file
      KDEV=2
      GOTO 218
C
  214   IF(CMD(2).EQ.'E') GOTO 999        !Exit
C
  216 WRITE(IDEV,103)
      GOTO 202
C
C     *****************************************************************
C     Ask for filenames
  218   WRITE(IDEV,104)
      READ(IDEV,105) NA,AFILE
      IF(NA.EQ.0) GOTO 999                 !Exit
C
C     Check for extension,that .IDN-file exists & open file
      CALL CEXTEN(AFILE,NA,MLEN,'I','D','N',IERR)
      IF(IERR.EQ.1) WRITE(IDEV,106)
      IF(IERR.EQ.1) GOTO 999               !Exit
C
      EXIST=FCHECK(JDEV,AFILE)
      IF(.NOT.EXIST.AND.KOPT.EQ.0) WRITE(IDEV,107)
      IF(.NOT.EXIST.AND.KOPT.GT.0) GOTO 218      !Try again
C
      IF(KOPT.GT.0.OR..NOT.EXIST) GOTO 220
      WRITE(IDEV,108)
      GOTO 999                    !Exit
C
```

```
C     IED continued.
  220 IF(KOPT.NE.4) GOTO 225
      OPEN(UNIT=KDEV,NAME='SY0:Z.IDN',ERR=996)
      WRITE(KDEV,109) (AFILE(I),I=1,NA)
C
  225     OPEN(UNIT=JDEV,TYPE='UNKNOWN',NAME=AFILE,ACCESS='DIRECT',
     1    RECORDSIZE=18,ERR=995)
C
      IF(KOPT.NE.2) GOTO 230
      OPEN(UNIT=LDEV,TYPE='NEW',NAME=AFILE,ACCESS='DIRECT',
     1    RECORDSIZE=18,ERR=995)
C
C     ****************************************************************
C
C     Identification codes loop                            Records 1 & 2
  230 IF(KOPT.EQ.0) GOTO 340
C
C     ................................................... (KOPT=1,2 or 4)
      KFLAG=0
C
      DO 330 K=1,2
C
      NKOUNT=NKOUNT+1
      MKOUNT=MKOUNT+1
      READ(JDEV'NKOUNT)(NM(I),DIST(I),I=1,12)
C
      IF(KFLAG.EQ.1) GOTO 251
C
  239 IF(K.EQ.1) WRITE(KDEV,110)
      DO 240 I=1,12
      IF(NM(I).NE.NULL1) GOTO 240
      KFLAG=1
      GOTO 250
  240 WRITE(KDEV,111) (K-1)*12+I,NM(I),DIST(I)
C
  250 IF(K.EQ.2.OR.KFLAG.EQ.1) WRITE(KDEV,112)
C
  251   IF(KOPT.NE.2) GOTO 330
C
C     ..................................................... (KOPT=2)
C     Alter if required
      DO 320 J=1,12
C
      IF(K.EQ.2.AND.NON.EQ.12) GOTO 321
      IF(INS.EQ.'E') GOTO 310
C
  260 WRITE(IDEV,113) NM(J),DIST(J)
C
      WRITE(IDEV,115)
      READ(IDEV,116) NCHAR,INS
C
      IF(INS.EQ.' ') GOTO 280
C
      DO 270 L=1,4
  270 IF(LST(L).EQ.INS) GOTO 290
C
C     Command not identified
      WRITE(IDEV,103)
  280 WRITE(IDEV,117)
      GOTO 260
C
C         ..C...I...D...E
  290 GOTO (300,305,320,310),L
C
C     ********************************************** C
C     Copy to file
  300 NON=NON+1
      NM1(NON)=NM(J)
      DIST1(NON)=DIST(J)
      GOTO 320
C     ********************************************** I
C     Input new name & DIST value to file
  305 NON=NON+1
      WRITE(IDEV,118) (K-1)*12+NON
      READ(IDEV,119) NM1(NON)
      WRITE(IDEV,120)
      READ(IDEV,121) DIST1(NON)
      GOTO 260
C     ********************************************** E
C     Copy to end of record
  310 NON=NON+1
      NM1(NON)=NM(J)
      DIST1(NON)=DIST(J)
C     **********************************************
  320 CONTINUE
C     **********************************************
C
  321     WRITE(LDEV'MKOUNT)(NM1(I),DIST1(I),I=1,12)
C
      IF(K.EQ.2) GOTO 330
      NON=NON-(J-1)
```

```
C     IED continued.
C
      IF(NON.EQ.0) GOTO 330
      DO 329 II=1,NON
  329 NM1(II)=NM(J+II)
C
  330 CONTINUE
C
      WRITE(KDEV,112)
      GOTO 400
C
C     ..................................................... (KOPT=0)
  340    NON=0
      NX=0
      DO 391 K=1,2
      MKOUNT=MKOUNT+1
C
      DO 390 J=1,12
C
      NM(J)=NULL1
      DIST(J)=0.000
C
      IF((K.EQ.2.OR.J.GT.1).AND.NX.EQ.0) GOTO 359
C
      NON=NON+1
      IF(NON.GT.22) GOTO 360
C
      WRITE(IDEV,118) NON
      READ(IDEV,122) NX,XNAME
C
      IF(NX.EQ.0) GOTO 370
C
      DECODE(NX,119,XNAME) NM(J)
C
      WRITE(IDEV,120)
      READ(IDEV,121) DIST(J)
C
  359 IF(J.EQ.12) GOTO 380
      GOTO 390
C
  360 WRITE(IDEV,123)
C
  370 NM(J)='NI'               !Final group not identified
      NM(J+1)=NULL1
C
  380 WRITE(JDEV'MKOUNT)(NM(I),DIST(I),I=1,12)
  390 CONTINUE
C
  391 CONTINUE
C
      GOTO 700
C
C     ****************************************************************
C
C     Conditions loop                                    Record 3 -->
C
C     ..................................................... (KOPT=1,2 or 4)
  400    MKOUNT=MKOUNT+1
      IF(KOPT.NE.2) GOTO 402
      IF(JJFLAG.LE.JFLAG) GOTO 402
C
      NTYPE=0
      NCOND=0
      DO 401 I=1,24
  401 ID(I)=0
      GOTO 680
C
  402 NKOUNT=NKOUNT+1
C
      READ(JDEV'NKOUNT) NTYPE,NCOND,(ID(I),I=1,24)
C
      IF(JJFLAG.LT.JFLAG) INS='R'
      IF(NTYPE.LT.1.AND.KOPT.EQ.2.AND.INS.EQ.'R') GOTO 426
C
      IF(KOPT.EQ.2) INS=' '
C
      IF(JFLAG.LE.0) GOTO 419
      INS='E'
      GOTO 426
C
  419 LCOND=NCOND
      MCOND=NCOND
      JJJ=0
      IFLAG=0
C
  420    WRITE(KDEV,124) MKOUNT/2
      IF(NTYPE.GT.1) GOTO 425
      IF(JFLAG.GT.0) GOTO 426
C
      NUMB=2
      WRITE(KDEV,125) NTYPE,ID(1)
      WRITE(KDEV,126) NCOND,ID(2)
```

```
      C
            DO 421 I=3,24
            NUMB=NUMB+1
            IF(ID(I).EQ.0) GOTO 426
        421 WRITE(KDEV,127) I,ID(I)
            GOTO 426
      C
        425     WRITE(KDEV,128)
            WRITE(KDEV,129) NTYPE,MCOND,ID(1),ID(2)
      C
            IF(KOPT.NE.2.AND.NTYPE.EQ.99) GOTO 990
        426 IF(KOPT.NE.2) GOTO 719
      C
      C     ................................................... (KOPT=2)
      C     Alter if required
            DO 670 J=1,26
      C
            JJ=J
      C
            IF(NTYPE.LE.1.AND.INS.EQ.'R'.AND.JJ.LE.1) GOTO 665
            IF(INS.EQ.'E'.OR.INS.EQ.'N'.OR.INS.EQ.'X'.OR.
           1    INS.EQ.'R')GOTO 670
      C
        440 IF(JJ.GT.2)GOTO 500
            GOTO(460,480),JJ
      C
        460 IF(NTYPE.GT.1) NUMB=2
            WRITE(IDEV,130) NTYPE
            GOTO 540
      C
        480 WRITE(IDEV,131) MCOND
            GOTO 540
      C
        500 IF(NTYPE.LE.1) GOTO 505
            GOTO(502,503,680),(JJ-2)     !GOTO 680 --> Exit from loop
      C
        502 WRITE(IDEV,132) ID(1)
            GOTO 540
      C
        503 WRITE(IDEV,133) ID(2)
            GOTO 540
      C
        505 IF(JJ-2.GT.NUMB) GOTO 680
            WRITE(IDEV,134) (JJ-2),ID(JJ-2)
      C
      C
        540 WRITE(IDEV,115)
            READ(IDEV,116) NCHAR,INS
      C
            IF(JJ.GT.1.AND.INS.EQ.'N') GOTO 570
            IF(INS.EQ.' ') GOTO 580
      C
            DO 560 L=1,7
        560 IF(LST(L).EQ.INS) GOTO 600
      C
      C     Command not identified
        570 WRITE(IDEV,103)
        580 WRITE(IDEV,135)
            GOTO 440
      C
      C         ..C...I...D...E...X...N...R
        600 GOTO (670,610,610,670,666,660,665),L
      C
      C     """""""""""""""""""""""""""""""""""""""""""""""" I or D
      C     Input new value to file
        610 IF(JJ.GT.2) GOTO 638
            GOTO (620,630),JJ
      C
        620 WRITE(IDEV,136)                 !Calculation type required
            READ(IDEV,137) NTYPE
            IF(NTYPE.GE.1.AND.NTYPE.LE.4) GOTO 670
            WRITE(IDEV,138)
            GOTO 620
      C
        630 GOTO(631,631,632,632,633),(NTYPE+1)
      C
        631 WRITE(IDEV,139)                 !No of elements used for clustering
            GOTO 635
        632 WRITE(IDEV,140)                 !No of conditions
            GOTO 635
        633 WRITE(IDEV,141)                 !No of elements used in discrim.funct.
      C
        635 READ(IDEV,137) NCOND
            IF(NTYPE.LE.1.OR.NTYPE.GE.4) NCOND=NCOND+1
            IF(NTYPE.LE.1.OR.NCOND.LE.5) GOTO 670
            WRITE(IDEV,142)
            GOTO 630
      C
        638 IF(NTYPE.LE.1) GOTO 645
            GOTO(640,641),(JJ-2)
```

```
C      IED continued.
C
   640 WRITE(IDEV,143)                  !Instruction if true
       READ(IDEV,144) ID(1)
       GOTO 670
C
   641 WRITE(IDEV,145)                  !Instruction if false
       READ(IDEV,144) ID(2)
       GOTO 670
C
   645 WRITE(IDEV,146) (JJ-2)
       READ(IDEV,144) ID(JJ-2)
       NUMB=NUMB+1
       GOTO 670
C      """""""""""""""""""""""""""""""""""""""""""""""""" N
C      Input new record
   660 MKOUNT=MKOUNT-1
       JDEV=LDEV
       GOTO 700
C      """""""""""""""""""""""""""""""""""""""""""""""""" R
C      Remove record
   665 MKOUNT=MKOUNT-2
       GOTO 719
C      """""""""""""""""""""""""""""""""""""""""""""""""" X
C      Exit
   666 NTYPE=99
       NCOND=0
       ID(1)=0
       ID(2)=0
       GOTO 680
C      """"""""""""""""""""""""""""""""""""""""""""""""""
   670 CONTINUE
C      """"""""""""""""""""""""""""""""""""""""""""""""""
C
       IF(INS.EQ.'N') GOTO 400
C
   680 IF(NTYPE.GT.0) NNCOND=NCOND
C
       WRITE(LDEV'MKOUNT) NTYPE,NCOND,(ID(I),I=1,24)
C
       IF(NTYPE.EQ.99) GOTO 990
       GOTO 719
C
C      ....................................................... (KOPT=0)
   700 WRITE(IDEV,124) (MKOUNT+1)/2
C
       IF(JFLAG.NE.1) GOTO 702
C
       NTYPE=0
       NCOND=0
       DO 701 I=1,NUMB
   701 ID(I)=0
       GOTO 717
C
   702   MMM=0
       WRITE(IDEV,136)                             !Calculation type required
       READ(IDEV,122) NX,XTYPE
C
       IF(NX.EQ.0) GOTO 980
C
       DECODE(NX,137,XTYPE) NTYPE
C
       IF(NTYPE.GE.1.AND.NTYPE.LE.4) GOTO 704
       WRITE(IDEV,138)
       GOTO 702
C
   704 GOTO(705,705,706,706,707),(NTYPE+1)
C
   705 WRITE(IDEV,139)                  !No of elements used for clustering
       GOTO 708
   706 WRITE(IDEV,140)                  !No of conditions required
       GOTO 708
   707 WRITE(IDEV,141)                  !No of elements used in discrim.funct.
C
   708 READ(IDEV,137) NCOND
       IF(NTYPE.EQ.1.OR.NTYPE.EQ.4) NCOND=NCOND+1
       LCOND=NCOND
C
       IF(NTYPE.EQ.1) GOTO 709
C
       IF(NCOND.LE.5) GOTO 711
       WRITE(IDEV,142)
       GOTO 704
C
   709 DO 710 I=1,24
       WRITE(IDEV,146) I
       READ(IDEV,147) NIDT,IDT
       NUMB=NUMB+1
       IF(NIDT.NE.0) GOTO 710
       ID(I)=0
       GOTO 717
```

```
C     ICD continued.
  710 DECODE(NIDT,144,IDT) ID(I)
      GOTO 717
C
  711 WRITE(IDEV,143)                        !Instruction if true
      READ(IDEV,144) ID(1)
C
      WRITE(IDEV,145)                        !Instruction if false
      READ(IDEV,144) ID(2)
C
      NUMB=3
      ID(NUMB)=0
C
C     Write record to file
  717   MKOUNT=MKOUNT+1
      WRITE(JDEV'MKOUNT) NTYPE,NCOND,(ID(I),I=1,24)
      GOTO 960
C
C     **************************************************************
C
C     Conditions
C     ..................................................... (KOPT=1,2 or 4)
  719 IF(KOPT.NE.2) GOTO 721
      IF(NTYPE.LE.1.AND.INS.EQ.'R') GOTO 720
      IF(JFLAG.EQ.JJFLAG) GOTO 721
C
      MKOUNT=MKOUNT+1
      IFLAG=1
      KCOND=0
      GOTO 731
C
  720 IFLAG=-1
  721 NKOUNT=NKOUNT+1
      MKOUNT=MKOUNT+1
C
      IF(NTYPE.GT.1.AND.JFLAG.LT.1) GOTO 722
      IF(LCOND-5) 722,722,723
C
  722 KCOND=LCOND
      IF(NTYPE.GT.1) KCOND=MCOND
      JFLAG=0              !No more elements to follow (NTYPE=1)
      IF(IFLAG.EQ.-1) GOTO 740
      GOTO 724
C
  723 KCOND=5
      LCOND=LCOND-5
      JFLAG=1              !More elements to follow (NTYPE=1)
      IF(IFLAG.EQ.-1) GOTO 740
C
  724 IF(KOPT.EQ.2.AND.INS.EQ.'R') GOTO 731
      IF(KOPT.EQ.2) INS=' '
C
  731 DO 732 I=1,5
      ELEM(I)=NULL2
      RO(I)=NULL1
  732 VAL(I)=NULL3                                      !Zero everything
C
      IF(IFLAG.EQ.1) GOTO 761
C
  740 READ(JDEV'NKOUNT)(ELEM(I),RO(I),VAL(I),I=1,KCOND)
C
      IF(KOPT.EQ.2.AND.INS.EQ.'R') GOTO 400                  !Remove record
C
  750 IF(NTYPE-1)756,751,755
C
  751 WRITE(KDEV,148)                        !1st reading (NTYPE=1)
      KKCOND=KCOND-1
      GOTO 757
  755 WRITE(KDEV,149)
  756 KKCOND=KCOND
  757   KFLAG=0
C
      DO 760 I=1,KKCOND
      II=I
      IF(KFLAG.GT.0) II=I+1
      IF(NTYPE.GT.1) GOTO 759
      IF(I.NE.1.OR.NTYPE.NE.1) GOTO 758
C
      WRITE(KDEV,151) ELEM(2),ELEM(1)
      KFLAG=1
      GOTO 760
C
  758 IF(KOPT.EQ.2.AND.II.EQ.1) WRITE(KDEV,152)
      WRITE(KDEV,151) ELEM(II)
      GOTO 760
C
  759 WRITE(KDEV,153) ELEM(I),RO(I),VAL(I)
  760 CONTINUE
C
      WRITE(KDEV,112)
```

```
      IF(KOPT.NE.2) GOTO 400
C
C     .................................................... (KOPT=2)
C     Alter if required
  761 IF(NTYPE.GT.1.AND.JJFLAG.LT.1) GOTO 762
      IF(NNCOND-5) 762,762,763
C
  762 ICOND=NNCOND
      JJFLAG=0     !No more elements to follow (NTYPE=1)
      GOTO 764
C
  763 ICOND=5
      NNCOND=NNCOND-5
      JJFLAG=1     !More elements to follow (NTYPE=1)
C
  764 NON=0
      KKK=0
      JJ=0
      IF(IFLAG.EQ.-1) GOTO 765
C
      IF(NTYPE.LE.1.AND.JFLAG.GT.0) WRITE(IDEV,154)
      IF(NTYPE.LE.1.AND.JFLAG.GT.0) WRITE(IDEV,155)
C
  765 DO 921 J=1,ICOND
      JJ=JJ+1
      IF(NTYPE.LT.1.OR.J.GT.1) JJJ=JJJ+1
      IF(JJ.GT.KCOND) GOTO 850            !Therefore input
C
  775 KKK=KKK+1
      IF(INS.EQ.'E') GOTO 900
C
  779 IF(KCOND.GE.ICOND) GOTO 780
      IF(IFLAG.EQ.1) GOTO 850
C
  780 WRITE(IDEV,112)
      IF(NTYPE.GT.1) GOTO 782
      IF(NTYPE.LT.1.OR.J.GT.1) GOTO 781
C
      WRITE(IDEV,156) ELEM(1)
      GOTO 786
C
  781 WRITE(IDEV,157) JJJ,ELEM(KKK)
      GOTO 786
C
  782    WRITE(IDEV,158) ELEM(KKK),RO(KKK),VAL(KKK)
C
  786    WRITE(IDEV,115)
      READ(IDEV,116) NCHAR,INS
C
      IF(INS.EQ.' ') GOTO 800
C
      DO 790 L=1,4
  790 IF(LST(L).EQ.INS) GOTO 810
C
C     Command not identified
      WRITE(IDEV,103)
  800 WRITE(IDEV,117)
      GOTO 779
C
C       ..C...I...D...E
  810 GOTO (830,850,919,900),L
C
C     ************************************************ C
C     Copy to file
  830 NON=NON+1
      ELEM1(NON)=ELEM(KKK)
      IF(NTYPE.GT.1) GOTO 840
C
      RO1(NON)=NULL1
      VAL1(NON)=NULL3
      GOTO 921
C
  840 RO1(NON)=RO(KKK)
      VAL1(NON)=VAL(KKK)
      GOTO 921
C     ************************************************ I
C     Input new name to file
  850 IF(NTYPE.GT.1.OR.JFLAG.LE.0) GOTO 860
      WRITE(IDEV,159)
      GOTO 786
C
  860 NON=NON+1
      KKK=KKK-1
      JJ=JJ-1
C
      IF(NTYPE.GT.1) GOTO 890
      IF(NTYPE.LT.1.OR.J.GT.1) GOTO 870
C
```

```
      WRITE(IDEV,160)
      READ(IDEV,161) ELEM1(1)
      GOTO 880
C
  870 WRITE(IDEV,162) JJJ
      READ(IDEV,161) ELEM1(NON)
C
  880 RO1(NON)=NULL1
      VAL1(NON)=NULL3
      GOTO 921
C
  890 IF(NTYPE.EQ.4.AND.NON.EQ.ICOND) GOTO 892
C
      WRITE(IDEV,163) NON                       !Element name required
      READ(IDEV,161) ELEM1(NON)
      IF(NTYPE.EQ.4) GOTO 894
      GOTO 893
C
  892 ELEM1(NON)=NULL2
      RO1(NON)='GT'
      WRITE(IDEV,164)
      GOTO 895
C
  893 WRITE(IDEV,165)                                  !Relational operator required
      READ(IDEV,119) RO1(NON)
      GOTO 895
C
  894 RO1(NON)=NULL1
C
  895 WRITE(IDEV,166)                                  !Value
      READ(IDEV,121) VAL1(NON)
      GOTO 921
C     ******************************************** E
C     Copy to end of record
  900 NON=NON+1
      ELEM1(NON)=ELEM(KKK)
      IF(NTYPE.GT.1) GOTO 904
C
      RO1(NON)=NULL1
      VAL1(NON)=NULL3
      GOTO 921
C
  904 RO1(NON)=RO(KKK)
      VAL1(NON)=VAL(KKK)
      GOTO 921
C     ******************************************** D
C     Deletion
  919 IF(NTYPE.LE.1.AND.JFLAG.GT.0) GOTO 920
      JJ=JJ-1
      GOTO 775
C
  920 WRITE(IDEV,167)
      GOTO 786
C     ********************************************
  921 CONTINUE
C     ********************************************
C
      IF(NON.GT.5) WRITE(IDEV,168)
C
  940     WRITE(LDEV'MKOUNT)(ELEM1(I),RO1(I),VAL1(I),I=1,ICOND)
C
      GOTO 400
C
C     ........................................................ (KOPT=0)
  960 IF(NTYPE.GT.1.AND.JFLAG.LT.1) GOTO 961
      IF(LCOND-5) 961,961,962
C
  961 KCOND=LCOND
      JFLAG=0               !No more elements to follow (NTYPE=1)
      GOTO 963
C
  962 KCOND=5
      LCOND=LCOND-5
      JFLAG=1               !More elements to follow (NTYPE=1)
C
  963 DO 970 I=1,KCOND
C
      IF(NTYPE.GT.1) GOTO 965
      IF(I.NE.1.OR.NTYPE.NE.1) GOTO 964
C
      WRITE(IDEV,160)
      READ(IDEV,161) ELEM(I)
      RO(I)=NULL1
      VAL(I)=NULL3
      GOTO 970
C
  964 MMM=MMM+1
      WRITE(IDEV,162) MMM
      READ(IDEV,161) ELEM(I)
```

```
      RO(I)=NULL1
      VAL(I)=NULL3
      GOTO 970
C
  965 IF(NTYPE.EQ.4.AND.I.EQ.LCOND) GOTO 966
C
      WRITE(IDEV,163) I                     !Element name required
      READ(IDEV,161) ELEM(I)
      IF(NTYPE.EQ.4) GOTO 968
      GOTO 967
C
  966 ELEM(I)=NULL2
      RO(I)='GT'
      WRITE(IDEV,164)
      GOTO 969
C
  967 WRITE(IDEV,165)                                 !Relational operator required
      READ(IDEV,119) RO(I)
      GOTO 969
C
  968 RO(I)=NULL1
C
  969 WRITE(IDEV,166)                                 !Value
      READ(IDEV,121) VAL(I)
C
  970 CONTINUE
C
C     Write record to file
      MKOUNT=MKOUNT+1
      WRITE(JDEV'MKOUNT)(ELEM(I),RO(I),VAL(I),I=1,KCOND)
C
      IF(KOPT.NE.2.OR.JFLAG.GT.0) GOTO 700       !Get next set of conditions
C
      JDEV=JJDEV
      NKOUNT=NKOUNT-1
      GOTO 670                              !Continue with /A in KOPT=2
C
  980   MKOUNT=MKOUNT+1
      WRITE(JDEV'MKOUNT) NEND
C     ....................................................
C     ....................................................
C
C
  990 CLOSE(UNIT=JDEV,ERR=995)
C
      IF(KOPT.NE.2) GOTO 200
      CLOSE(UNIT=LDEV,ERR=995)
C
C     ****************************************************************
      GOTO 200                              !Return for new instructions
C     ****************************************************************
C
  995 WRITE(IDEV,169)
      GOTO 999
C
  996 WRITE(IDEV,170)
C
  999 STOP
C
C     ............................ formats ...............................
  100 FORMAT('$CMD> ')
  101 FORMAT(Q,2A1)
  102 FORMAT(' Valid responses to CMD>'/
     1 '     /C .... Create file'/
     2 '     /L .... List file'/
     3 '     /A .... Alter file'/
     4 '     /F .... Copy to formatted sequential file Z.IDN'/
     5 '     /E .... Exit                               ')
  103   FORMAT(' Command not identified .... Try again!')
  104 FORMAT('$Filename; ')
  105 FORMAT(Q,30A1)
  106 FORMAT(' Warning...Resulting filename too long....ignored')
  107 FORMAT(' Ignore preceeding warning')
  108 FORMAT(' File already exists .... Can not create ...... EXIT')
  109 FORMAT(' File;',/4X,30A1)
  110    FORMAT(' Identication          Max distance from centroid'/
     1 '   codes                (KMEAN option)')
  111 FORMAT(2X,'-',I2,4X,A2,7X,F8.3)
  112 FORMAT(1H )
  113 FORMAT(' Next name; ',A2,6X,' Max distance;',F8.3)
  115 FORMAT('$INS>')
  116 FORMAT(Q,A1)
  117 FORMAT('....... Valid responses to INS>'/
     1 '          <ret> Shows these valid responses'/
     2 '            C   Copy above to file'/
     3 '            I   Input new name & distance to file'/
     4 '            D   Delete above from file'/
     5 '            E   Copy to end of record'/
     6 '          Warning..Input new name & distance prior to deletion')
```

```
C       IED continued.
      118       FORMAT(/'$Type 2 letter identification code for group;',I2,' ')
      119 FORMAT(A2)
      120 FORMAT('$Type max distance from centroid (KMEAN option) or '0' ')
      121 FORMAT(F10.0)
      122 FORMAT(Q,2A1)
      123 FORMAT(' Warning .. Max no of groups(22). Prog continues')
      124 FORMAT(/,6X,' +++++++ ',I2,' +++++++')
      125 FORMAT(' NTYPE;',I2,6X,'Id.code for cluster gp 1;'I3)
      126 FORMAT(' NCOND;',I2,6X,'Id.code for cluster gp 2;'I3)
      127 FORMAT(15X,'Id.code for cluster gp'I2';'I3)
      128       FORMAT(' ..NTYPE.. ..NCOND.. ..TR.. ..FA..')
      129 FORMAT(4X,I2,8X,I2,6X,I3,4X,I3)
      130 FORMAT(' NTYPE; ',I2)
      131 FORMAT(' NCOND; ',I2)
      132 FORMAT(' TR; ',I3)
      133 FORMAT(' FA; ',I3)
      134 FORMAT(' Id.code for cluster gp'I2'; ',I3)
      135 FORMAT('....... Valid responses to INS>'/
         1 '        <ret> Shows these valid responses'/
         2 '          C   Copy above to file'/
         3 '          I   Input new & delete old name above from file'/
         4 '          D   Delete old name above & input new name to file'/
         5 '          E   Copy to end of record'/
         6 '          N   Input new record'/
         7 '          R   Remove record'/
         8 '          X   Exit '/
         9 '          NB. I & D above are identical')
      136 FORMAT(' Calculation type required;   Type <ret> to exit'/
         1 ' ....1   Non-hierachical clustering technique. Final option'/
         2 ' ....2   Relational operator .. >1 condition true'/
         3 ' ....3   Relational operator .. all conditions true'/
         4 '$....4   Discriminant function .. 4 elements max        ')
      137 FORMAT(I2)
      138 FORMAT(' Warning ... NTYPE out of range .... Try again')
      139 FORMAT('$No of elements to be used for clustering; ')
      140 FORMAT('$No of conditions; ')
      141 FORMAT('$No of elements to be used in discrim.funct.; ')
      142 FORMAT(' Warning ... Exceeded 5 conditions .... Try again')
      143 FORMAT('$Record no instruction if true; ')
      144 FORMAT(I3)
      145 FORMAT('$Record no instruction if false; ')
      146 FORMAT('$Id.code for cluster gp'I2'; ')
      147 FORMAT(Q,3A1)
      148 FORMAT(/' ..Element..  ..Seed filename..')
      149 FORMAT(/' ..Element..  ..RO..  ......Value...')
      151 FORMAT(3X,A8,5X,A8)
      152 FORMAT(/' ..Element..')
      153 FORMAT(3X,A8,5X,A2,6X,F10.3)
      154 FORMAT(' NTYPE=1; Can only input & delete in last record.')
      155 FORMAT(' If wish to delete before last record,type 'E' until'/
         1  ' end,restart IED then delete whole record (using 'R') &'/
         2  ' re-insert.')
      156 FORMAT(' Seed filename; ',A8)
      157 FORMAT(' Element'I2,'; ',A8)
      158 FORMAT(' Next;',3X,A8,5X,A2,6X,F10.3)
      159 FORMAT(' Insert option inoperative. Try again!')
      160 FORMAT(/'$Seed filename (8 max); ')
      161 FORMAT(A8)
      162 FORMAT('$Element name ',I2,'; ')
      163 FORMAT(/'$Element name;',I2,' ')
      164 FORMAT(' Relational operator .... 'GT'')
      165 FORMAT('$Relational operator required ... ie.LE or GT; ')
      166 FORMAT('$Value; ')
      167 FORMAT(' Delete option inoperative. Try again!')
      168 FORMAT(' Warning ... Exceeded 5 conditions .... excess ignored')
      169 FORMAT(' Error in opening/closing .IDN-file')
      170 FORMAT(' Error in opening SYO:Z.IDN')
C
          END

          PROGRAM IDN
C         Identification program using direct access files xxx.IDN
C         created by editor IED.
C         Takes one sample at a time from a .RAW-file & attempts
C         a classification.
C
C         Subroutines used;   CHANGE  FCHECK  CEXTEN  GTHED   GTREC
C                             SERADD  KSTDZ   KMEAN
C         Options;
C             Default ... Uses all xxx.IDN to identifying 'unknown'
C             C ......... Uses clustering option only (ignores rest)
C                         Results of classification may
C                         be stored in 'SYO:Z.CLD'.
C             D ......... Records distance from specified seed
C                         centroid in file DREF.RAW
C
```

```
C     IDN continued.
C     Calculation options;
C         NTYPE.... 1   Non-hierachical clustering technique. Final option.
C        NTYPE.... 2   Relational operator .... >0 condition true
C        NTYPE.... 3   Relational operator .... all conditions true
C        NTYPE.... 4   Discriminant function .. 4 elements max
C
C     """"""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""
      LOGICAL *1 AFILE(30),TIT(80),TIT1(80),FMT(80),BUF(80),FCHECK,
     1    EXIST,A,CMD(14),INS,TIT2(80),FMT1(80)
C
      REAL *8 VARNAM(50),SN2,ELEM(5),ELEM1(30),NM2,VNAM(50)
C
      INTEGER SN1,KG,NM(24),RECNO,NAME,RO(5),ID(24),IDT(24),
     1    NM1,KG1,SOPT
C
      DIMENSION VAL(5),JADD(50),DATA1(50),DATA2(50),DATA3(50),
     1    KADD(50),DIST(24)
C
      DATA MNC,MNV,MCT/24,50,15*50/,
     1    CMD/'1','0','0','0','1','0','0','0','0','0','0','0','1','0'/,
     2    TIT2/' ','S','Y','0',':','D','R','E','F','.','R','A','W',67*'0/,
     3    FMT1/'(','X','F','1','2','.','5',')',72*'0/,
     4    IOPT,SOPT/1,0/,
     5    IDEV,JDEV,KDEV,LDEV,MDEV,MMDEV,NDEV,N7DEV,N9DEV/5,
     6    1,2,3,4,8,5,7,9/,
     6    NUMB,IFLAG,JFLAG,IIFLAG,MLEN,IERR,IEOF/4*0,30,2*0/,
     7    ISOF,NFLAG,MFLAG/2*1,0/
C     """"""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""
C
C     Select options
  200 WRITE(IDEV,100)
      READ(IDEV,101) NA,A
C
      IF(NA.NE.0) GOTO 210
  205 WRITE(IDEV,102) CMD(13),CMD(14),CMD(7)
      GOTO 200
C
  210 IF(A.NE.'V') GOTO 215
      CALL CHANGE(CMD(13))                    !...VDU/File
      GOTO 200
C
  215 IF(A.NE.'C') GOTO 220
      CALL CHANGE(CMD(14))                    !Only use clustering option
      GOTO 200
C
  220 IF(A.NE.'D') GOTO 225
      CALL CHANGE(CMD(7))           !Record values of DREF
      GOTO 200
C
  225 IF(A.EQ.'E') GOTO 980                   !Exit
C
  230 IF(A.NE.'G') GOTO 205                   !...INS not identified
C     .... GO!
C     """"""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""
C
      IF(CMD(13).EQ.'1') NDEV=5
      IF(CMD(13).EQ.'0') NDEV=7
C
C     Open file to store results
      IF(NDEV.NE.5.AND.CMD(7).NE.'1') OPEN(UNIT=NDEV,NAME='SY0:Z.CLD')
C
      IF(CMD(7).NE.'1') GOTO 240
C     Open file DREF.RAW to hold values of DREF
      OPEN(UNIT=N7DEV,TYPE='NEW',NAME='SY0:DREF.RAW')
C     Write header to DREF.RAW
      WRITE(N7DEV,103) (TIT2(II),II=1,80)
      WRITE(N7DEV,103) (FMT1(II),II=1,80)
      WRITE(N7DEV,104) 1,0
      WRITE(N7DEV,105) 'DREF    '
C
C     Ask for IDN-filename
  240     WRITE(IDEV,106)
      READ(IDEV,107) NA,AFILE
C
      IF(NA.EQ.0) GOTO 980
C
C     Check for extension,that .IDN-file exists & open file
      CALL CEXTEN(AFILE,NA,MLEN,'I','D','N',IERR)
      IF(IERR.EQ.1) WRITE(IDEV,108)
      IF(IERR.EQ.1) GOTO 980                  !Exit
C
      EXIST=FCHECK(JDEV,AFILE)
      IF(.NOT.EXIST) GOTO 240                 !Try again
C
      IF(NDEV.EQ.5.OR.CMD(7).EQ.'1') GOTO 250
      WRITE(NDEV,109) (AFILE(II),II=1,30)
C
  250     OPEN(UNIT=JDEV,TYPE='OLD',NAME=AFILE,ACCESS='DIRECT',
     1    RECORDSIZE=18,ERR=960)
C     .......................................................................
```

```
C     IDN continued.
C     Read in first part of IDN-file, do once only
C
C     Read in 2 letter identification codes & max           (Records 1 & 2)
C     distances from seed centroids (KMEAN option)
      NON1=0
      DO 310 K=1,2
      GOTO(260,270),K
C
  260 READ(JDEV'1)(NM(I),DIST(I),I=1,12)
      GOTO 280
C
  270 READ(JDEV'2)(NM(I),DIST(I),I=13,24)
C
C     Identify group for samples not identified
  280     DO 290 I=1,12
      NON1=NON1+1
  290     IF(NM(NON1).EQ.'NI') GOTO 300
      GOTO 310
C
  300     NI=-NON1
C
  310 CONTINUE
C
C     ***************************************************************
C     ***************************************************************
C
C     Ask for 'unknowns' filename
  320     WRITE(IDEV,110)
      READ(IDEV,107) NA,AFILE
      IF(NA.EQ.0) GOTO 910                    !Exit
C
C     Check for extension,that .RAW-file exists & open file
      CALL CEXTEN(AFILE,NA,MLEN,'R','A','W',IERR)
      IF(IERR.EQ.1) WRITE(IDEV,108)
      IF(IERR.EQ.1) GOTO 910                  !Exit
C
      EXIST=FCHECK(KDEV,AFILE)
      IF(.NOT.EXIST) GOTO 320                 !Try again
C
      IF(NDEV.EQ.5.OR.CMD(7).EQ.'1') GOTO 330
      WRITE(NDEV,111) (AFILE(II),II=1,30)
C
  330     OPEN(UNIT=KDEV,TYPE='OLD',NAME=AFILE,ERR=970)
C
C     Read in header info from .RAW-file
      CALL GTHED(NVAR,NSMP,VARNAM,MNV,TIT,FMT,KDEV,IERR)
      IF(IERR.NE.1) GOTO 340
      WRITE(IDEV,112)
      GOTO 900                      !Exit
C
  340 IF(IERR.NE.2) GOTO 350
      WRITE(IDEV,113)IERR,(AFILE(I),I=1,30)
      GOTO 900                      !Exit
C     .............................................................
C
C     Start identification procedure
C     Read in data for 1 sample at a time
  350 NON=1
      CALL GTREC(KDEV,NVAR,SN1,SN2,DATA1,MNV,FMT,KG,IEOF,IERR)
      IF(IERR.EQ.0) GOTO 360
      WRITE(IDEV,114)(AFILE(I),I=1,30)
      GOTO 900                          !Exit
C
  360 IF(IEOF.LT.1) GOTO 370                    !Continue
C
      CLOSE(UNIT=KDEV,ERR=970)
      ISOF=0
      GOTO 320                          !Next filename
C
C     Into conditions loop ................................ Record 3 -->
C
  370 RECNO=(NON*2)+1
      READ(JDEV'RECNO) NTYPE,NCOND,(ID(I),I=1,24) !Control line
C
      IF((CMD(7).NE.'1'.AND.CMD(14).NE.'1').OR.NTYPE.LE.1) GOTO 380
      NON=NON+1
      GOTO 370
C
  380 IF(IIFLAG.LE.0.OR.NTYPE.GT.1) GOTO 390
C     Check if all/some cluster info needs to read again
      GOTO(660,790),(ISOF+1)
C
  390 IF(JFLAG.GT.0) GOTO 420
      IF(NTYPE.EQ.99) GOTO 900      !Exit
      IF(NTYPE.LE.1.OR.(NTYPE.GT.1.AND.NCOND.LE.5)) GOTO 400
      WRITE(IDEV,115)
      GOTO 900                      !Exit
C
  400 KCOND=NCOND
C     ..............................
```

```
C     IDN continued.
C     Check conditions
  410 ICOND=0                               !Set counter
      SUM=0.0
C
      IF(NTYPE.GT.1) GOTO 430
  420 IF(KCOND-5) 430,430,440
C
  430 LCOND=KCOND
      JFLAG=0                               !End of record read
      GOTO 450
C
  440 LCOND=5
      KCOND=KCOND-5
      JFLAG=1                               !More to follow
C
  450 READ(JDEV'(RECNO+1))(ELEM(I),RO(I),VAL(I),I=1,LCOND)
C
      IF(NTYPE.GT.1) GOTO 510
      DO 460 I=1,LCOND
      NUMB=NUMB+1
  460 ELEM1(NUMB)=ELEM(I)        !Store element names for future clustering
C
      IF(IFLAG.GT.0) GOTO 500
C
      DO 470 I=1,24
      IF(ID(I).EQ.0) GOTO 480
  470     IDT(I)=ID(I)                  !Store id codes for future clustering
C
  480 IFLAG=1
      NUMB1=I-1                 !No of id.codes
C
      IF(CMD(7).NE.'1') GOTO 500
C     CMD(7)='1' .. Asks which group you wish samples to be assigned to
C                                      (DREF recorded in DREF.RAW)
      WRITE(IDEV,116)
      DO 490 I=1,NUMB1
      II=IABS(IDT(I))
  490 WRITE(IDEV,117) I,NM(II)
C
      WRITE(IDEV,118)
      READ(IDEV,119) NDREF
C
  500 IF(JFLAG.LT.1) GOTO 660  !ie. No more to follow,perform k-means calcn
      NON=NON+1
      GOTO 370
C
  510     DO 570 I=1,KCOND
C
      IF(NTYPE.EQ.4.AND.I.EQ.KCOND) GOTO 560
C
C     Search for element address
      CALL SERADD(IADD,ELEM,VARNAM,I,1,1,1,NVAR,MNV,IDEV,IERR)
      IF(IERR.GE.1) GOTO 900                !Exit
C
C     ......2...3...4....NTYPE
      GOTO(520,520,550),(NTYPE-1)
C     ......................................
C     Relational operator
  520 IF(RO(I).EQ.'GT') GOTO 530  !Identify relational operator
      IF(RO(I).EQ.'LE') GOTO 540
      WRITE(IDEV,120)                       !Warning ... RO not identified
      GOTO 900                        !Exit
C
  530 IF(DATA1(IADD).GT.VAL(I)) ICOND=ICOND+1
      GOTO 570
  540 IF(DATA1(IADD).LE.VAL(I)) ICOND=ICOND+1
      GOTO 570
C     ......................................
C     Discriminant function
  550 SUM=SUM+DATA1(IADD)*VAL(I)
      GOTO 570
C
  560 IF(SUM.GT.VAL(I)) ICOND=ICOND+1
C     ......................................
C
  570 CONTINUE
C
C
C     ......2...3...4....NTYPE
      GOTO(580,590,580),(NTYPE-1)
C     ......................................
C     Test if any conditions are met (used by discrim functn also)
  580 IF(ICOND.GT.0) GOTO 620
      GOTO 600
C     ......................................
C     Test if all conditions are met
  590 IF(ICOND.EQ.KCOND) GOTO 620
      GOTO 600
C     ......................................
C     ......................................
```

```
C       IDN continued.
C       ************************************** False
    600 IF(ID(2).EQ.NI) GOTO 610
        IF(ID(2).LT.0) GOTO 640
        NON=ID(2)
        GOTO 370                        !Continue ... try next record
C
    610 WRITE(NDEV,121) NON,SN1,SN2 !Not identified
        GOTO 350                    !Get new sample
C
C       ************************************** True
    620 IF(ID(1).LT.0) GOTO 630
C
        NON=ID(1)
        GOTO 370                        !Continue ... try next record
C
    630 IDENT=IABS(ID(1))                       !Sample classified
        GOTO 650
C
    640 IDENT=IABS(ID(2))
C
    650 NAME=NM(IDENT)
C
        WRITE(NDEV,122) NON,SN1,SN2,NAME
C
        GOTO 350                        !Get new sample
C       ***************************************
C
    660 IF(MFLAG.GE.1) GOTO 670
C
        NC=0
        NE=NUMB1+1              !No of samples
        NVAR2=NUMB-1                    !Actual no of variables used for clustering
C
C       Search element address & store in JADD -- Do once per .RAW-file only
    670 CALL SERADD(JADD,ELEM1,VARNAM,2,1,NUMB,MNV,NVAR,MNV,IDEV,IERR)
        IF(IERR.GE.1) GOTO 900          !Exit
C
        IF(MFLAG.GE.1) GOTO 790
        MFLAG=1
C
C       Open scratch file to hold all unstandardised data
        OPEN(UNIT=MDEV,TYPE='SCRATCH',FORM='UNFORMATTED',
      1    NAME='SY0:Z1.SCR',ERR=940)
C
C       Read in seed points & one unknown
C       Read in seed filename
        ENCODE(30,123,AFILE) ELEM1(1)
C
C       Identify no of active letters in AFILE ... needed by CEXTEN
        DO 680 I=1,8
    680 IF(AFILE(I).EQ.' ') GOTO 690
C
    690 NF=I-1
C
C       Check for extension, that file exists & open file
        CALL CEXTEN(AFILE,NF,MLEN,'R','A','W',IERR)
        IF(IERR.GT.0) GOTO 900                  !Exit
C
C       Check .RAW-file exists
        EXIST=FCHECK(LDEV,AFILE)
        IF(.NOT.EXIST) GOTO 900                 !Exit
C
        OPEN(UNIT=LDEV,TYPE='OLD',NAME=AFILE,ERR=930)
C
C       Get all data out of .RAW-file & store in DATA2 temporarily
    700 CALL GTHED(NVAR1,NSMP,VNAM,MNV,TIT1,BUF,LDEV,IERR)
        IF(IERR.NE.1) GOTO 710
        WRITE(IDEV,124)
        GOTO 890                        !Exit
C
    710 IF(IERR.NE.2) GOTO 720
        WRITE(IDEV,125)IERR,(AFILE(I),I=1,30)
        GOTO 890                        !Exit
C
C       Search for element address & store in KADD -- Do once only
    720 CALL SERADD(KADD,ELEM1,VNAM,2,1,NUMB,MNV,NVAR1,MNV,IDEV,IERR)
        IF(IERR.GE.1) GOTO 890
C
    730 CALL GTREC(LDEV,NVAR1,NM1,NM2,DATA2,MNV,BUF,KG1,IEOF,IERR)
        IF(IERR.GT.0) WRITE(IDEV,126)(AFILE(I),I=1,30)
        IF(IERR.GT.0) GOTO 890                  !Exit
C
        IF(IEOF.NE.1) GOTO 740
        IF(NC.EQ.NUMB1) GOTO 770
C
        WRITE(IDEV,127)
        GOTO 890                        !Exit
C
```

```
C       IDN continued.
  740 NC=NC+1
      II=IABS(IDT(NC))
      IF(NC.LE.II) GOTO 750
      WRITE(IDEV,128)
      GOTO 890               !Exit
C
C     Reform DIST array, only hold values if group appears in KMEAN option
  750 DIST(NC)=DIST(II)
C
      IF(DIST(NC).LT.0.00001.OR.CMD(7).EQ.'1') NFLAG=0
      DO 760 I=1,NVAR2
      JJ=KADD(I)
  760 DATA3(I)=DATA2(JJ)
C
C     Write data to scratch file on unit=MDEV
      WRITE(MDEV) NM1,NM2,KG1,(DATA3(I),I=1,NVAR2)
      GOTO 730
C
  770 IF(NC.LE.MNC) GOTO 780
      WRITE(IDEV,129)
      GOTO 890
C
  780 CLOSE(UNIT=LDEV)
      IIFLAG=1
      GOTO 800
C
  790 BACKSPACE MDEV                        !Used if IIFLAG=1
      IF(CMD(7).EQ.'1') NE=NUMB1+1          !Reset number of samples
C
  800 DO 810 I=1,NVAR2
      JJ=JADD(I)
  810 DATA3(I)=DATA1(JJ)
C
C     Write 'unknown' data to scratch file on unit=MDEV
      WRITE(MDEV) SN1,SN2,KG,(DATA3(I),I=1,NVAR2)
C
C     Open  second scratch file for use with KSTDZ
      OPEN(UNIT=LDEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1    NAME='SY0:Z2.SCR',ERR=950)
C
C     Open direct access file to hold means & std devns temporarily
      OPEN(UNIT=N9DEV,TYPE='SCRATCH',NAME='SY0:Z9.SCR',
     1    ACCESS='DIRECT',RECORDSIZE=2)
C
C     Standardise data & read new values into LDEV
      CALL KSTDZ(MDEV,LDEV,DATA1,DATA2,DATA3,NE,NVAR2,MNV,IOPT,N9DEV)
      CLOSE(UNIT=N9DEV)
C
      IF(CMD(7).NE.'1') GOTO 850
      REWIND LDEV
      KKFLAG=1
C
      DO 840 J=1,NE
      GOTO(820,830),KKFLAG
C
  820 READ(LDEV) SN1,SN2,KG,(DATA3(II),II=1,NVAR2)
      IF(J.NE.NDREF) GOTO 840
      KKFLAG=2
      GOTO 840
C
  830 READ(LDEV) NM1,NM2,KG,(DATA2(II),II=1,NVAR2)
  840 CONTINUE
C
      REWIND LDEV            !Insert new values into LDEV
C                             Seed first, then unknown.
      WRITE(LDEV) SN1,SN2,KG,(DATA3(II),II=1,NVAR2)
      WRITE(LDEV) NM1,NM2,KG,(DATA2(II),II=1,NVAR2)
C
C
      NE=2
      NC=1                   !Modify ..... CMD(7)='1' only
C
C
C     Open scratch file to hold membership details
  850 OPEN(UNIT=MMDEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1    NAME='SY0:Z3.SCR')
C
C     Open direct access file to hold centroid values (NC records),
C     NVAR2 records in each.
      OPEN(UNIT=N9DEV,TYPE='SCRATCH',NAME='SY0:Z10.SCR',
     1    ACCESS='DIRECT',RECORDSIZE=30)
C
      CALL KMEAN(NDUMMY,DATA1,DATA2,DIST,NFLAG,DREF,
     1    NDUMMY,NE,NVAR2,NC,MNV,MNC,IDEV,LDEV,NDUMMY,NDUMMY,MMDEV,NDUMMY,
     2    N9DEV,DUMMY,CMD,SOPT,NDUMMY,DUMMY,NDUMMY,DUMMY,NDUMMY,NDUMMY,
     3    DUMMY,DUMMY,NDUMMY,DUMMY,DUMMY,DUMMY,DUMMY,DUMMY,1,1,1,1)
C
      CLOSE(UNIT=LDEV)
      CLOSE(UNIT=N9DEV)
```

```
C       IDN continued.
        IF(CMD(7).NE.'1') GOTO 860
C
C       Write value of DREF to file
        WRITE(N7DEV,130) NM1,NM2,KG
        WRITE(N7DEV,FMT1) DREF
        GOTO 880                        !Get next sample
C
  860 REWIND MMDEV
        READ(MMDEV) NCLID
        IDENT=IABS(IDT(NCLID))
C
        NAME=NM(IDENT)
C
        IF(CMD(5).EQ.'1'.AND.NFLAG.EQ.1.AND.DREF.GT.1.0000) GOTO 870
C                                               !Identify 'unknowns group'
C
        WRITE(NDEV,122) NON,SN1,SN2,NAME      !Identified
        GOTO 880
  870 WRITE(NDEV,131) NON,SN1,SN2,DREF,NAME          !Not identified
  880 NON=1
C
        CLOSE(UNIT=MMDEV)
        GOTO 350                                !Get new sample
C
C
  890 CLOSE(UNIT=LDEV)
  900 CLOSE(UNIT=KDEV,ERR=960)
  910     CLOSE(UNIT=JDEV,ERR=970)
C
        IF(CMD(7).NE.'1') GOTO 920
        WRITE(N7DEV,130) '**','********'
        CLOSE(UNIT=N7DEV)
C
  920 IF(NDEV.EQ.5.OR.CMD(7).EQ.'1') GOTO 980
        CLOSE(UNIT=NDEV)
        WRITE(IDEV,132)
        GOTO 980
C
C
  930 WRITE(IDEV,133)
        GOTO 980
  940 WRITE(IDEV,134)
        GOTO 980
  950 WRITE(IDEV,135)
        GOTO 980
  960 WRITE(IDEV,136)
        GOTO 980
  970 WRITE(IDEV,137)
C
C
  980 STOP
C
C
C       ......................... formats ...........................
  100 FORMAT('$INS> ')
  101 FORMAT(Q,A1)
  102 FORMAT(' ...Valid responses to INS>'/
     1  '  G ',',' GO (switches as set)'/
     2  '  V ',A1,'  Results to vdu (1) or file (0)'/
     3  '  C ',A1,'  Only uses clustering option in IDN-file (1)'/
     4  '  D ',A1,'  Record values of DREF to DREF.RAW'/
     5  '  E ',','  Exit')
  103 FORMAT(X,80A1)
  104 FORMAT(X,I5,I6)
  105 FORMAT(X,A8)
  106 FORMAT('$.IDN filename; ')
  107 FORMAT(Q,30A1)
  108 FORMAT(' Warning...Resulting filename too long....Exit')
  109 FORMAT(/' IDN-filename; ',30A1)
  110 FORMAT('$.RAW filename; ')
  111 FORMAT(/' RAW-filename; ',30A1)
  112 FORMAT(' Ignored--exceeded allowed no of variables')
  113 FORMAT(' Error',I2,'in GTHED in',30A1,'File ignored')
  114 FORMAT(' Reading error in GTREC in',30A1)
  115 FORMAT(' Exit ... Too many conditions')
  116 FORMAT(' Address',3X,'Id code')
  117 FORMAT(X,I3,3X,'... ',A2)
  118 FORMAT('$(DREF.RAW required) ... Id code address; ')
  119 FORMAT(I2)
  120 FORMAT(' Warning ... R0 not identified ....... Exit')
  121     FORMAT(X,I2,2X,A2,A8,'....... not identified.')
  122 FORMAT(X,I2,2X,A2,A8,'....... ',A2)
  123 FORMAT(A8)
  124 FORMAT(' Ignored--exceeded allowed no of variables')
  125 FORMAT(' Error',I2,'in GTHED in',30A1,'File ignored')
  126 FORMAT(' Error in file;',30A1)
  127 FORMAT(' Exit ... No of seed points different to no of id.codes
     1  in IDN-file')
```

```
C     IDN continued.
  128 FORMAT(/' EXIT .... May have overwritten DIST value in KMEAN
     1 option'/'            Put id.codes for cluster groups in increasing
     2 numerical order using IED.')
  129 FORMAT(' Error -- exceeded allowed no of values of clusters')
  130 FORMAT(X,A2,A8,A2)
  131     FORMAT(X,I2,2X,A2,A8,'....... not identified.',3X,'(DIST;'
     1    F6.2,' from ',A2')')
  132 FORMAT(' Results of classification stored in 'SY0:Z.CLD'')
  133 FORMAT(' Error in opening/closing .RAW-file')
  134 FORMAT(' Error in opening/closing scratch-file on unit MDEV')
  135 FORMAT(' Error in opening scratch-file on unit LDEV')
  136 FORMAT(' Error in opening/closing .IDN-file')
  137 FORMAT(' Error in opening/closing .RAW-file')
C
      END


      PROGRAM MIX
C     Program to combine seed centroids of various rock groups.
C     50/50, 66/33, 33/66, 75/25, 25/75 calculated.
C     Results sent to .RAW-file (MIX.RAW) for later use with IDN.
C
C     Subroutines used;   CEXTEN  GTHED   GTREC
C
C     ****************************************************************
      LOGICAL *1 AFILE(30),TIT(80),FMT(80),FCHECK,EXIST,X(2),XNAME2(8),
     1    Y(2),XNAME1(2)
C
      REAL *8 VARNAM(50),SN2,NM2
C
      INTEGER SN1,KG,KG1(20),NM1
C
      DIMENSION DATA(50),XDATA(50),YDATA(50)
C
      DATA IDEV,JDEV,KDEV,LDEV/5,1,2,3/,MLEN,IERR,IEOF,NSMP,MNV/30,3*0,50/
C     ****************************************************************
C
C     Open scratch direct access file
      OPEN(UNIT=JDEV,TYPE='SCRATCH',ACCESS='DIRECT',
     1    RECORDSIZE=50)
C
C     Open .RAW-file to hold mixed data
      OPEN(UNIT=LDEV,TYPE='NEW',NAME='SY0:MIX.RAW')
C
C     Ask for filenames
  200     WRITE(IDEV,100)
      READ(IDEV,101) NA,AFILE
      IF(NA.EQ.0) GOTO 600
C
C     Check for extension,that .RAW-file exists & open file
      CALL CEXTEN(AFILE,NA,MLEN,'R','A','W',IERR)
      IF(IERR.EQ.1) WRITE(IDEV,103)
      IF(IERR.EQ.1) GOTO 600
C
      EXIST=FCHECK(KDEV,AFILE)
      IF(.NOT.EXIST) GOTO 200
C
C     Open .RAW-file holding seed centroids
      OPEN(UNIT=KDEV,TYPE='OLD',NAME=AFILE)
C
C     Read in header info from .RAW-file
      CALL GTHED(NVAR,NS,VARNAM,MNV,TIT,FMT,KDEV,IERR)
      IF(IERR.NE.1) GOTO 258
      WRITE(IDEV,122)
      GOTO 600
C
  258 IF(IERR.NE.2) GOTO 259
      WRITE(IDEV,124)IERR,(AFILE(II),II=1,30)
      GOTO 600
C
  259 WRITE(LDEV,99) (TIT(II),II=1,80)
      WRITE(LDEV,99) (FMT(II),II=1,80)
      WRITE(LDEV,102) NVAR,0
      WRITE(LDEV,104) (VARNAM(II),II=1,NVAR)
C
C     Read in data for 1 sample at a time
  260     CALL GTREC(KDEV,NVAR,SN1,SN2,DATA,MNV,FMT,KG,IEOF,IERR)
      IF(IERR.EQ.0) GOTO 265
      WRITE(IDEV,123)(AFILE(II),II=1,30)
      GOTO 600
C
  265     IF(IEOF.GT.0) GOTO 270            !Escape from loop
C
C     Write data to Direct Access file
      NSMP=NSMP+1
      KG1(NSMP)=KG
      WRITE(JDEV'NSMP)(DATA(II),II=1,NVAR)
      GOTO 260                         !Next record
C
  270 CLOSE(UNIT=KDEV)
C     ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

```
C      IDN continued.
C      Mix data values for all combinations of seed centroids
C      M=1 ...   0.50XX / 0.50YY      M=2 ...   0.66XX / 0.33YY
C      M=3 ...   0.33XX / 0.66YY.     M=4 ...   0.75XX / 0.25YY
C      M=5 ...   0.25XX / 0.75YY
C
       DO 230 M=1,5
C
       DO 230 I=1,(NSMP-1)
       N1=I
       READ(JDEV'N1)(XDATA(II),II=1,NVAR)
C
       DO 230 J=(I+1),NSMP
       N2=J
       READ(JDEV'N2)(YDATA(II),II=1,NVAR)
C
       DO 207 K=1,NVAR
       XX=XDATA(K)
       YY=YDATA(K)
       GOTO(202,203,204,205,206),M
   202 DATA(K)=(XX+YY)/2
       GOTO 207
   203 DATA(K)=(2*XX+YY)/3
       GOTO 207
   204 DATA(K)=(XX+2*YY)/3
       GOTO 207
   205 DATA(K)=(3*XX+YY)/4
       GOTO 207
   206 DATA(K)=(XX+3*YY)/4
   207 CONTINUE
C
       ENCODE(2,97,X) KG1(I)
       ENCODE(2,97,Y) KG1(J)
C
       GOTO(208,209,209,210,210),M
   208 XNAME1(1)=' '
       GOTO 211
   209 XNAME1(1)='2'
       GOTO 211
   210 XNAME1(1)='3'
   211 GOTO(212,212,213,212,213),M
   212 XNAME1(2)=X(1)
       GOTO 214
   213 XNAME1(2)=Y(1)
       GOTO 216
C
   214 XNAME2(1)=X(2)
       GOTO 217
   216 XNAME2(1)=Y(2)
   217 XNAME2(2)='/'
C
       DO 220 L=1,2
       GOTO(218,218,219,218,219),M
   218  XNAME2(L+2)=Y(L)
       GOTO 220
   219  XNAME2(L+2)=X(L)
   220 CONTINUE
C
       DO 225 L=1,4
   225 XNAME2(L+4)=' '
C
       DECODE(2,97,XNAME1) NM1
       DECODE(8,96,XNAME2) NM2
C
       WRITE(LDEV,98) NM1,NM2,' '
       WRITE(IDEV,98) NM1,NM2,' '
       WRITE(LDEV,FMT)(DATA(II),II=1,NVAR)
C
   230 CONTINUE
C
       WRITE(LDEV,98) '**','********',' '
C
   600 STOP
C
C      ........................ formats ..........................
    96 FORMAT(A8)
    97 FORMAT(A2)
    98 FORMAT(X,A2,A8,A2)
    99 FORMAT(X,80A1)
   100 FORMAT('$.RAW filename; ')
   101 FORMAT(Q,30A1)
   102 FORMAT(X,I5,I6)
   104 FORMAT(8(X,A8))
   103 FORMAT(' Warning...Resulting filename too long....ignored')
   122 FORMAT(' Ignored--exceeded allowed no of variables')
   123 FORMAT(' Reading error in GTREC in',30A1)
   124 FORMAT(' Error',I2,'in GTHED in',30A1,'File ignored')
C
       END
```

```
      SUBROUTINE CEXTEN(FILE,NF,MLEN,A,B,C,IERR)
C     Subroutine to check if an extension is present on the end
C     of a filename.
C     If no extension is present,the subroutine adds the extension .ABC
C     & terminates the filename with a null.
C     The prefix SY0: is added to each filename.
C     IERR......Error flag.    0 = o.k
C                              1 = resulting filename to long
C
      LOGICAL *1 FILE(MLEN),A,B,C
      IERR=0
C
C     Check addition of SY0: does not exceed MLEN
      IF(NF+4.GT.MLEN) GOTO 106
C
C     Copy filename up 4 characters
      DO 100 I=NF,1,-1
  100 FILE(I+4)=FILE(I)
C
C     Insert prefix SY0:
      FILE(1)='S'
      FILE(2)='Y'
      FILE(3)='0'
      FILE(4)=':'
C
      NF=NF+4
C
C     Check for extension
      DO 104 I=1,NF
  104 IF(FILE(I).EQ.'.') GOTO 105
C
C     Check addition of extension does not exceed MLEN
      IF(NF+5.GT.MLEN) GOTO 106
C
      FILE(NF+1)='.'
      FILE(NF+2)=A
      FILE(NF+3)=B
      FILE(NF+4)=C
      FILE(NF+5)="0
C
      NF=NF+5
      GOTO 108
C
  105 FILE(NF+1)="0
      GOTO 108
C
  106 IERR=1
      GOTO 110
C
  108 WRITE(5,200)(FILE(I),I=1,NF)
C
  110 RETURN
C
  200 FORMAT(' CEXTEN; ',30A1)
C
      END
```

```
      SUBROUTINE CHANGE(CMD)
C     Subroutine to alter values of a LOGICAL *1
C     from '0' to '1' or vice versa.
C
      LOGICAL *1 CMD
C
      IF(CMD.NE.'0') GOTO 210
      CMD='1'
      GOTO 220
C
  210 IF(CMD.NE.'1') GOTO 220
      CMD='0'
C
  220 RETURN
C
      END
```

```
      FUNCTION DIST(X,Y,NVAR,NV)
C     Subroutine to compute the distance between two data units or
C     between a data unit & a cluster centroid.
C
      DIMENSION X(NV),Y(NV)
C
      DIST=0.0
C
      DO 200 I=1,NVAR
      AA=X(I)-Y(I)
      AB=AA*AA
  200 DIST=DIST+AB
C
  250 RETURN
C
      END
```

```
      LOGICAL *1 FUNCTION FCHECK(LU,FN)
C     Check to see if a file exists
C     LU    Device no. associated with the file
C     FN    Filename in LOGICAL *1 FN(30)
C     FCHECK is returned as .TRUE. if the file exists, else .FALSE.
C
      LOGICAL *1 FN(30)
      INTEGER LU,ERR
C
      CALL ERRSET(29,.TRUE.,.FALSE.,.TRUE.,.FALSE.)
      CALL ERRSNS
C
      OPEN(UNIT=LU,NAME=FN,TYPE='OLD',ERR=200)
C
      CALL ERRSNS(ERR)
      IF (ERR.NE.0) GOTO 200
      CALL CLOSE(LU)
      FCHECK = .TRUE.
      GOTO 201
C
  200 FCHECK = .FALSE.
      WRITE(5,100) (FN(I),I=1,30)
C
  201 RETURN
C
  100 FORMAT(' ....can''t find ',30A1,/)
C
      END
```

```
      SUBROUTINE FSEED(DATA1,DATA2,NE,NVAR,NC,MNV,MNC,IDEV,LDEV,
     1NDEV,MDEV,KOPT,IFLAG,MDIST,YDIST)
C     Subroutine designed to find NC seed points which span the
C     data set.
C     ie. Most data units are relatively close to a seed point but
C     the seed ponts are well separated from each other.
C     After Ball & Hall(1967),p72-74.
C     DATA1....1-d data matrix (MNV)
C     DATA2....1-d data matrix (MNV)
C     MDIST...Min distance between seeds (KOPT=2)
C     YDIST...Array holding min distances from seed points (MNC)
C     KOPT=2 only
C     NE......No of entities (data units)
C     NVAR....No of variables                      MNV..Max no of variables
C     NC......No of clusters                       MNC..Max no of clusters
C
C     IDEV....VDU (5)
C     LDEV....Unformatted scratch file (stdzd data)
C     NDEV....Unformatted scratch file (new seed points in 1st NC samples)
C     MDEV....Temporary unformatted scratch file
C
C     Options. KOPT .... 1 Subroutine used once only to determine
C                          best seed points
C                        2 Subroutine used several times (loop within
C                          KEXEC) to determine optimum no of clusters.
C                          MDIST stored in YDIST.
C                          Runs automatically.
C                          Once optimum NC decided upon,then use KOPT=1
C
C     Function used;    DIST
C
      LOGICAL *1 ANS(1)
      REAL *8 SN2,NM2
      REAL MDIST
      INTEGER SN1,NM1,KG,CL
      DIMENSION DATA1(MNV),DATA2(MNV),YDIST(MNC)
      DATA A,KOUNT/0.0,0/
```

```
C     FSEED continued.
C
      ASSIGN 204 TO NSTEP
C
C     Open scratch file to hold all unstandardised data
  200    OPEN(UNIT=MDEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1   NAME='SY0:Z8.SCR')
      OPEN(UNIT=NDEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1   NAME='SY0:Z9.SCR')
C
C     Write overall vector mean of data set to NDEV (-->1st seed)
      WRITE(NDEV) '++','++++++++','//',(A,I=1,NVAR)
C
      NSEED=1
      ASSIGN 210 TO JUMP
C
      IF(NC.GT.1) GOTO 201
      ASSIGN 230 TO JUMP
      GOTO 203
C
  201 IF(KOPT.EQ.2) GOTO 203
      IF(KOPT.EQ.1.AND.IFLAG.LT.1) GOTO 202
      MDIST=YDIST(NC)
      GOTO 203
C
  202 WRITE(IDEV,100) NC
      READ(IDEV,101) MDIST
C
C
  203    REWIND LDEV
C
      IF(IFLAG.LT.1) GOTO 205
      READ(LDEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
      GOTO NSTEP
  204 NE=NE-1
C
  205 DO 300 I=1,NE
C
      READ(LDEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
      GOTO JUMP
C
  210 NON=0
      REWIND NDEV
C
      DO 220 J=1,NSEED
      READ(NDEV) NM1,NM2,CL,(DATA2(II),II=1,NVAR)
C
C     Compute distance to cluster centroid
      XDIST=DIST(DATA1,DATA2,NVAR,MNV)
C
  220 IF(XDIST.GE.MDIST) NON=NON+1
C
      IF(NON.EQ.NSEED) GOTO 240     !Select sample as a seed point
C
C     .... not a seed point ... store temporarily in MDEV
  230    WRITE(MDEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
      GOTO 300
C
C     .... seed point ... store in NDEV
  240 WRITE(NDEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
      NSEED=NSEED+1
      WRITE(IDEV,102) I,NE,SN1,SN2,KG,NSEED,MDIST
C
      IF(NSEED.EQ.NC) ASSIGN 230 TO JUMP
C
  300 CONTINUE             !Next sample
C
C
      IF(NSEED.EQ.NC.AND.KOPT.EQ.2) GOTO 400
      IF(NSEED.EQ.NC) GOTO 350     !Continue
C
      IF(KOPT.EQ.1) WRITE(IDEV,103) MDIST
      GOTO 380                     !Insufficient seed points...try again!
C
  350 IF(NC.EQ.1.OR.(KOPT.EQ.1.AND.IFLAG.GE.1)) GOTO 400
      WRITE(IDEV,104)
      READ(IDEV,105) NX,ANS
C
      IF(ANS(1).EQ.'Y') GOTO 400
C
  380 IF(KOPT.NE.2) GOTO 390
      MDIST=MDIST-(0.15*MDIST)
      ASSIGN 205 TO NSTEP
C
  390 CLOSE(UNIT=MDEV)
      CLOSE(UNIT=NDEV)
      GOTO 200                     !Repeat
C     +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
  400 IF(KOPT.EQ.2) WRITE(IDEV,106)
```

```
C     FSEED continued.
C     Write details of remaining data units into NDEV
      YDIST(NC)=MDIST
      REWIND MDEV
      NE=NE+1                                  !To take account of 1st seed
C
      DO 420 I=(NSEED+1),NE
      READ(MDEV) SN1,SN2,KG,(DATA2(II),II=1,NVAR)
D     WRITE(IDEV,1000) I,SN1,SN2,KG
D1000 FORMAT(X,I4,X,A2,A8,A2)
  420    WRITE(NDEV) SN1,SN2,KG,(DATA2(II),II=1,NVAR)
C
      CLOSE(UNIT=MDEV)
      CLOSE(UNIT=LDEV)
C
  500 RETURN
C
C     ..................... formats ....................................
C
  100 FORMAT(/'$(',I2,' clusters). Min distance from seed point; ')
  101 FORMAT(F10.0)
  102 FORMAT(' Sample',I4,' out of',I4,'(',A2,A8,A2,
     1    ') is cluster',I2,' seed point.    MDIST=',F8.3)
  103 FORMAT(' Choice of MDIST=',F8.3,' has resulted in insufficient
     1 seed points being formed.'/
     2    ' Must repeat subroutine run using a lesser value for MDIST')
  104 FORMAT('$If satisfied with seed points chosen, type 'Y'. (d=N) ')
  105 FORMAT(Q,A1)
  106 FORMAT(1H )
C
      END


      SUBROUTINE GETSTD(IDEV,STD,OPNM,IADD,NSP,NC,LEN,SNAME,VALS,LVAL,K)
C     Subroutine to extract data from the geochemical reference
C     standards file for a named standard .
C     IDEV      i    device no. for .STD file
C     STD       i    name of standards file with .STD ext.    L*1 (30)
C     OPNM      i    list of ordered element names            R*8 (LEN)
C     IADD      b    addresses in .STD of elements in OPNM    I*2 (LEN)
C     NSP       i    number of elements for extraction
C     LEN       i    length of the array OPNM
C     SNAME     i    name of the sample for searching         L*1 (10)
C     NC        i    number of active characters in SNAME
C     VALS      o    standard values on exit
C     LVAL      i    length of the array VALS
C     K         b    control switch - values as follows:-
C                    K =  0  set to zero first time through (opens file)
C                    K = -1  named standard not found on file (EOF)
C                    K =  1  standard located and values extracted
C                    K = -2  error in opening standards file
C
C     The standards file must be opened and K set to zero before the
C     first pass of this subroutine. This causes the element addresses
C     to be obtained once .   On exit from the subroutine the file is
C     left OPEN .  When all passes through the routine are complete
C     the file MUST be closed in the calling pringram { CLOSE(IDEV) } .
C ......................................................................
C
      LOGICAL *1 STD(30),SNAME(10),STR(72)
      REAL *8 OPNM(LEN),ELEM(64),S2,SS2,ANALNM
      INTEGER IADD(45),S1,SS1
      DIMENSION VALS(LVAL),X(64)
C ......................................................................
C
      DECODE(NC,110,SNAME) S1,S2
C
C     Read header data from the standards file
      READ(IDEV) NSVAR,NSTINF
      READ(IDEV) (STR(I),I=1,72)
      READ(IDEV) (ELEM(I),I=1,NSVAR)
C
C     If this is not the first pass jump the element search
      IF (K.NE.0) GOTO 401
C
C     Now check each OPNM(i) against ELEM(j) list to see if data on
C     analysed elements are in the .STD file.
      DO 350 I=1,NSP
      ANALNM=OPNM(I)
      DO 351 J=1,NSVAR
  351 IF (ANALNM.EQ.ELEM(J)) GOTO 352
C
C     Element not located
      IADD(I)=0   ! Set address to indicate no data
      GOTO 350
C
C     Element located - store .STD location address
  352 IADD(I)=J
```

```
C     GETSTD continued.
  350 CONTINUE
C
C     Now go through .STD file and pull out matching reference data
  401 DO 361 I=1,NSTINF
      READ(IDEV) SS1,SS2
      READ(IDEV) (X(J),J=1,NSVAR)
C
C     See if this standard is one of those measured
      IF (SS1.EQ.S1) GOTO 363             ! First two characters match
      GOTO 361                      ! No match
  363 IF (SS2.EQ.S2) GOTO 364             ! Remainder match o.k.
C
C     Standard not one of those measured - try the next one
      GOTO 361
C
C     Standard measured - strip out reference values
  364 K=1
      DO 366 KN=1,NSP
      KSQ=IADD(KN)
      IF (KSQ.EQ.0) GOTO 367                 ! No data on this element
      VALS(KN)=X(KSQ)
      GOTO 366
  367 VALS(KN)=-999.0
  366 CONTINUE
C
C     Required data obtained - exit loop and rewind file
      GOTO 999
C
  361 CONTINUE
C
C     Standard not located - set switch and rewind
      K=-1
      GOTO 999
C
  110 FORMAT(A2,A8)
  111 FORMAT(' Standard not in STD. file')
C
  999 IF(K.EQ.-1) WRITE(5,111)
      REWIND IDEV ! Ready for the next standard
C
      RETURN
      END


      SUBROUTINE GRAPH(X,Y,VNAM,LEN1,LEN2,NVAR,MLEN1,MLEN2,NC,
     1NUM,NN,BLEG,NB,IDEV,IO,INS,NG,SYMB,MNG,NCOL,B,C,NY,
     2K1DEV,K2DEV,M1FLAG)
C
C     X     Array of length LEN1 holding X (vertical values)
C     Y     Array of length LEN2 holding Y (horiz. values)
C     VNAM  Variable name for graph heading
C     LEN1  No of samples in [A] ......MLEN1; Max no allowed
C     LEN2  No of samples in [B] ......MLEN2; Max no allowed
C     NC    Used with geostats program.Equals no of couples
C     WIDTH Width of plot in inches - allow 1 inch for space for
C           the left-hand scale
C     IDEV  Output device channel
C     NG    No of groups
C     SYMB  Group symbols
C
C     IO    0 .... Using GDAT program
C           1 .... Using geostats prog.
C
C     INS   Option carried over from GDAT.
C                   /R ... Repeat last run
C
C             /A ...}
C                   } Automatic repeat required
C             $W ...}
C
C     Subroutines used:   OMNMX   G2SORT
C
C     ***********************************************************
      LOGICAL *1 ORD(2),INS(2),SYMB(MNG),C(NY),KG1,XX(4)
      REAL *8 VNAM
      DIMENSION X(MLEN1),Y(MLEN2),NC(MLEN1),NUM(NN),BLEG(NB),B(NY)
      DATA SMALL/-9998.0/
C     ***********************************************************
C
      ASSIGN 652 TO JUMP
      KFLAG=0
      NON=0
C
      IF(INS(1).EQ.'/'.AND.(INS(2).EQ.'W'.OR.INS(2).EQ.'R')) GOTO 410
C                                                           Rerun last run
C     Check on length of x-axis & modify if necessary
      INCR=1
```

```
C     GRAPH continued.
  200 ILEN=INCR*LEN1
      IF(ILEN.GE.12) GOTO 210
      INCR=INCR+1            !Used later to modify graph
      GOTO 200
C
  210 NQ=(NCOL+5)/10
C
C     Determine the max & min limits for Y array
      CALL OMNMX(Y,LEN1*NG,1,1,MLEN2,YMIN,YMAX)
C
C     YMAX and YMIN now hold the max / min values for Y arrays
C     Now redefine this to give a +/- 5% extension to the range
      RVAL=0.05*(YMAX-YMIN)
      YMAX=YMAX+RVAL
      IF ((YMIN-RVAL).LT.0.0) GOTO 250
      YMIN=YMIN-RVAL
      GOTO 260
  250 YMIN=0.0
C     ............................................................
  260    N1FLAG=0
      N2FLAG=0
      IF(INS(1).EQ.'$'.OR.INS(2).EQ.'A') GOTO 330
C
      WRITE(IDEV,100) VNAM,YMIN,YMAX
C
  270 WRITE(IDEV,101)                   !Do you wish to alter max or min
      READ(IDEV,102) NO,ORD
C
      IF(NO.EQ.0) GOTO 320
      IF(ORD(1).NE.'/') GOTO 310
C
      IF(ORD(2).EQ.'C') GOTO 330                        !Continue
C
      IF(ORD(2).NE.'N'.AND.ORD(2).NE.'B') GOTO 280            !Alter min
      WRITE(IDEV,103)
      READ(IDEV,1104) NX,XX
      IF(NX.NE.0) GOTO 1105
      Y1MIN=YMIN
      N1FLAG=1
      GOTO 1106
 1105 DECODE(NX,104,XX) YMIN
 1106    IF(ORD(2).EQ.'B') GOTO 290                           !Alter both
      GOTO 330
C
  280 IF(ORD(2).NE.'X') GOTO 300                        !Alter max
  290 WRITE(IDEV,105)
      READ(IDEV,1104) NX,XX
      IF(NX.NE.0) GOTO 1107
      Y1MAX=YMAX
      N2FLAG=1
      GOTO 330
 1107 DECODE(NX,104,XX) YMAX
      GOTO 330
C
  300 IF(ORD(2).NE.'Z') GOTO 310                        !Set min to zero
      YMIN=0.0
      GOTO 330
C
  310 WRITE(IDEV,106)
  320 WRITE(IDEV,107)
      GOTO 270                                   !Unidentified ... Try again
C
C     ............................................................
C     Max & min values selected
  330 IF(N2FLAG.EQ.0) Y1MAX=YMAX
      IF(N1FLAG.EQ.0) Y1MIN=YMIN
C
C     Compute Y scaling parameters
      YINK=(Y1MAX-Y1MIN)/NCOL
C
      DO 560 I=1,NQ
  560 BLEG(I)=Y1MIN+FLOAT(I)*10*YINK
C
  410    IF(IO.EQ.0) GOTO 470
C
C     Use if IO=1
      WRITE(IDEV,110)
      DO 420 I=1,LEN
  420 WRITE(IDEV,111) X(I),Y(I),NC(I)
      WRITE(IDEV,112)
      GOTO 470
C
  470 IF(IO.EQ.0) WRITE(IDEV,116)
C
C     Write legend
      WRITE(IDEV,160) VNAM
      WRITE(IDEV,1158) (BLEG(II),II=1,NQ,2)
      WRITE(IDEV,1159) Y1MIN,(BLEG(II),II=2,NQ,2)
C
```

```
C     GRAPH continued.
C
  653 DO 650 I=1,NCOL+1
  650 NUM(I)=22
C
      DO 651 I=1,NCOL+1,10
  651 NUM(I)=21
C
C     Plot top/bottom line of graph
      WRITE(IDEV,1000) (SYMB(NUM(I)),I=1,NCOL+1)
      GOTO JUMP
C
C     ...............................................................
C     For each row at a time -
  652  DO 550 J=1,LEN1
C
C     1.  fill up NUM with the appropriate symbol addresses
      NUM(1)=21              !Store border
      DO 490 K=2,NCOL+1
  490 NUM(K)=1               !Store line of zeros
C
C
C     2.  determine the plotting cell positions for Y values
      DO 478 I=1,NG
      II=I
      LPOS=LEN1*(I-1)+J
      B(I)=Y(LPOS)
C
      ENCODE(1,1020,KG1) II
 1020 FORMAT(I1)
      C(I)=KG1
  478 CONTINUE
C
C     Sort row into ascending [B]
      CALL G2SORT(B,XDUMMY,C,NG,MNG)
C
      IXT=0
      NON3=0
      NON4=0
C
      DO 803 IX=1,NG
C
      BB=B(IX)
      IF (B(IX).LT.SMALL) GOTO 803
C
      N2=IXT                 !Old column position
C
      KG1=C(IX)
      DECODE(1,1010,KG1) NGP                              !New group id.
C
      IXT=(BB-Y1MIN)/YINK+1.5                             !New column position
D     WRITE(IDEV,1014) J,BB,IXT
D1014 FORMAT(' J,BB,IXT ',I5,F8.3,I5)
      IF (IXT.LT.1.OR.IXT.GT.NCOL) GOTO 803
C     ...................................................................
C
      IF(N2.EQ.IXT) GOTO 402
      IF(M1FLAG.EQ.1) GOTO 702
C
C     First value of new column
      K1FLAG=0
      IF(KFLAG.EQ.1.OR.NON.EQ.0) GOTO 911
  900 BACKSPACE K1DEV
      NON=NON-1
C
  911 KFLAG=0
C
  702 NUM(IXT)=NGP+1                  !....Gp symbol
C
      IF(M1FLAG.EQ.1) GOTO 803    !M1FLAG=1
      GOTO 404               !M1FLAG=0 .. Write details to scratch file,
C                            if not needed backspace file later (line 900).
C     ...................................................................
C
C     .... M1FLAG=0
C     Different groups
  402 IF(M1FLAG.EQ.1) GOTO 704
      KFLAG=1
      NUM(IXT)=19            !....."?"
C
  404 NON=NON+1
      WRITE(K1DEV,1011) J,IXT,(NGP+1),BB
      GOTO 803
C     ...................................................................
C
C     .... M1FLAG=1
  704    CONTINUE
      NON3=NON3+1            !No of entries in scratch file
      WRITE(K1DEV,433) IXT,(NGP+1)
C     ...................................................................
```

```
C     GRAPH continued.
C
  803 CONTINUE
C     ..................................................................
C     ..................................................................
C
C
C     3.  write out the line
  209 WRITE(IDEV,1001) X(J),(SYMB(NUM(I)),I=1,NCOL+1)
C
C     ..................................................................
C     ..................................................................
C
  809 IF(M1FLAG.EQ.0.OR.NON3.EQ.0) GOTO 549
C
      DO 706 I=1,NCOL
  706 NUM(I)=1                       !Store whole line of zeros
      IXT=0
C
      REWIND K1DEV
      DO 707 I=1,NON3
      N2=IXT                !Old column position
      READ(K1DEV,433) IXT,NGP
C
      IF(N2.EQ.IXT) GOTO 708
C
      NUM(IXT)=NGP
      GOTO 707
C
  708 NON4=NON4+1           !No of entries in scratch file
      WRITE(K2DEV,433) IXT,NGP
C
  707 CONTINUE
C
      WRITE(IDEV,711)(SYMB(NUM(M)),M=1,NCOL)
C
      KK=K1DEV
      K1DEV=K2DEV
      K2DEV=KK
      REWIND K2DEV
      NON3=NON4
      NON4=0
      GOTO 809
C
  549 IF(INCR.EQ.1) GOTO 550
      DO 540 IN=1,(INCR-1)
  540 WRITE(IDEV,122)
C
  550 CONTINUE
C
C
C     Plot bottom line of graph
      ASSIGN 654 TO JUMP
      GOTO 653
C
C     Write legend
  654 WRITE(IDEV,1159) Y1MIN,(BLEG(II),II=2,NQ,2)
      WRITE(IDEV,1158) (BLEG(II),II=1,NQ,2)
      WRITE(IDEV,160) VNAM
      WRITE(IDEV,112)
C
C
      IF(M1FLAG.EQ.0.AND.KFLAG.EQ.0) NON=NON-1
C     ..................................................................
C     ..................................................................
C
C     Write details of overwritten points
      IF(M1FLAG.EQ.1.OR.NON.EQ.0) GOTO 891
      NN1=0
      NN2=0
      REWIND K1DEV
      WRITE(IDEV,130)
      WRITE(IDEV,1013)
      DO 810 I=1,NON
      NN1=MCOL
      NN2=MROW
      READ(K1DEV,1011) MROW,MCOL,NGP,BB
      IF(NN1.NE.MCOL.OR.NN2.NE.MROW) WRITE(IDEV,161)
      WRITE(IDEV,1012) X(MROW),MCOL,SYMB(NGP),BB
  810 CONTINUE
C
  891 WRITE(IDEV,151)
C
  600  RETURN
C
C     ........................formats...........................
C
  100 FORMAT(X,A8,'Min=',F7.2,4X,'Max='F10.2)
  101 FORMAT('$ORD> ')
  102 FORMAT(Q,2A1)
```

```
C      GRAPH continued.
   103 FORMAT('$New value for min; ')
   104 FORMAT(F10.0)
   105 FORMAT('$New value for max; ')
   106 FORMAT(/' Not recocognised ... Try again!')
   107 FORMAT(' Valid responses to ORD>'/
     1    ' <ret> .. Show these responses'/
     2    '   /C .... Continue'/
     3    '   /N .... Alter min'/
     4  '   /X .... Alter max'/
     5    '   /B .... Alter both'/
     6    '   /Z .... Set min to zero   ')
   110 FORMAT('          -Lag-     -Exptl s/v value-  -No of'
     1  'couples-'/)
   111 FORMAT(2F15.6,7X,I10)
   112 FORMAT(1H0)
   116 FORMAT(/' X-axis; Distance along traverse line'/
     1      22X,'or down profile')
   122 FORMAT(8X,'I')
   130 FORMAT('/Details of overwritten data')
   160 FORMAT(' Y-axis; ',A8)
   161 FORMAT(1H )
  1158 FORMAT(8X,6(:5X,F8.2,:7X))
  1159 FORMAT(3X,F8.2,7X,6(:5X,F8.2,7X))
  1000 FORMAT(8X,122A1)
  1001 FORMAT(F7.2,X,122A1)
C
   151 FORMAT(//)
  1010 FORMAT(I1)
  1011 FORMAT(3I4,2F12.3)
   433 FORMAT(I3,I2)
C  711    FORMAT(8X,120A1)
   711 FORMAT(1H+,7X,120A1)
  1013 FORMAT('.....Row..Column....Gp........-Y-..')
  1012 FORMAT(F8.2,5X,I3,5X,A1,5X,F8.3)
  1104 FORMAT(Q,4A1)
C
       END



       SUBROUTINE GTHED(NVAR,NSMP,VARNAM,LVN,TIT,FMT,DKU,IERR)
C      Subroutine to read in the contents of a .RAW file
C      NVAR    number of variables
C      NSMP    number of samples ( or zero )
C      VARNAM  array of variable names (A8)
C      LVN     actual length of VARNAM
C      TIT     file title (80A1)
C      FMT     format per record for raw data (80A1)
C      DKU     input device channel for .RAW file
C      IERR    error code - following meanings on output:-
C        = 0     no errors - transfer complete and o.k.
C        = 1     too many variables involved ( NVAR>LVN )
C        = 2     unspecified error (ERR=) reading from .RAW file
C      ..............................................................
C
       LOGICAL *1 FMT(80),TIT(80)
       REAL *8 VARNAM(LVN)
       INTEGER DKU
C
C      Read in file title, data format, no. variables & samples (or 0)
       READ(DKU,100,ERR=800) (TIT(I),I=1,80)
       READ(DKU,100,ERR=800) (FMT(I),I=1,80)
       READ(DKU,101,ERR=800) NVAR,NSMP
C
C      Check if there is enough processing space
       IF (NVAR.GT.LVN) GOTO 801
C
C      Read in the names of the variables
       READ(DKU,102,ERR=800) (VARNAM(I),I=1,NVAR)
       GOTO 900
C
C      Error - reading from .RAW
   800 IERR=2
       GOTO 900
C
C      Error - too many variables
   801 IERR=1
       GOTO 900
C
   900 RETURN
C
   100 FORMAT(X,80A1)
   101 FORMAT(X,I5,I6)
   102 FORMAT(8(X,A8))
C
       END
```

```
      SUBROUTINE GTREC(IDEV,NVARS,SN1,SN2,VALS,NLEN,FMT,KG,IEOF,IERR)
C     Subroutine to read in the data for a single sample from an open
C     formatted self-describing file .
C     IDEV      i     Channel number on which the file is to be read
C     NVARS     i     Number of variables on the file
C     SN1       o     First two characters of sample name (I*2)
C     SN2       o     Last eight characters of sample name (R*8)
C     VALS      o     Array of sample values read from the file
C     NLEN      i     Actual length of the array VALS
C     FMT       i     80 byte buffer with FORMAT for 1 data record
C     KG        o     Group symbol (2 character)
C     IEOF      o     End of file flag: on exit =1 end of file, =0 o.k.
C     IERR      o     Error flag: on exit =1 error in reading, =0 o.k.
C
      LOGICAL *1 FMT(80)
      REAL *8 SN2
      INTEGER SN1
      DIMENSION VALS(NLEN)
C
      IERR=0
      IEOF=0
      READ(IDEV,100,ERR=998) SN1,SN2,KG
      IF (SN1.EQ.'**' .AND. SN2.EQ.'********') GOTO 990
C
      IERR=0
      READ(IDEV,FMT,ERR=998) (VALS(I),I=1,NVARS)
      GOTO 999
C
  990 IEOF=1
      GOTO 999
C
  998 IERR=1
C
  999 RETURN
C
  100 FORMAT(X,A2,A8,A2)
C
      END
```

```
      SUBROUTINE G2SORT(A,B,C,N,NX)
C     Subroutine to sort 3 arrays.
C     Sort is on A into ascending order, B & C (LOGICAL *1) follows.
C     Uses the Shell sort method.
C
      LOGICAL *1 C(NX),XX
      DIMENSION A(NX),B(NX)
C
C     Sort routine.....
C
      M=2*N-1
  100 M=M/2
C
      IF(M.EQ.0) GOTO 120
      K=N-M
C
      DO 110 J=1,K
      DO 110 L=1,J,M
C
      I=J-(L-1)
      IA=I+M
C
      IF(A(IA).GT.A(I)) GOTO 110
C
      X=A(I)                              !Swop A values
      A(I)=A(IA)
      A(IA)=X
C
      X=B(I)                              !Swop B values
      B(I)=B(IA)
      B(IA)=X
C
      XX=C(I)                             !Swop C values
      C(I)=C(IA)
      C(IA)=XX
C
  110 CONTINUE
      GOTO 100
C
  120    RETURN
C
      END
```

```
      SUBROUTINE KMEAN(NUMBR,DATA1,DATA2,YDIST,NFLAG,DREF,
     1MAXIT,NE,NVAR,NC,MNV,MNC,N5DEV,N4DEV,N1DEV,N2DEV,N3DEV,N7DEV,
     2N8DEV,VARNAM,CMD,KOPT,IFLAG,GRA,CL,SD,NCOMB,MCOMB,SM,SUM1,
     3KOUNT,SUM,VDELTM,SORT,CDELTM,MADD,N1,N2,N3,N4)
C
C      NUMBR...No of samples in clusters (MNC)
C      DATA1...1-d data matrix (MNV)
C      DATA2...1-d data matrix (MNV)
C      DREF....Distance between cluster & sample seed point
C      MAXIT...Max no of iterations
C      NE......No of entities (data units)
C      NVAR....No of variables                    MNV..Max no of variables
C      NC......No of clusters                     MNC..Max no of clusters
C
C      N5DEV...VDU (5)
C      N4DEV...Unformatted scratch file (stdzd data)
C      N1DEV...Output device
C      N2DEV...Unformatted scratch file (for KSTDZ subroutine)
C                  Also holds membership details temporarily
C                  Also holds similarity matrix temporarily
C      N3DEV...Unformatted scratch file holding membership details
C      N7DEV...Unit no for MCLD & DREF raw-files
C      N8DEV...Unit no holding complete centroid & sums of data values
C                                                  (Direct Access file)
C      VARNAM..Variable names (MNV)
C
C      CMD.....Options (See KEXEC)
C           CMD(5) ....With IDN only.
C                      Assign each sample to nearest seed point (fixed).
C                      One pass only.
C
C                      If > 0 YDIST's equal to 0.00 , assign sample to
C                      group on basis of equal distance.
C
C                      If all > 0.00 , assign sample to group on basis of
C                      distance/YDIST ratio.
C                      If ratio > 1.00 sample assigned as 'not identified'
C
C         CMD(7).....With CMD(5)='1' only.
C                      Record values of DREF in DREF.RAW
C         CMD(10)....KOPT=0
C          CMD(11)....KOPT=1
C          CMD(12)....KOPT=2
C
C      Subroutines/{functions} used; MATNUL  KSTDZ  TCAP   KSORT   DIST
C
C      """"""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""
      LOGICAL *1 XNAME(2),FMT(80),TIT1(80),CMD(13)
C
      REAL *8 SN2,VARNAM(MNV)
C
      INTEGER SN1,ADDRES,BDDRES,KG,CL(MNC)
C
      DIMENSION NUMBR(MNC),GRA(MNC),YDIST(MNC),DATA1(MNV),DATA2(MNV),
     1   SD(N1),NCOMB(N2),MCOMB(N2),SM(N3,N3),SUM1(N2),KOUNT(MNC),
     2   SUM(MNV),VDELTM(N4),SORT(N2),CDELTM(N2),MADD(N4)
C
      DATA IOPT/2/,FMT/'(','X','F','1','2',',','5',')',72*'0/,
     1   TIT1/' ','S','Y','0',':','M','C','L','D','.','R','A','W',67*'0/
C      """"""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""
C
D     WRITE(N1DEV,170) NC,NE,NVAR
C
      IF(CMD(5).EQ.'1'.OR.CMD(6).EQ.'1') GOTO 198
C
      IF(NC.EQ.1) GOTO 260                     !Looking for centroid value of single
C                                    cluster....Have 'a priori' knowledge
  198 REWIND N4DEV
C
C      Set up initial seed points as the first NC samples
      DO 200 I=1,NC
      IKOUNT=I
      IF(CMD(5).EQ.'1') GOTO 199
C
      NUMBR(I)=1
      WRITE(N3DEV) I
  199    READ(N4DEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
C
      WRITE(N8DEV'IKOUNT) (DATA1(J),J=1,NVAR)      !Write centroid values
      IF(CMD(5).EQ.'1'.OR.CMD(6).EQ.'1') GOTO 200
C
      III=IKOUNT+NC
      WRITE(N8DEV'III) (DATA1(J),J=1,NVAR)         !Write sum of data values
  200 CONTINUE
C
D     WRITE(N1DEV,103)
D     WRITE(N1DEV,181) (VARNAM(I),I=1,NVAR)
C
D     DO 201 I=1,NC
```

```
D     KMEAN continued.
D     IKOUNT-1
D     READ(N8DEV'IKOUNT) (DATA1(J),J=1,NVAR)      !Read centroid values
D     WRITE(N1DEV,171) I,(DATA1(J),J=1,NVAR)
D     III=IKOUNT+NC
D     READ(N8DEV'III) (DATA1(J),J=1,NVAR) !Read sums of data values
D 201     WRITE(N1DEV,172) I,(DATA1(J),J=1,NVAR)
D     WRITE(N1DEV,103)
C
      IF(CMD(6).NE.'1') GOTO 209
C     ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
C     Calculate standardised distances between seed points -For use with IDN
      WRITE(N1DEV,103)
C
C     Read data of Ith centroid
      DO 205 I=1,(NC-1)
      IKOUNT=I
      READ(N8DEV'IKOUNT) (DATA1(JJ),JJ=1,NVAR)
C
C     Read data of Jth centroid
      DO 205 J=(I+1),NC
      JKOUNT=J
      READ(N8DEV'JKOUNT) (DATA2(JJ),JJ=1,NVAR)
C
      DREF=DIST(DATA1,DATA2,NVAR,MNV)
  205     WRITE(N1DEV,104) I,J,DREF
C
      GOTO 600                    !Exit -- CMD(6)='1' only
C     ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
C     Assign each data unit to the nearest centroid
  209 KK=NC+1
C
      DO 245 K=KK,NE
C
D     WRITE(N1DEV,173) K
C
C     Read data of Kth sample
      READ(N4DEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
C
C     Read data of 1st centroid
      READ(N8DEV'1) (DATA2(J),J=1,NVAR)
C
C     Compute distance to first cluster centroid
      DREF=DIST(DATA1,DATA2,NVAR,MNV)
      IF(CMD(5).EQ.'1'.AND.NFLAG.EQ.1) DREF=DREF/YDIST(1)
C
D     WRITE(N1DEV,174) DREF
C
      IF(CMD(7).EQ.'1') GOTO 600  !Return...Only testing against 1 group
C
      JREF=1
C
C     Test distances to remaining cluster centroids
      DO 230 J=2,NC
      JKOUNT=J
C
C     Read data of Jth centroid
      READ(N8DEV'JKOUNT) (DATA2(JJ),JJ=1,NVAR)
C
      DTEST=DIST(DATA1,DATA2,NVAR,MNV)
      IF(CMD(5).EQ.'1'.AND.NFLAG.EQ.1) DTEST=DTEST/YDIST(J)
C
D     WRITE(N1DEV,175) J,DTEST
C
      IF(DTEST.GE.DREF) GOTO 230
C
      DREF=DTEST
      JREF=J
C
  230 CONTINUE
C
D     WRITE(N1DEV,176) SN1,SN2,JREF
C
C     Allocate data unit -K- to cluster -JREF-
  235 WRITE(N3DEV) JREF
      IF(CMD(5).EQ.'1') GOTO 245
      NUMBR(JREF)=NUMBR(JREF)+1
C
C     Read old sum of data values from file
      III=JREF+NC
      READ(N8DEV'III) (DATA2(J),J=1,NVAR)
C
      DO 240 J=1,NVAR
  240     DATA2(J)=DATA2(J)+DATA1(J)
C
C     Write new sum of data values to file
      WRITE(N8DEV'III) (DATA2(J),J=1,NVAR)
C
```

```
      C     KMEAN continued.
        245 CONTINUE
      C
      C
      D     WRITE(N1DEV,181) (VARNAM(I),I=1,NVAR)
      D     DO 246 I=1,NC
      D     III=I+NC
      D     READ(N8DEV'III) (DATA2(J),J=1,NVAR) !Read sum of data values
      D 246     WRITE(N1DEV,172) I,(DATA2(J),J=1,NVAR)
      D     WRITE(N1DEV,103)
      C
      C
            IF(CMD(5).EQ.'1') GOTO 600
      C                                   !Return if CMD(5)='1'
      C
      C     Calculate new centroid positions
            DO 250 I=1,NC
            IKOUNT=I
            III=IKOUNT+NC
            READ(N8DEV'III) (DATA2(J),J=1,NVAR)
      C
            DO 850 J=1,NVAR
        850 DATA2(J)=DATA2(J)/NUMBR(I)
      C
        250 WRITE(N8DEV'IKOUNT) (DATA2(J),J=1,NVAR)     !Write new centroid value
      C
      D     DO 251 I=1,NC
      D     IKOUNT=I
      D     WRITE(N1DEV,177) I,NUMBR(I),(VARNAM(II),II=1,NVAR)
      D     READ(N8DEV'IKOUNT) (DATA2(J),J=1,NVAR)      !Read centroid values
      D 251 WRITE(N1DEV,178) 1,(DATA2(J),J=1,NVAR)
      D     WRITE(N1DEV,103)
      C
      C     First run thro data now completed
      C ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      C
      C     All data units allocated to initial configuration
      C     Reallocate data units to fixed seed points
            NUM=1
      C
      C     Open temporary scratch file for membership details
        260 OPEN(UNIT=N2DEV,TYPE='SCRATCH',FORM='UNFORMATTED',
           1    NAME='SY0:Z4.SCR')
            REWIND N4DEV
            IF(NC.GT.1) REWIND N3DEV
      C
      C     Counter for no of iterations (min=2)
            NUM=NUM+1
      D     WRITE(N1DEV,179) NUM
            NON=0
            TDIST=0.0
      C
      C     Keep and zero no of items/cluster group
            DO 270 J=1,NC
        270 NUMBR(J)=0
      C
      C     Zero Sum of data values
            DO 280 J=1,NVAR
        280     DATA2(J)=0.0000
      C
            DO 281 I=1,NC
            III=I+NC
        281 WRITE(N8DEV'III) (DATA2(J),J=1,NVAR)
      C
      C
      C     Reallocate data units
            DO 320 K=1,NE
      C
      C     Record cluster no of which data unit is a member
            IF(NC.GT.1) READ(N3DEV) JJREF
      C
      C     Read data of Kth sample
            READ(N4DEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
      C
      C     Read data of 1st centroid
            READ(N8DEV'1) (DATA2(J),J=1,NVAR)
      C
      C     Compute distance to first cluster centroid
            DREF=DIST(DATA1,DATA2,NVAR,MNV)
      C
            JREF=1
      C
            IF(NC.EQ.1) GOTO 310
      C
      C     Test distances to remaining cluster centroids
            DO 300 J=2,NC
            JKOUNT=J
      C
      C     Read data of Jth centroid
            READ(N8DEV'JKOUNT) (DATA2(JJ),JJ=1,NVAR)
```

```
C     KMEAN continued.
C
      DTEST=DIST(DATA1,DATA2,NVAR,MNV)
C
      IF(DTEST.GE.DREF) GOTO 300
C
      DREF=DTEST
      JREF=J
C
  300 CONTINUE
C
C     Count of no of alterations made from last iteration
      IF(JJREF.EQ.JREF) GOTO 310
C
      NON=NON+1
D     WRITE(N1DEV,183) SN1,SN2,JREF,JJREF
C
C
C     Allocate data unit -K- to cluster -JREF-
  310   NUMBR(JREF)=NUMBR(JREF)+1
      WRITE(N2DEV) JREF
  315 TDIST=TDIST+DREF
C
C
C     Read old sum of data values from file
      III=JREF+NC
      READ(N8DEV'III) (DATA2(J),J=1,NVAR)
C
      DO 820 J=1,NVAR
  820     DATA2(J)=DATA2(J)+DATA1(J)
C
C     Write new sum of data values to file
      WRITE(N8DEV'III) (DATA2(J),J=1,NVAR)
C
  320 CONTINUE
C
C
D     WRITE(N1DEV,103)
D     WRITE(N1DEV,181) (VARNAM(I),I=1,NVAR)
D     DO 321 I=1,NC
D     III=I+NC
D     READ(N8DEV'III) (DATA2(J),J=1,NVAR) !Read sum of data values
D 321     WRITE(N1DEV,172) I,(DATA2(J),J=1,NVAR)
D     WRITE(N1DEV,103)
C
C
C     Calculate new centroid positions
      DO 322 I=1,NC
      IKOUNT=I
      III=IKOUNT+NC
      READ(N8DEV'III) (DATA2(J),J=1,NVAR)
C
      DO 822 J=1,NVAR
  822 DATA2(J)=DATA2(J)/NUMBR(I)
C
  322 WRITE(N8DEV'IKOUNT) (DATA2(J),J=1,NVAR)     !Write new centroid values
C
D     DO 324 I=1,NC
D     IKOUNT=I
D     WRITE(N1DEV,177) I,NUMBR(I),(VARNAM(II),II=1,NVAR)
D     READ(N8DEV'IKOUNT) (DATA2(J),J=1,NVAR)    !Read centroid values
D 324 WRITE(N1DEV,178) NUM,(DATA2(J),J=1,NVAR)
D     WRITE(N1DEV,103)
C
D     WRITE(N1DEV,182) NON
C
      MD=N3DEV
      N3DEV=N2DEV
      N2DEV=MD
      IF(NC.GT.1) CLOSE(UNIT=N2DEV)
      IF(NUM.GE.MAXIT.AND.NON.GT.0) GOTO 323      !Exit from loop
      IF(NON.GT.0) GOTO 260                       !Try another iteration
C
C
      IF(KOPT.EQ.2)GOTO 325
      IF(N1DEV.NE.5) WRITE(N1DEV,101) NUM
      WRITE(N5DEV,101) NUM
      GOTO 325
C
  323 IF(KOPT.EQ.2)GOTO 325
      IF(N1DEV.NE.5) WRITE(N1DEV,105) NUM
      WRITE(N5DEV,105) NUM
C
C     All data units allocated
  325 IF(KOPT.EQ.2) GRA(IFLAG+1)=TDIST
      IF(KOPT.NE.2) WRITE(N1DEV,102) TDIST
C
C
C
      IF(NC.EQ.1.OR.(CMD(2).NE.'1'.AND.CMD(4).NE.'1')) GOTO 600
```

```
C     KMEAN continued.
C
C     Assessing rel importance of variables
C     Zero similarity matrix
      DO 939 I=1,NC
      DO 939 J=1,NC
  939 SM(I,J)=0.00
C
      MATHF=(NC**2-NC)/2
C
      DO 940 I=1,MATHF
  940 SUM1(I)=0.00
C
      NUM=0
C
C     Calculating std devns of points within each cluster
      DO 350 I=1,NC
C
      IF(CMD(4).NE.'1') GOTO 330
      WRITE(N5DEV,110) I
C
  330 REWIND N4DEV                   !Containing stdzd data
C
      IF(CMD(3).NE.'1') GOTO 331
      WRITE(N1DEV,103)
C
C     Open scratch file to hold individual cluster data
  331 OPEN(UNIT=N2DEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1    NAME='SY0:Z5.SCR')
C
      IREF=I
      NON=0
      REWIND N3DEV
C
      DO 340 J=1,NE
C
      READ(N4DEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
C
      READ(N3DEV) JREF
C
      IF(IREF.NE.JREF) GOTO 340
C
C     Count of no of samples in scratch file
      NON=NON+1
C
      WRITE(N2DEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
C
      IF(CMD(4).EQ.'1') WRITE(N5DEV,111) SN1,SN2,KG
C
  340 CONTINUE
C
      KOUNT(I)=NON
C
C     Open direct access file to hold means & std devns
C     (NVAR records, 2 values in each)
      OPEN(UNIT=N7DEV,TYPE='SCRATCH',NAME='SY0:Z7.SCR',
     1    ACCESS='DIRECT',RECORDSIZE=2)
C
C     Calculate means & std devns
      CALL KSTDZ(N2DEV,NODEV,DATA1,DATA2,SUM,NON,NVAR,MNV,IOPT,N7DEV)
      CLOSE(UNIT=N2DEV)
C
C     Place std devns into larger data matrix
      DO 349 K=1,NVAR
      KK=K
      NUM=NUM+1
      READ(N7DEV'KK) AM,STDV
  349   SD(NUM)=STDV
C
      CLOSE(UNIT=N7DEV)
C
  350 CONTINUE
C
      IF(CMD(4).NE.'1') GOTO 370
C
C     Open file MCLD.RAW to hold no of samples misclassified & delta values
      OPEN(UNIT=N7DEV,TYPE='NEW',NAME='SY0:MCLD.RAW')
C
      WRITE(N7DEV,163) (TIT1(II),II=1,80)
      WRITE(N7DEV,163) (FMT(II),II=1,80)
      WRITE(N7DEV,160) 2,0
      WRITE(N7DEV,161) 'MCLD    ','DELTA   '
C
C     Assign name to clusters to assist in identifying misclassified units
C     (Assuming an 'a priori' knowledge)
C
      DO 360 I=1,NC
C
      WRITE(N5DEV,112) I
C
```

```
C     KMEAN continued.
      READ(N5DEV,113) NX,XNAME
C
C     Check for capital letters
      CALL TCAP(XNAME(1))
      CALL TCAP(XNAME(2))
C
      DECODE(2,114,XNAME) CL(I)
C
  360 CONTINUE
C
C     Calculate distances between each centroid
C     Place these distances into  similarity matrix together with
C     corrected sum of squares & calculate value of delta by
C     [dist]/[pooled std devn]
C
  370 CONTINUE
      IF(CMD(3).EQ.'1') WRITE(N1DEV,120)
C
      OPEN(UNIT=N2DEV,TYPE='SCRATCH',FORM='UNFORMATTED',
     1    NAME='SY0:Z6.SCR')
C
      NON=0
C
      DO 450 K=1,NVAR
C
      SUM(K)=0.0
C
      IF(CMD(3).EQ.'1') WRITE(N1DEV,121) VARNAM(K)
C
      DO 380 KA=1,NC
C
      ADDRES=NVAR*(KA-1)+K
C
      V=SD(ADDRES)
      KK=KOUNT(KA)-1
      IF(KK.LT.29) KK=KK+1
      SPA=V*V*FLOAT(KK)
C
  380 SM(KA,KA)=SPA
C
      LL=0
C
      DO 430 I=1,(NC-1)
      IKOUNT=I
C
      DO 429 J=(I+1),NC
      JKOUNT=J
C
      LL=LL+1
      READ(N8DEV'IKOUNT) (DATA1(II),II=1,NVAR)
      C1=DATA1(K)
      READ(N8DEV'JKOUNT) (DATA1(II),II=1,NVAR)
      C2=DATA1(K)
C
      DIFF=ABS(C1-C2)
      SM(I,J)=DIFF
C
C     Calculate other half of similarity matrix
      NO=KOUNT(I)-1
      IF(NO.LT.29) NO=NO+1
      NU=KOUNT(J)-1
      IF(NU.LT.29) NU=NU+1
      SPA=SM(I,I)
      SPB=SM(J,J)
      PVAR=(SPA+SPB)/FLOAT(NO+NU)
C
      DELTA=DIFF/SQRT(PVAR)
      SM(J,I)=DELTA
C
      SUM(K)=SUM(K)+DELTA
      SUM1(LL)=SUM1(LL)+DELTA
C
      WRITE(N2DEV) SM(J,I)
C
C
      IF(CMD(4).NE.'1') GOTO 429
C
C     How many units misclassified using this single element partition
C     between clusters I & J
C
      IF(C1.GT.C2) GOTO 390
C
      PART=C1+(DIFF/2)
      GOTO 400
C
  390 PART=C2+(DIFF/2)
C
  400 REWIND N4DEV
      NON=0
```

```
C       KMEAN continued.
C
C
        DO 425 JA=1,NE
C
        READ(N4DEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
C
        XDATA=DATA1(K)                  !Variable interested in
C
        IF(CL(I).NE.KG.AND.CL(J).NE.KG) GOTO 425     !Data not required
        IF(C1.GT.C2) GOTO 415
        IF(CL(J).EQ.KG) GOTO 410
        IF(XDATA.GE.PART) NON=NON+1
        GOTO 425
C
    410 IF(XDATA.LT.PART) NON=NON+1
        GOTO 425
C
    415 IF(CL(J).EQ.KG) GOTO 420
        IF(XDATA.LT.PART) NON=NON+1
        GOTO 425
C
    420 IF(XDATA.GE.PART) NON=NON+1
    425 CONTINUE
C
C       Write values of MCLD & DELTA to file
        WRITE(N7DEV,162)' ','---------','//'
        WRITE(N7DEV,FMT) FLOAT(NON),DELTA
    429 CONTINUE
C
    430 CONTINUE
C
C
        IF(CMD(4).EQ.'1') GOTO 521                              !Exit
C
        IF(CMD(3).NE.'1') GOTO 450
C       Write out similarity matrix for this element
        DO 440 JA=1,NC
C
        WRITE(N1DEV,131) JA,(SM(JA,JB),JB=1,NC)
C
    440 CONTINUE
C
        WRITE(N1DEV,132) (I,I=1,NC)
        WRITE(N1DEV,103)
C
    450 CONTINUE
C
C
C
C       Record address of each cluster combination
    451 LL=0
        DO 460 I=1,(NC-1)
C
        DO 460 J=(I+1),NC
C
        LL=LL+1
C
        NCOMB(LL)=I
    460 MCOMB(LL)=J
C
C
        WRITE(N1DEV,138)                 !Write summary of delta values
C
C
        DO 470 I=1,NVAR
    470   VDELTM(I)=SUM(I)/MATHF
C
        CALL KSORT(VDELTM,NVAR,MNV,MADD)
C
        NON=0
        DO 480 I=1,NVAR
        NON=NON+1
        II=MADD(I)
C
        IF(NON.EQ.1) GOTO 472
        IF(NON.EQ.NVAR) GOTO 474
C
        WRITE(N1DEV,140) VARNAM(II),VDELTM(I)
        GOTO 480
    472 WRITE(N1DEV,141) VARNAM(II),VDELTM(I)
        GOTO 480
    474 WRITE(N1DEV,142) VARNAM(II),VDELTM(I)
    480 CONTINUE
C
C
        WRITE(N1DEV,139)
C
C
        DO 500 J=1,MATHF
```

```
C     KMEAN continued.
C
      REWIND N2DEV
C
      LL=0
      JJ=J
C
      DO 490 I=1,(MATHF*NVAR)
C
      READ(N2DEV)Y
C
      IF(I.NE.JJ) GOTO 490
C
      LL=LL+1
      SORT(LL)=Y
      JJ=JJ+MATHF
  490 CONTINUE
C
      CALL KSORT(SORT,NVAR,MNV,MADD)
C
      NON=0
      DO 500 I=1,NVAR
      NON=NON+1
      II=MADD(I)
C
      IF(NON.EQ.1) GOTO 492
      IF(NON.EQ.NVAR) GOTO 494
C
      WRITE(N1DEV,143) VARNAM(II),SORT(I)
      GOTO 500
  492 WRITE(N1DEV,144) VARNAM(II),NCOMB(J),MCOMB(J),SORT(I)
      GOTO 500
  494 WRITE(N1DEV,145) VARNAM(II),NCOMB(J),MCOMB(J),SORT(I)
  500 CONTINUE
C
      CLOSE(UNIT=N2DEV)
C
      WRITE(N1DEV,139)
C
C
      LL=0
      DO 510 I=1,MATHF
      LL=LL+1
  510    CDELTM(LL)=SUM1(LL)/NVAR
C
      CALL KSORT(CDELTM,MATHF,MAXHF,MADD)
C
      NON=0
      DO 520 I=1,MATHF
C
      NON=NON+1
      II=MADD(I)
C
      IF(NON.EQ.1) GOTO 512
      IF(NON.EQ.MATHF) GOTO 514
C
      WRITE(N1DEV,146) NCOMB(II),MCOMB(II),CDELTM(I)
      GOTO 520
  512 WRITE(N1DEV,147) NCOMB(II),MCOMB(II),CDELTM(I)
      GOTO 520
  514 WRITE(N1DEV,148) NCOMB(II),MCOMB(II),CDELTM(I)
  520 CONTINUE
C
C
  521 CONTINUE
      WRITE(N1DEV,139)
      WRITE(N1DEV,139)
C
C
C
  600 IF(CMD(4).NE.'1') GOTO 620
      WRITE(N7DEV,162) '**','********'
      CLOSE(UNIT=N7DEV)
C
C
  620 RETURN
C
C     .................. formats .....................................
C
  101 FORMAT(/X,I3,' iterations required for convergence')
  102 FORMAT(' Summed deviation about seed points = 'E16.8/)
  103 FORMAT(1H )
  104 FORMAT(' Standardised distance between clusters',I2,' &',I2,'='
     1    ,F7.2)
  105 FORMAT(/' Exit forced after',I3,' iterations')
  110 FORMAT('Cluster',I2)
  111 FORMAT(X,A2,A8,A2)
  112 FORMAT('$Write first two letters of name of cluster ',I2)
  113 FORMAT(Q,2A1)
  114 FORMAT(A2)
```

```
      C     KMEAN continued.
        120 FORMAT(' Similarity matrices for each variable'/
           1    ' Diagonal elements....Corrected sum of squares for each
           2 cluster'/
           3  ' Upper triangle.......Distance between cluster centroids'/
           4  ' Lower triangle.......Delta; an indication of importance of'/
           5  '                      variable in distinguishing between 2
           6 clusters'/
           7  '                      DELTA=[dist]/[pooled std devn]'/)
        121     FORMAT(' +++ ',A8,' +++')
        131 FORMAT(5X,I2,4X,7(X,F9.4),2(/,11X,7(X,F9.4)))
        132 FORMAT(X,'Clusters',2X,7(6X,I2,2X),2(/,11X,7(6X,I2,2X)))
        138 FORMAT(/' +++++ Summary of delta values +++++')
        139 FORMAT(/18X,'-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-')
        140 FORMAT(X,A8,32X,F6.2)
        141 FORMAT(/X,A8,' Overall least important element',
           1  F6.2,' {Mean of delta values}')
        142 FORMAT(X,A8,' Overall most important element',
           1  X,F6.2,' {Mean of delta values}')
        143 FORMAT(X,A8,34X,F6.2)
        144 FORMAT(/X,A8,' Worst element for clusters',I2,' &',I2,X,
           1  F6.2,' {Delta}')
        145 FORMAT(X,A8,' Best element for clusters',I2,' &',I2,2X,
           1  F6.2,' {Delta}')
        146 FORMAT(' Clusters',I2,' &',I2,39X,F6.2,' {Means}')
        147 FORMAT(/' Clusters',I2,' &',I2,
           1  '  Hardest combination to distinguish',3X,F6.2,' {Means}')
        148 FORMAT(' Clusters',I2,' &',I2,
           1  '  Simplest combination to distinguish',2X,F6.2,' {Means}')
        160 FORMAT(X,I5,I6)
        161 FORMAT(5(X,A8))
        162 FORMAT(X,A2,A8,A2)
        163 FORMAT(X,80A1)
      D 170 FORMAT(/' No of clusters.....  ',I2/
      D    1   ' No of samples......',I4/
      D    2   ' No of variables....  ',I2)
      D 171 FORMAT(' Cluster',I2,' stdzd centroid values; ',5(X,F8.2))
      D 172 FORMAT(' Sum of stdzd values in cluster',I2,';',5(X,F8.2))
      D 173 FORMAT(' *** Sample no',X,I2,' ***')
      D 174 FORMAT(' Distance from cluster 1 ..... ',F8.2)
      D 175 FORMAT(' Distance from cluster',I2,' ..... ',F8.2)
      D 176 FORMAT(X,A2,A8,'in cluster',I2)
      D 183 FORMAT(X,A2,A8,'moved from cluster',I2,' to cluster',I2)
      D 177 FORMAT(/' No of samples in cluster',I2,' .....',I4,14X,
      D    1    5(X,A8))
      D 178 FORMAT(' Stdzd centroid values after iteration no ',I2,' ..'
      D    1   ,5(X,F8.2))
      D 179 FORMAT(/' """""""""""" Iteration no',I2,' """""""""""""""""""'/)
      D 181 FORMAT(38X,5(X,A8))
      D 182 FORMAT(/' No of alterations made from last iteration ... ',I3)
      C
            END


            SUBROUTINE KRSLTS(NUMBR,DATA1,NE,NVAR,NC,MNV,MNC,N4DEV,
           1N1DEV,N3DEV,N8DEV,N9DEV)
      C     Subroutine to print the results from the k-means clustering
      C     operation
      C     CENTR...Centroid values for each variable in cluster (MNV)
      C     NUMBR...No of samples in clusters (MNC)
      C     DATA1....1-d data matrix (MNV)
      C     NE......No of entities (data units)
      C     NVAR....No of variables                 MNV..Max no of variables
      C     NC......No of clusters                  MNC..Max no of clusters
      C
      C     N4DEV...Unformatted scratch file (stdzd data)
      C     N1DEV...Output device
      C     N3DEV...Device holding membership details
      C     N8DEV...Device holding centoid values (Direct Access file)
      C     N9DEV...Device holding means & std devns (Direct Access file)
      C
      C
            INTEGER SN1,KG,NM1(6),CL(6)
            REAL *8 SN2,NM2(6)
            DIMENSION NUMBR(MNC),DATA1(MNV)
      C
      C     Print results for each cluster
            DO 240 J=1,NC
      C
            KOUNT=J
            NON=0
            NUM=0
      C
            WRITE(N1DEV,102) J,NUMBR(J)
      C
            READ(N8DEV'KOUNT) (DATA1(I),I=1,NVAR)
      C
      C     Convert centroid values from standardized units
```

```
C     KRSLTS continued.
      DO 200 I=1,NVAR
      II=I
      READ(N9DEV'II) AM,SD
  200 DATA1(I)=DATA1(I)*SD+AM
C
      WRITE(N1DEV,103) (DATA1(I),I=1,NVAR)
C
      WRITE(N1DEV,104)
C
      REWIND N4DEV                    !Containing stdzd data
      REWIND N3DEV                    !Containing membership details
C
      IREF=J
C
      DO 230 JJ=1,NE
C
      IF(NUM.EQ.6) NUM=0
C
      READ(N4DEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
      READ(N3DEV) JREF
C
      IF(IREF.NE.JREF) GOTO 230
      IF(NON.GT.0) GOTO 210
C
      WRITE(N1DEV,105) SN1,SN2,KG
C
      GOTO 220
C
  210     NUM=NUM+1
      NM1(NUM)=SN1
      NM2(NUM)=SN2
      CL(NUM)=KG
C
      IF(NUM.NE.6) NON=2
      IF(NUM.NE.6) GOTO 230
C
      WRITE(N1DEV,106) (NM1(II),NM2(II),CL(II),II=1,NUM)
C
  220 NON=1
  230 CONTINUE
C
C
      IF(NON.NE.2) GOTO 240
C
C     Print last few names missed in leaving previous loop early
      WRITE(N1DEV,106) (NM1(II),NM2(II),CL(II),II=1,NUM)
C
  240     CONTINUE
C
      RETURN
C
C     ................ formats ..............................
  102 FORMAT(//' Cluster',I2,' contains',I3,' data units')
  103 FORMAT(' Centroid coordinates',6(/,X,5E12.4))
  104 FORMAT(' Membership list;')
  105 FORMAT(' Seed point (if used);'X,A2,A8,A2)
  106 FORMAT(6(X,A2,A8,A2))
C
      END
```

```
      SUBROUTINE KSORT(A,NVAR,NV,MADD)
C     Subroutine to sort a one row data group into acending order.
C     Uses the Shell sort method.
C     [A].......Row data matrix
C     NVAR......No.of variables
C     NV........Max.no.of values allowed
C     [MADD]....Address of sorted variable
C           ie.MADD(1) = Lowest value
C
      DIMENSION A(NV),MADD(NV)
C
C     Set addresses
      DO 99 I=1,NVAR
   99 MADD(I)=I
C
C     Sort routine.....
      M=2*NVAR-1
  100 M=M/2
C
      IF(M.EQ.0) GOTO 120
C
      K=NVAR-M
C
      DO 110 J=1,K
      DO 110 L=1,J,M
C
```

```
C     KSORT continued.
      I=J-(L-1)
      IA=I+M
C
      IF(A(IA).GT.A(I)) GOTO 110
C
C     Exchange address
      JJ=MADD(I)
      MADD(I)=MADD(IA)
      MADD(IA)=JJ
C
C     Exchange values
      C=A(I)
      A(I)=A(IA)
      A(IA)=C
C
  110 CONTINUE
      GOTO 100
C
  120    RETURN
C
      END


      SUBROUTINE KSTDZ(KDEV,JDEV,DATA1,DATA2,XSUM,NSMP,NVAR,NV,IOPT,
     1N9DEV)
C     Subroutine to standardize data held in scratch files.
C     KDEV     Scratch file unit no holding:
C                 For option 1... Unstandardised data
C                 For option 2... Data on which mean & std dev required
C     JDEV     Scratch file unit no holding standardised data
C     DATA        1-d matrix holding NVAR data values (used by scratch file)
C     DATA        1-d matrix holding NVAR data values (used by scratch file)
C     NSMP     Number of samples in the array
C     NVAR     Number of variables in the array
C     NV       Real length of arrays DATA1,DATA2 & XSUM
C     IOPT     Option;   1.... Standardisation
C                        2.... Calculation of mean & std dev only
C     N9DEV
C
      INTEGER SN1,KG
      REAL *8 SN2
      DIMENSION DATA1(NV),DATA2(NV),XSUM(NV)
C
      XN=FLOAT(NSMP)
      XR=FLOAT(NSMP-1)
C
C     Calculate mean for each variable
      REWIND KDEV
C
      DO 200 J=1,NVAR
  200 XSUM(J)=0.0
C
      DO 210 I=1,NSMP
      READ(KDEV) SN1,SN2,KG,(DATA1(K),K=1,NVAR)
      DO 210 J=1,NVAR
  210    XSUM(J)=XSUM(J)+DATA1(J)
C
      DO 220 J=1,NVAR
  220 DATA2(J)=XSUM(J)/NSMP                   !Mean value
C
C
C     Calculate std devn for each variable
      REWIND KDEV
      DO 221 I=1,NVAR
  221 XSUM(I)=0.0
C
      DO 230 I=1,NSMP
      READ(KDEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
C
      DO 230 J=1,NVAR
      DEV=DATA1(J)-DATA2(J)
      D=DEV*DEV
  230 XSUM(J)=XSUM(J)+D                       !Sumation for std.dev.
C
      DO 240 I=1,NVAR
      II=I
      V=XSUM(I)/XN
      IF (NSMP.LT.30) V=XSUM(I)/XR            !Variance
      XSUM(I)=SQRT(V)                         !Std.dev.
C
  240 WRITE(N9DEV'II) DATA2(I),XSUM(I)        !Write mean & std devn to file
      IF(IOPT.GT.1) GOTO 270
C
C     Standardise each data value
      REWIND KDEV
      DO 250 K=1,NSMP
      READ(KDEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
```

```
C      RSTDZ continued.
C
       DO 260 L=1,NVAR
  260    DATA1(L)=(DATA1(L)-DATA2(L))/XSUM(L)
C
  250 WRITE(JDEV) SN1,SN2,KG,(DATA1(II),II=1,NVAR)
C
C
  270 RETURN
C
      END


      SUBROUTINE MATINV(A,B,N,N1,DET)
C     Subroutine to invert A(N,N). The inverted matrix is returned
C     in B(N,N) of the matrix B(N1,N1). Matrix [A] is destroyed.
C     The determinant of A is returned as DET . Matrix [A]
C     becomes the Identity Matrix.
C
C     Subroutine used;    MATNUL
C
      DIMENSION A(N1,N1),B(N1,N1)
C
C     Zero the B matrix
      CALL MATNUL(B,N,N,N1,N1)
C
C     Transform B to an Identity matrix
      DO 100 I=1,N
  100 B(I,I)=1.0
C
      DET=1.0
C
      DO 101 I=1,N
      D=A(I,I)
      DET=D*DET
C
      DO 102 J=1,N
      A(I,J)=A(I,J)/D
  102 B(I,J)=B(I,J)/D
C
      DO 104 J=1,N
      IF (I.EQ.J) GOTO 104
      R=A(J,I)
C
      DO 105 K=1,N
      A(J,K)=A(J,K)-R*A(I,K)
  105 B(J,K)=B(J,K)-R*B(I,K)
C
  104 CONTINUE
C
  101 CONTINUE
C
C     Check.
C     [A] should now be the Identity matrix.
      DO 106 I=1,N
  106 IF(A(I,I).NE.1.0000) GOTO 108
      DO 107 J=1,N
      DO 107 I=1,N
      IF(J.EQ.I) GOTO 107
      IF(A(J,I).NE.0.0000) GOTO 108
  107 CONTINUE
C
      RETURN
C
  108 WRITE (5,110)
  110 FORMAT (' Failure in MATINV subroutine')
C
      END


      SUBROUTINE MATNUL(A,N,M,N1,M1)
C     Subroutine to null A(N,M) of the matrix A(N1,M1)
C
      DIMENSION A(N1,M1)
C
      DO 100 I=1,N
      DO 100 J=1,M
  100 A(I,J)=0.0
C
      RETURN
C
      END
```

```
      SUBROUTINE MREG(A,AS,SD,AMEAN,X,N,M,NV,MNE,MNY,KDEV,IDEV,HADDR,
     1LDEV,IO,C,B,YY,W,T,XX,JADD,KADD,XDATA,MNV,NVAR,JOPT)
C     Multiple regression subroutine                               Max size
C     A   Raw data                                                    (MNE)
C     AS  Standardized data                                           (MNE)
C     IO  Input/Output switch       0 .. In                           (MNE)
C                                   1 .. Out
C     SD  Standard deviations                                         (NV)
C     AMEAN       Means                                               (NV)
C     X   Correlation coefficients                                    (MNY)
C     YY  Correlation coefficients for dependant variables            (NV)
C     XX  Correlation coefficients for independant variables          (NV,NV)
C     C   Standardized partial regression coefficients                (NV)
C     B   Partial regression coefficients                             (NV)
C     T   t-values for variables                                      (NV)
C     HADDR       Variables names                                     (MNV)
C     JADD        Variable addresses in HADDR (1=Dependant variable)  (MNV)
C     KADD        Variable addresses in HADDR ('        "         ')  (MNV)
C     XDATA       Temporary data array used by scratch file (LDEV)    (MNV)
C
C     N   No of samples in [A]
C     M   No of variables in [A]
C     NVAR        No of variables in scratch file (LDEV)
C
C     KDEV        Output device      (Terminal/File)
C     IDEV        Output device for regression coefficients (Used in conjunction
C                                                     with XRFA)
C     LDEV        Scratch file unit no
C
C     JOPT        Run option:     1 .. Summary of results to screen
C                           2 .. Full results to screen
C                           3 .. Full results to file .RCO
C                           4 .. Regression coefficients to file .RCF
C
C     Subroutine to carry out a multiple regression calculation on
C     the raw data set A(MNE). This is transformed to a standardized
C     data set AS(MNE); the means & std. deviations of the variables
C     in [A] are also calculated. A correlation matrix [X] is then
C     calculated from [AS].
C     From [X] the standardized partial regression coefficients are
C     calculated by firstly splitting up [X] into it's dependant &
C     independant variable components (XX & YY), then by matirx inversion
C     of [XX] & finally by multiplying [XX]-1 & [YY] to give [C].
C     From [C] the partial regression coefficients [B] are calculated.
C     Using the [B]'s the estimated values of the dependant variable
C     can be calculated together with the deviations.
C     Summary statistics are also computed including F-test value & the
C     correlation coefficient.
C     The regression coeffs are then inputed into a file .RCF if required.
C
C     Subroutines used:   OSTAND  PMAT    OCORRL  MATNUL  MATINV
C
C     **************************************************************
      LOGICAL *1 IO(MNE),OUT
C
      INTEGER SN1,KG,JADD(NV),KADD(NV),ADDRES
C
      REAL *8 HADDR(MNV),SN2
C
      DIMENSION A(MNE),AS(MNE),SD(NV),AMEAN(NV),X(MNY),XDATA(MNV),C(MNV)
     1 ,B(MNV),YY(MNV),W(NV,NV),T(MNV),XX(NV,NV)
C
      DATA IOPT,KOPT,SMALL/4,2,-9998.0/
C     **************************************************************
C
C     Check to see if any samples missing
      NA=0
      REWIND LDEV
      DO 100 I=1,N
      NIO=0
      READ(LDEV) SN1,SN2,KG,(XDATA(II),II=1,NVAR)
      DO 102 J=1,M
      ADDRES=M*(I-1)+J
      IF(IO(ADDRES).EQ.'0')GOTO 102
      NIO=NIO+1
  102 CONTINUE
      IF(NIO.EQ.M) WRITE(KDEV,2008) SN1,SN2
      IF(NIO.EQ.M) GOTO 100
      NA=NA+1
  100 CONTINUE
C
      FN=FLOAT(NA)         !No of samples active in this run thro subroutine
C
C     Check to see if any variables missing
      MA=0
      DO 110 J=1,M
      NIO=0
      DO 115 I=1,N
```

```
C       MREG continued.
        ADDRES=M*(I-1)+J
        IF(IO(ADDRES).EQ.'0')GOTO 115
        NIO=NIO+1
  115 CONTINUE
        KKK=JADD(J)
        IF(NIO.EQ.N) WRITE(KDEV,2009) HADDR(KKK)
        IF(NIO.EQ.N) GOTO 110
        MA=MA+1
        KADD(MA)=JADD(J)
  110 CONTINUE
C
        FM=FLOAT(MA)          !No of variables active in this run thro subroutine
D       WRITE(KDEV,1113) N,M,FN,FM
D1113 FORMAT(2(X,I5),2(X,F5.1))
C
C
C       Standardize data
        CALL OSTAND(A,AS,AMEAN,SD,DUMMY,DUMMY,N,M,MNE,MNV,IOPT,IO,KOPT)
D       CALL PMAT(AS,1,(N*M),1,NX)
C
C       Create correlation matrix [X]
        CALL OCORRL(AS,X,N,M,NX,IO,KOPT,0)
D       CALL PMAT(X,1,((M*M-M)/2),1,MNY)
C
C
        L=MA-1                !No of independant variables
C
C
C       Finding [C] from eqn. having form [XX][C]=[YY]
C       [XX]=Correlation coeffs. of independant variables
C       [C]=Standardized partial regression coeffs.
C       [YY]=Correlation coeffs. of dependant variables
C
        NON=0
        DO 124 J=1,L
  122 NON=NON+1
        IF(X(NON).LT.2.0) GOTO 124
        GOTO 122
  124 YY(J)=X(NON)
C
C
        DO 125 I=1,L
        DO 125 J=I,L
        IF(I.EQ.J) GOTO 126
C
  128 NON=NON+1
        IF(X(NON).LT.2.0) GOTO 123
        GOTO 128
C
  126 XX(I,I)=1.0
        GOTO 125
C
  123 XX(J,I)=X(NON)
        XX(I,J)=X(NON)
  125 CONTINUE
C
C
D       WRITE (KDEV,1114) (YY(I),I=1,L)
D       WRITE(KDEV,3030)
D3030 FORMAT(' ')
D       DO 1115 I=1,L
D1115 WRITE (KDEV,1114) (XX(I,J),J=1,L)
D1114 FORMAT(' ',4F16.10)
C
C       Null correlation coeff. matrix [W]
        CALL MATNUL(W,L,L,NV,NV)
C
C       Use matrix inversion subroutine on [XX]
        CALL MATINV(XX,W,L,NV,DUMMY)
D       CALL PMAT(W,L,L,NV,NV)
C
C
C       Calculate [c] by matrix multiplication
         DO 131 I=1,L
        C(I)=0.0
        DO 131 J=1,L
  131 C(I)=C(I)+W(I,J)*YY(J)
C
C
C       Calculating partial regression coeffs.(beta's)
        II=1
        B0=0.0
        DO 140 I=2,MA
        NX=KADD(I)
  141 II=II+1
        NY=JADD(II)
        IF(NY.NE.NX) GOTO 141
        B(I-1)=C(I-1)*SD(1)/SD(II)
C       Calculating beta(0) value
```

```
C     MREG continued.
  140   B0=B0+B(I-1)*AMEAN(I)
      B0=AMEAN(1)-B0
C
C
      IF(JOPT.NE.4) GOTO 147
C     Write to .RCF-file if required """""""""""""""""""""""""""""""" JOPT=4
      II=1
      DO 146 I=1,MA
      NX=KADD(I)
  142 II=II+1
      NY=JADD(II)
      IF(NY.NE.NX) GOTO 142
  146   WRITE (IDEV,2010)HADDR(NY)
C
      WRITE (IDEV,2011)B0,(B(J),J=1,L)
      GOTO 180
C     ...............................................................
C
C     Calculate estimated values & deviation of each observation
C     Calculate sums & sums of squares of all Y values
  147 NX=KADD(1)
      WRITE(KDEV,1998) HADDR(NX)
      WRITE (KDEV,2000)
      REWIND LDEV
C
C     Sums=zero
      SY=0.0
      SYS=0.0
      SYE=0.0
      SYES=0.0
      DIFF=0.0
C
      DO 150 I=1,N
      XA=0.0
      XB=0.0
      XC=0.0
      READ(LDEV) SN1,SN2,KG,(XDATA(II),II=1,NVAR)
      NX=KADD(1)
      XA=XDATA(NX)
      ADDRES=M*(I-1)+1
      OUT=' '
      IF(IO(ADDRES).EQ.'1') OUT='d'
      IF(IO(ADDRES).EQ.'1') GOTO 152
      IF(XA.LT.SMALL) XA=0.0000
      IF(XA.LT.SMALL) GOTO 150
      SY=SY+XA
      SYS=SYS+XA*XA
C
  152 II=1
      NON=0
      DO 151 J=2,MA
      NX=KADD(J)
  143 II=II+1
      NY=JADD(II)
      IF(NY.NE.NX) GOTO 143
      XD=XDATA(NX)
      IF(XD.LT.SMALL) GOTO 151
      XB=XB+B(J-1)*XD
      ADDRES=M*(I-1)+J
      IF(IO(ADDRES).EQ.'0') NON=NON+1
  151 CONTINUE
C
      XB=XB+B0
C
      IF(NON.EQ.0) GOTO 154
C
      SYE=SYE+XB
      SYES=SYES+XB*XB
  154   XC=XB-XA
      WRITE (KDEV,2001) OUT,I,SN1,SN2,XA,XB,XC
C
      IF(NON.EQ.0) GOTO 150
      CAL=XC*XC/(FN-FM-1)
      DIFF=DIFF+CAL
  150 CONTINUE
C
C
      DO 153 J=2,MA
  153 T(J)=B(J-1)/DIFF*W(J-1,J-1)
C
C
      IF(JOPT.EQ.1) GOTO 2020
C     Write partial regression coeffs """"""""""""""""""""""""" JOPT=2 or 3
      WRITE (KDEV,2002) B0
      DO 170 J=2,MA
      NX=KADD(J)
  170   WRITE (KDEV,2003) J,HADDR(NX),(J-1),B(J-1),(J-1),T(J)
C     .........................................................
C
```

```
C     MREG continued.
C
C     Statistical tests (correlation coeff.(R))
C                       (goodness of fit (R2)
C                       (F-test)
C     SST:total sum of squares
C     SSR:sum of square of residuals; XMSR:mean square of residuals
C     SSD:sum of square of deviations; XMSD:mean square of deviations
C
 2020 SSR=SYES-SYE*SYE/FN
      XMSR=SSR/(FM-1)
      SST=SYS-SY*SY/FN
      SSD=SST-SSR
      XMSD=SSD/(FN-FM)
      R2=SSR/SST
      R=SQRT(R2)
      F=XMSR/XMSD
C     Compare F(calculated) against value from tables
C
C
C     Write required stats
      IF(JOPT.EQ.1) GOTO 178
      WRITE (KDEV,2004) SSR,(FM-1),XMSR,F       !****************** JOPT=2 or 3
      WRITE (KDEV,2005) SSD,(FN-FM),XMSD
      WRITE (KDEV,2006) SST,(FN-1)
      WRITE (KDEV,2007) R
  178 WRITE(KDEV,2012) (R2*100)                 !****************** JOPT=1
C
C
  180  RETURN
C
C
C     ..................... FORMATS ................................
 1998 FORMAT(/' Dependant variable;'A8)
 2000 FORMAT(/19X,'      -Y-        -Y-EST-     -DEVIATION-    ')
 2001 FORMAT(2X,A1,I4,2X,A2,A8,3X,F10.4,3X,F10.4,3X,F10.4)
 2002 FORMAT(/' Regression coeffs.'/6X,
     1 'Constant term B(0)='F20.4)
 2003 FORMAT(I4,2X,A8,6X,'B('I2')='F20.4,6X,'T('I2')='F15.4)
 2004 FORMAT(/' Sum of square of residuals='F20.3/
     1 ' No. of degrees of freedom='F4.1/
     2    ' Mean square of residuals='F20.3/
     3   ' F-test value='F10.3/)
 2005 FORMAT(' Sum of square of deviations='F20.3/
     1 ' No. of degrees of freedom='F4.1/
     2 ' Mean square of deviations='F20.3/)
 2006 FORMAT(' Sum of square of totals='F20.3/
     1     ' No. of degrees of freedom='F4.1/)
 2007 FORMAT(5X,'Correlation coeff.='F7.4)
 2012 FORMAT(/5X,'Goodness of fit='F8.3'%')
 2008 FORMAT(' Sample removed;'X,A2,A8)
 2013 FORMAT(X,'I/O;',10(X,30A1))
 2009 FORMAT(' Element removed;',X,A8)
 2010 FORMAT(' ',A8)
 2011 FORMAT(8F20.4)
C
       END


      SUBROUTINE DCORRL(AS,X,N,M,NX,IO,IOPT,IDEV)
C     Calculation of correlation coeffifients.
C     [AS] is a one-dimensional data matrix
C     All data <-9998 ignored by subroutine
C     [X] is a one-dimensional correlation coefficient matrix
C     Set equal to 2.0 if no data
C     Capable of holding coeffs of upto 50 variables
C     [N] is the number of samples
C     [M] is the number of variables
C     NX is the max. no. of values allowed in [AS]
C     IOPT   Option required;
C                           1 ... No I/O switch used
C                           2 ... I/O switch used
C
C     IO  Input/Output switch
C                           0 ... IN
C                           1 ... OUT
C     IDEV  Output device
C
C     Subroutine used;    MATNUL
C
      LOGICAL *1 IO(NX)
      DIMENSION AS(NX),X(1225)
C
C     No.of values expected in [X]
      MA=(M*M-M)/2
C
      SMALL=1.0E-12
C
C     Null correlation coeff. matriX [X]
```

```
      C      OCORRL continued.
             CALL MATNUL(X,MA,1,1225,1)
      C
             NON=0
      C
      C      To calculate correlation matrix [X] between
      C      columns J & K of matrix [AS]
             DO 110 J=1,(M-1)
             DO 110 K=J+1,M
      C
      C      Set sums to zero
             SX1=0.0
             SX2=0.0
             SX1S=0.0
             SX2S=0.0
             SX1X2=0.0
      C
             NK=0
             F=0.0
      C
      C      Calculate sums,sums of squares & sums of products
      C      of columns J & K
             DO 111 L=1,N
      C
             JADD=M*(L-1)+J
             KADD=M*(L-1)+K
             IF((IO(JADD).EQ.'1'.AND.IOPT.EQ.2).OR.AS(JADD).LT.-9998.0)GOTO 111
             IF((IO(KADD).EQ.'1'.AND.IOPT.EQ.2).OR.AS(KADD).LT.-9998.0)GOTO 111
      C
             NK=NK+1
      C
               VAL1=AS(JADD)
             VAL2=AS(KADD)
      C
             SX1=SX1+VAL1
             SX2=SX2+VAL2
             SX1S=SX1S+VAL1*VAL1
             SX2S=SX2S+VAL2*VAL2
              SX1X2=SX1X2+VAL1*VAL2
      C
         111 CONTINUE
      C
      D      IF(IDEV.GT.0) WRITE(IDEV,1111) SX1,SX2,SX1S,SX2S,SX1X2
      C
             NON=NON+1
             IF(NK.EQ.0) GOTO 116
             F=FLOAT(NK)
      C
      C      Compute correlation coefficient (R) & store
      C      in matrix [X]
             SQ=SQRT((SX1S-SX1*SX1/F)*(SX2S-SX2*SX2/F))
             IF (SQ.GT.SMALL) GOTO 114
      C
         116 IF(IDEV.GT.0) WRITE(IDEV,1000) J,K
             X(NON)=2.0
             GOTO 110
      C
         114 X(NON)=(SX1X2-SX1*SX2/F)/SQ
      D      IF(IDEV.GT.0) WRITE (IDEV,1113) X(NON)
      C
         110 CONTINUE
      C
             RETURN
      C
        1000 FORMAT(' Warning...Correlation coeffs for groups',I2,' &',I2,
           1 ' set to 2.0')
      D1111 FORMAT (' ',2(X,F19.2),3(X,F19.2))
      D1113 FORMAT (' ',F12.6//)
      C
             END


             SUBROUTINE OMNMX(A,NSMP,NVAR,NV,NX,XMIN,XMAX)
      C      Subroutine to calculate max.& min. of data matrix.
      C      [A] One-dimensional data matrix
      C          All data <-9998 ignored by subroutine
      C      NSMP        No of samples
      C      NVAR      No of variables
      C      NV  Max no of variables
      C      NX  Max.no.of data values
      C      [XMIN]      Min values
      C      [XMAX]      Max values
      C
      C      Subroutines used:   MATNUL  PMAT
             INTEGER ADDRES
             DIMENSION A(NX),XMIN(NV),XMAX(NV)
      C
```

```
C     OMNMX continued.
C     Null matrices [XMAX] & [XMIN]
      CALL MATNUL(XMAX,NVAR,1,NV,1)
      CALL MATNUL(XMIN,NVAR,1,NV,1)
C
      DO 20 J=1,NVAR
      Z=-1.0E10
      Y=1.0E10
      DO 21 I=1,NSMP
      ADDRES=NVAR*(I-1)+J
      W=A(ADDRES)
      IF(W.GT.Z) Z=W
   21 IF(W.LT.Y.AND.W.GE.-9998.0) Y=W
      XMAX(J)=Z
      XMIN(J)=Y
   20 CONTINUE
C
D     CALL PMAT(XMIN,NVAR,1,NV,1)
D     CALL PMAT(XMAX,NVAR,1,NV,1)
C
      RETURN
C
      END


      SUBROUTINE OSTAND(A,AS,AMEAN,SD,SK,KU,NSMP,NVAR,NX,NV,IOPT,IO,
     1KOPT)
C     A    Basic one-dimensional data array
C          All data <-9998 ignored by subroutine
C          Option 3 returns a standardized data array
C          Option 4 returns standardized data to array [AS]. Original
C          data array [A] retained.
C     AS           Used by option 4 only
C     AMEAN    Arithmetic average values on exit
C     SD     Standard deviation of values on exit
C     SK   Skewness of values on exit
C     KU   Kurtosis of values on exit
C     NSMP     Number of samples in the array
C     NVAR     Number of variables in the array
C     NX       Real length of A
C     NV       Real length of arrays AMEAN,SD,SK & KU
C     IO       Input/Output switch
C     IOPT     Option required      1....Means & std.devns. only
C                                   2....Means,std.devns,skewness &
C                                        kurtosis
C                                   3....Means,std.devns,skewness,
C                                        kurtosis & standardize data.
C                                        Uses significantly less storage.
C                                   4....Standardize data. Original data
C                                        retained.
C
C
C     KOPT         Option required          1....No I/O switch
C                                   2....I/O switch used.
C                                                      0 ... IN
C                                                      1 ... OUT
C     Subroutines used:   MATNUL
C
      LOGICAL *1 IO(NX)
      INTEGER ADDR
      REAL KU(NV)
      DIMENSION A(NX),AS(NX),AMEAN(NV),SD(NV),SK(NV)
C
      SMALL=1.0E-12
      IF(IOPT.EQ.4) CALL MATNUL(AS,(NSMP*NVAR),1,NX,1)
C
C     Calculate mean and std.dev. for each variable
      DO 109 J=1,NVAR
C
      AMEAN(J)=0.0
      SD(J)=0.0
      NF=0
C
      IF(IOPT.NE.2.AND.IOPT.NE.3) GOTO 113
      SK(J)=0.0
      KU(J)=0.0
C
C     Set sums to zero
  113 SUM=0.0
C
C     Sum values
      DO 111 I=1,NSMP
C
      ADDR=NVAR*(I-1)+J
      IF((IO(ADDR).EQ.'1'.AND.KOPT.EQ.2).OR.A(ADDR).LT.-9998.0)GOTO 111
C
      NF=NF+1
      SUM=SUM+A(ADDR)
  111 CONTINUE
```

```
C     OSTAND continued.
C
      IF(NF.EQ.0) GOTO 109
      XN=FLOAT(NF)
      XR=FLOAT(NF-1)
C
C     Compute means
      AM=SUM/XN
      AMEAN(J)=AM
C
C     Set sums to zero
      SUM=0.0
C
      IF(IOPT.NE.2.AND.IOPT.NE.3) GOTO 114
C
      SUM3=0.0
      SUM4=0.0
C
C     Compute standard deviations
  114 DO 112 I=1,NSMP
C
      ADDR=NVAR*(I-1)+J
      IF((IO(ADDR).EQ.'1'.AND.KOPT.EQ.2).OR.A(ADDR).LT.-9998.0)GOTO 112
C
      DEV=A(ADDR)-AM
C
      D=DEV*DEV
      SUM=SUM+D          !Sumation for std.dev.
C
      IF(IOPT.NE.2.AND.IOPT.NE.3) GOTO 112
C
      SUM3=SUM3+D*DEV               !Sumation for skewness
      SUM4=SUM4+D*D                 !Sumation for kurtosis
C
  112 CONTINUE
C
      V=SUM/XN
      IF (NF.LT.30) V=SUM/XR        !Variance
      SM=SQRT(V)                    !Std.dev.
      SD(J)=SM
C
      IF((IOPT.NE.2.AND.IOPT.NE.3).OR.SM.LT.SMALL) GOTO 108
      SD3=SM*SM*SM
      SD4=SD3*SM
C
      SK(J)=(SUM3/XN)/SD3
      IF(NF.LT.30) SK(J)=(SUM3/XR)/SD3     !Skewness
      KU(J)=(SUM4/XN)/SD4-3.0
      IF(NF.LT.30) KU(J)=(SUM4/XR)/SD4-3.0          !Kurtosis
C
  108 IF(IOPT.LT.3) GOTO 109
      GOTO(120,121),(IOPT-2)
C
C     Standardise each element
  120 DO 110 K=1,NSMP
      IF(SM.LT.SMALL) GOTO 110
      ADDR=NVAR*(K-1)+J
      IF((IO(ADDR).EQ.'1'.AND.KOPT.EQ.2).OR.A(ADDR).LT.-9998.0)GOTO 110
        A(ADDR)=(A(ADDR)-AM)/SM
  110 CONTINUE
      GOTO 109
C
  121 DO 115 K=1,NSMP
      IF(SM.LT.SMALL) GOTO 115
      ADDR=NVAR*(K-1)+J
      IF((IO(ADDR).EQ.'1'.AND.KOPT.EQ.2).OR.A(ADDR).LT.-9998.0)GOTO 116
        AS(ADDR)=(A(ADDR)-AM)/SM
      GOTO 115
  116 AS(ADDR)=A(ADDR)
  115 CONTINUE
C
  109 CONTINUE
C
      RETURN
C
      END
```

```
      SUBROUTINE PMAT(A,N,M,N1,M1)
C     Subroutine to print a matrix having N rows
C     and M columns.
C
      DIMENSION A(N1,M1)
C
C     Print matrix out in rows of 4 columns each.
      DO 100 I=1,N
      WRITE (5,1112) I
  100 WRITE (5,1111) (A(I,J),J=1,M)
C
      RETURN
C
 1112 FORMAT (//' Row',I3)
 1111 FORMAT (' ',4F16.7)
C
      END
```

```
      SUBROUTINE SERADD(JADD,ELEM1,ELEM2,N1,N2,NV1,MNV1,NV2,MNV2,IDEV,
     1IERR)
C     Subroutine to search for the addresses of an array of elements stored
C     in ELEM1 (when cf array of elements in ELEM2) & to store them in JADD.
C     IERR=0 .... OK
C     IERR=1 .... Unable to find ELEM1
C
      REAL *8 ELEM1(MNV1),ELEM2(MNV2)
      DIMENSION JADD(MNV1)
C
      IERR=0
C
C     Begin search
      DO 220 J=N1,NV1
C
      JJ=J-(N1-1)
      JADD(JJ)=0
C
      DO 200 I=N2,NV2
  200 IF(ELEM1(J).EQ.ELEM2(I)) GOTO 210
C
      IF(IDEV.GT.0) WRITE(IDEV,100) ELEM1
      GOTO 230                !Variable not found......post warning via IERR
C
C     To get here variable has been identified
  210 JADD(JJ)=I
  220 CONTINUE
C
      GOTO 240
C
  230 IERR=1
C
  240 RETURN
C
  100 FORMAT(' Variable ',A8,' not present!')
C
      END
```

```
      SUBROUTINE SOLVE(A,B,N,M,IERR)
C     Subroutine to solve the matrix equation  A * b = B
C     Where A is an M*M matrix, B and b are M*1 vectors and the
C     system describes a set of N simultaneous equations with a
C     coefficients vector b.  IERR is returned as zero if b can
C     be determined else as 1 if A is singular .
C     The coefficients are returned in B, both A and B being dest-
C     royed by the routine .
C
      DIMENSION A(M,M),B(M)
C
      ALIM=1.0E-20
      BLIM=1.0E+06
C
      DO 100 I=1,N
      K=1
      DO 101 J=I+1,N
  101 IF (ABS(A(J,I)).GT.ABS(A(K,I))) K=J
C
      IF (ABS(A(K,I)).LT.ALIM) GOTO 900
      CLIM=BLIM*ABS(A(I,I))
      IF (ABS(A(K,I)).LE.CLIM) GOTO 105
C
      DO 102 J=I,N
      Y=A(K,J)
      A(K,J)=A(I,J)
```

```
C     SOLVE continued.
  102 A(I,J)=Y
C
      Y=B(K)
      B(K)=B(I)
      B(I)=Y
  105 Y=1.0/A(I,I)
C
      DO 103 J=I+1,N
  103 A(I,J)=A(I,J)*Y
      B(I)=B(I)*Y
C
      DO 104 J=I+1,N
      Y=A(J,I)
C
      DO 106 K=I+1,N
  106 A(J,K)=A(J,K)-Y*A(I,K)
  104 B(J)=B(J)-Y*B(I)
C
  100 CONTINUE
C
      DO 108 I=N-1,1,-1
      DO 108 J=I+1,N
  108 B(I)=B(I)-B(J)*A(I,J)
C
      IERR=0
      GOTO 999
C
  900 IERR=1
C
  999 RETURN
      END
```

```
      SUBROUTINE TCAP(C)
C     Subroutine to convert (if necessary) any letter to a capital
C
      LOGICAL *1 C
C
      IF(C.GE.'a'.AND.C.LE.'z') C=C-"40
C
      RETURN
C
      END
```

```
      SUBROUTINE XCRMLT(JDEV,N1,KDEV,N2,C,B,A,DATA,NVAR,MSIZ)
C     Subroutine to compute a cross-products matrix and vectors
C     between two corresponding data matrices held in a scratch
C     file.
C
      INTEGER SN1,KG
      REAL *8 SN2
      DIMENSION C(2,MSIZ),B(MSIZ),A(MSIZ,MSIZ),DATA(MSIZ)
C
C     Zero primary matrices
      DO 200 J=1,NVAR
      C(1,J)=0.0
      C(2,J)=0.0
      DO 200 K=1,NVAR
  200 A(J,K)=0.0
C
C     Accumulate terms for the first data set
      REWIND JDEV
      DO 201 K=1,N1
      READ(JDEV)SN1,SN2,KG,(DATA(II),II=1,NVAR)
C
      DO 201 J=1,NVAR
      XA=DATA(J)
      C(1,J)=C(1,J)+XA
C
      DO 201 L=1,NVAR
  201 A(J,L)=A(J,L)+XA*DATA(L)
C
C     Accumulate terms for the second data set
      REWIND KDEV
      DO 202 K=1,N2
      READ(KDEV)SN1,SN2,KG,(DATA(II),II=1,NVAR)
C
      DO 202 J=1,NVAR
      XA=DATA(J)
      C(2,J)=C(2,J)+XA
C
      DO 202 L=1,NVAR
  202 A(J,L)=A(J,L)+XA*DATA(L)
C
```

```
C       XCRMLT continued.
        AN1=FLOAT(N1)
        AN2=FLOAT(N2)
        AN3=AN1+AN2-2.0
C
        DO 203 J=1,NVAR
        B(J)=C(1,J)/AN1-C(2,J)/AN2
C
        DO 203 L=1,NVAR
  203   A(J,L)=(A(J,L)-C(1,J)*C(1,L)/AN1-C(2,J)*C(2,L)/AN2)/AN3
C
        RETURN
C
        END
```

Raw data files

Most of the files accessed by the computer programs read their data from standard format files. These are easily accessed by both computer programs and by the user directly.

An example of the sequential, self-formatting file (all have the extension .RAW) developed at the Geology Department, Nottingham University is shown below.

It consists of a header which holds a title and a format statement describing the form of the data held in the individual records (each 80 character maximum); two integer values representing the number of variables (NVAR) and the number of samples or records (NSMP, this may be left equal to zero); and an array of variable names (8 characters maximum and NVAR in length) corresponding to the records below.

The header is followed by a series of records consisting of a sample name and the data (NVAR in length). The sample name (10 characters maximum) may be followed by a two character alphanumeric identifier whose default is "//".

The end of the record is indicated either by the value of NSMP or by a special character string ("**********") in place of the sample name.

Example of a .RAW-file.

```
Title -- .RAW-file example                                ]
(X,4F10.4)                                                ] Header
    5     4                                               ]
SIO2      AL2O3     TIO2      FE2O3     MGO               ]
S-177     //                                           ]
42.0110    5.2330    0.4190    6.7820                  ]
21.8930                                                ] Records
S-178     //                                           ]
43.0520    5.1200    0.3840    6.6400                  ]
22.4770                                                ]
S-179     //                                           ]
43.9970    5.7480    0.4720    6.4460                  ]
20.3710                                                ]
S-180     //                                           ]
43.9890    5.6610    0.4750    6.6920                  ]
20.8960                                                ]
**********                                         ] End statement
```

B. <u>XRF operating conditions</u>

Most of the major and trace element data (Appendices D,E,F,G,I) described in this work were analyzed at the Department of Geology, University of Nottingham using a Philips PW1400 spectrometer. The machine conditions used during analyses are shown overleaf.

<u>Electron microprobe analyses</u>

Two different electron microprobes were used during the project; the energy dispersive spectrometer (EDS) and the wavelength dispersive spectrometer (WDS).

a) EDS; Modified Cambridge Instrument Company Geoscan.

This was used for the silicate analyses and is an electronic device using a Li-doped Si detector. It has a detection limit of approximately 0.2 Wt% and is capable of detecting elements from Na to U. The operation of the device is rapid as X-rays of all energies are detected simultaneously.

The machine comprises a Kevex detector, a Harwell 2010 pulse processor and Link Systems 290 Electronics. Link Systems ZAF-4/FLS software is used to convert the X-ray spectra obtained from the specimen into a chemical analysis.

<u>Operating conditions</u>

15 kV electron beam accelerating voltage.

75° X-ray take-off angle.

3nA specimen current on Cobalt metal.

2.5 kCPS output count rate from Cobalt metal with 18% detection system dead time.

Element	Tube	line	Angle	Wavelength (Angstrom)	kV	mA	crystal	coll.	det.	ct. (peak)	ct. (bkd.)	O'lap	Detection limit (1s)
Si	Rh	K(a)	109.200	7.1262	40	70	PE	C	F	10	2	-	0.010
Al	Rh	K(a)	145.100	8.3401	40	70	PE	C	F	10	2	-	0.010
Ti	Rh	K(a)	86.220	2.7497	40	70	LiF200	F	F	10	6	-	0.005
Fe	Rh	K(a)	57.610	1.9373	60	50	LiF200	F	F	4	2	-	0.010
Mg	Rh	K(a)	45.285	9.8890	40	70	TlAP	C	F	10	4 *	-	0.010
Ca	Rh	K(a)	113.360	3.3595	40	70	LiF200	C	F	4	2	-	0.010
Na	Rh	K(a)	55.195	11.9090	40	70	TlAP	C	F	16	4	-	0.015
K	Rh	K(a)	50.700	3.7440	40	70	PE	C	F	4	2	-	0.010
Mn	Rh	K(a)	95.245	2.1030	60	50	LiF220	F	FS	4	2		0.010
F	Rh	K(a)	141.185	6.1580	40	70	Ge	C	F	6	2	-	0.010
Ba	Rh	L(a)	87.290	2.7759	50	60	LiF200	F	F	40	20	Ti	8.3
Ce	Rh	L(b)	111.795	2.3561	50	60	LiF220	F	F	80	80	Ba	7.0
Co	Rh	K(a)	77.93	1.7903	60	50	LiF220	F	FS	40	32 *	Fe	2.5
Cr	Rh	K(a)	69.455	2.2910	50	60	LiF200	F	F	20	8	V, Ba	2.8
Cs	Cr	L(a)	91.830	2.8920	50	40	LiF200	F	F	40	40 *	-	1.0
Cu	Rh	K(a)	45.075	1.5418	70	40	LiF200	F	FS	20	10	-	0.8
Ga	Rh	K(a)	38.995	1.3414	75	40	LiF200	F	FS	20	20 *	-	1.3
La	Rh	L(a)	138.905	2.6657	50	60	LiF220	F	F	80	80	-	4.0
Ni	Rh	K(a)	48.730	1.6592	70	40	LiF200	F	FS	16	8	-	1.7
Nb	Rh	K(a)	30.440	0.7476	75	40	LiF220	F	S	20	16 *	-	1.2
Pb	Rh	L(b)	40.465	0.9829	75	40	LiF220	F	S	20	20 *	-	1.5
Rb	Rh	K(a)	38.025	0.9269	75	40	LiF220	F	S	20	16 *	-	0.7
Sc	Cr	K(a)	97.775	3.0320	40	70	LiF200	F	F	40	40	-	1.0
Sc	Rh	K(a)	97.775	3.0320	40	70	LiF200	F	F	80	80	-	1.0
Sr	Rh	K(a)	35.885	0.8766	75	40	LiF220	F	S	20	16 *	-	0.9
S	Rh	K(a)	75.900	5.3731	40	70	PE	C	F	20	10	-	3.5
Sn	Rh	K(a)	19.860	0.4921	75	40	LiF220	F	S	40	40 *	-	2.0
V	Rh	K(a)	123.335	2.5048	40	70	LiF220	F	F	20	10	Ti	1.9
W	Rh	L(a)	62.530	1.4764	50	60	LiF220	F	FS	50	50	Zn	1.6
Y	Rh	K(a)	33.920	0.8302	75	40	LiF220	F	S	20	16 *	Rb	1.2
Zn	Rh	K(a)	60.600	1.4364	75	40	LiF220	F	FS	20	10	-	3.0
Zr	Rh	K(b)	28.585	0.7017	75	40	LiF220	F	S	40	40 *	Mo	3.10

Notes

line: (a) = alpha line, (b) = beta line.
coll. C = coarse, F = fine.
det. F = Gas flow proportional counter, S = scintillation counter.
ct(peak) : normal counting time on the peak position (seconds).
ct(bkd.) : normal total counting time on the background.
* Background sloping - usually measured on both sides of the peak.

X-ray tube: side window 3kW Rhodium or side window 2kW Chromium (specified in list).
Spectrometer: Philips PW 1400 with a 3kW 100kV generator.

Appendix B. XRF operating conditions.

The ZAF-4/FLS software deconvolutes overlapping X-ray peaks and subtracts a background radiation by reference to a previously obtained library of standard peak profiles. X-ray intensities are automatically ZAF corrected using a procedure based on the TIM1 program of Duncumb and Jones (1969).

The machine is calibrated for Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P, Co, Ni, Zr and Ba.

Up to 14 elements, including oxygen, can be analyzed simultaneously.

b) WDS; C.A.M.E.C.A. CAMEBAX.

This was used for the analyses of opaque minerals and is a mechanical device which detects elements individually diffracted from a crystal with a known lattice spacing. It has a detection limit of approximately 0.002 Wt% and detects elements from Ba to U. The machine is fitted with two wavelength dispersive spectrometers and a Link Systems 860-500 EDS system. ZAF-4/FLS software is used for the manually operated EDS and software called "SPECTA" for automated EDS or EDS+WDS analysis.

<u>Operating conditions</u>

15 kV accelerating potential.

40° take-off angle.

3nA beam current for EDS analysis.

14.5nA beam current for EDS+WDS analysis.

The ZAF correction is the same as for the Geoscan machine.

The machine can be operated in a variety of modes including both the use of EDS and WDS analysis together with the option for either manual or automated operation.

Recalculation of Fe^{2+}/Fe^{3+} proportions

The recalculation referred to in Chapter 7.3.2 is based on the following assumptions:

a) The microprobe analysis includes all the elements present.

b) Fe is the only element with a variable valence state.

c) Oxygen is the only anion present.

d) Stoichiometry and charge balance is maintained.

An oxide/silicate can be considered to comprise a number of cations M, and a number of oxygens N. If all the Fe* is assumed to be present as Fe^{2+}, a mineral analysis calculated on the basis of N oxygens would result in a total of M′ cations (where M′ > M, the expected number of cations). Assuming there is an excess, this is because too much Fe as Fe^{2+} (rather than Fe^{3+}) has been combined with the oxygen. The proportion of Fe^{2+} and Fe^{3+} can therefore be recalculated relative the true number of cations, M. The number of oxygens and the number of cations for the recalculation of the various minerals were provided by the Geology Department at Manchester University.

Overlapping relationship between Ti and V

Carmichael (1967) stated that the error in the estimation of V in Ti-bearing minerals is severe due to the near coincidence of the Ti $k\beta$ line with the V $k\alpha$ line. Sufficient separation between these two lines was achieved by using a different analyzing crystal. The use of PET as the analyzing crystal caused a significant overlap between the two peaks when the Ti and V standards were analyzed. The use of the V kβ line to measure the V concentration was also ruled out as this overlaps with the Cr kα line. Whilst the overlap between the V kβ and Ti kα could be corrected for by the use of a simple linear regression: $V = -28.74\ TiO_2 + V^*$ it was found that by using LiF as the analyzing crystal the overlap between the two lines could be avoided.

C. Non-hierarchical K-means clustering

This Appendix is divided into two parts; a summary of the operation of the algorithm described in Chapter 5.2.2. and a simple 3-group, 2-dimensional example.

Summary of K-means clustering algorithm

Non-hierarchical techniques are partitioning methods where objects are classified into a specific number of mutually exclusive groups or clusters. Their iterative nature is their main advantage over hierarchical methods with reallocation of objects between clusters being possible. The data are repartitioned until a stable solution is achieved.

The technique used here consists of the following basic steps:

1) Select number of clusters (k) required;
2) Choose maximum number of iterations (preset at 4);
3) Select variables to be used;
4) Read in all data (held in sequential scratch file);
5) Standardize data;
6) Start K-means procedure;
   a) Take k samples from the entire data set and re-insert these so as they are the first samples in the data set. These become the cluster nuclei around which the remaining samples are grouped.
   b) Allocate each of the remaining samples to the cluster with the nearest centroid (using the squared euclidean distance). The seed point remains fixed for a full cycle through the

entire data set.

c) Compute a new centroid value for each of the k groups.

d) Alternate steps c) and d) until a full cycle through the data set fails to cause any change in cluster membership, or until the maximum number of iterations is reached.

7) Print cluster group details to screen or file.

<u>Selection of initial seed points</u>

These may be generated in a number of ways:

1) Choose first k data units;

2) Subjectively choose any k samples;

3) Select k samples at random;

4) Generate k synthetic points;

5) If working with some "a priori" knowledge, seed the data with k extra samples;

6) Choose a set of seed points which span the data set, that is, most data units are relatively close to a seed point but the seed points are well separated from each other.

<u>How many clusters</u>

In normal operation the number of clusters must be specified <u>a priori</u>, it may however be determined as part of the clustering technique. This may be achieved by setting the number of clusters (k) to 2,3,4,etc and then interpreting some measure of "goodness of fit". The sum of the distances between each unknown and its corresponding cluster centroid is used for this purpose. The result may be shown in graph form;

```
                      Y-axis...Summed deviation about centroids
     I---------I---------I---------I---------I---------I---------I
2.00 I                                                        +
3.00 I                                     +
4.00 I                           +
5.00 I                         +
6.00 I                      +
7.00 I                     +
     I---------I---------I---------I---------I---------I---------I
X-axis...No of clusters
```

In this instance, a significant break of slope can be seen at k=4, therefore k is set equal to 4 and K-means repeated.

```
Convergent non-hierachical K-means method of cluster analysis
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Simple 3 group, 2-dimensional example.
Files read for clustering operation;
SYO:SEED.RAW     (File containing seed centroids)
SYO:NAS118.RAW
SYO:NAS120.RAW
SYO:NAS121.RAW

Variables used;
V
ZR

V            Mean .... 119.62       Std devn ....  39.95
ZR           Mean .... 230.75       Std devn ....  96.93

No of clusters.....   3
No of samples......  64
No of variables....   2

                                           V          ZR
Cluster 1 stdzd centroid values;         0.24      -1.06
Sum of stdzd values in cluster 1;        0.24      -1.06
Cluster 2 stdzd centroid values;        -1.19       1.55
Sum of stdzd values in cluster 2;       -1.19       1.55
Cluster 3 stdzd centroid values;         1.52      -0.67
Sum of stdzd values in cluster 3;        1.52      -0.67

*** Sample no  4 ***
Distance from cluster 1 .....      0.25
Distance from cluster 2 .....      6.25
Distance from cluster 3 .....      2.73
S-26       in cluster 1
*** Sample no  5 ***
Distance from cluster 1 .....      0.58
Distance from cluster 2 .....     12.69
Distance from cluster 3 .....      0.70
S-30       in cluster 1
*** Sample no  6 ***
Distance from cluster 1 .....      0.08
Distance from cluster 2 .....      9.72
Distance from cluster 3 .....      1.18
S-31       in cluster 1

*** Sample no 60 ***
Distance from cluster 1 .....      0.83
Distance from cluster 2 .....      5.99
Distance from cluster 3 .....      1.22
S-120      in cluster 1
*** Sample no 61 ***
Distance from cluster 1 .....      0.90
Distance from cluster 2 .....      7.94
Distance from cluster 3 .....      0.51
S-121      in cluster 3
*** Sample no 62 ***
Distance from cluster 1 .....      0.97
Distance from cluster 2 .....      8.73
Distance from cluster 3 .....      0.33
S-122      in cluster 3
*** Sample no 63 ***
Distance from cluster 1 .....      1.44
Distance from cluster 2 .....     11.10
Distance from cluster 3 .....      0.03
S-124      in cluster 3
*** Sample no 64 ***
Distance from cluster 1 .....      1.76
Distance from cluster 2 .....     11.20
Distance from cluster 3 .....      0.03
S-125      in cluster 3
                                           V          ZR
Sum of stdzd values in cluster 1;        1.71     -18.32
Sum of stdzd values in cluster 2;      -24.58      26.27
Sum of stdzd values in cluster 3;       22.87      -7.95
```

```
No of samples in cluster 1 .....  24                          V         ZR
Stdzd centroid values after iteration no  1 ..              0.07      [illegible]

No of samples in cluster 2 .....  19                          V         ZR
Stdzd centroid values after iteration no  1 ..             -1.29      1.38

No of samples in cluster 3 .....  21                          V         ZR
Stdzd centroid values after iteration no  1 ..              1.09     -0.38


~~~~~~~~~~~~~ Iteration no 2 ~~~~~~~~~~~~~~~~~~

S-30       moved from cluster 3 to cluster 1
S-35       moved from cluster 3 to cluster 1
S-36       moved from cluster 3 to cluster 1
S-120      moved from cluster 3 to cluster 1

                                          V        ZR
Sum of stdzd values in cluster 1;      -1.05    -15.70
Sum of stdzd values in cluster 2;     -24.58     26.27
Sum of stdzd values in cluster 3;      25.62    -10.57


No of samples in cluster 1 .....  20                          V         ZR
Stdzd centroid values after iteration no  2 ..             -0.05     -0.78

No of samples in cluster 2 .....  19                          V         ZR
Stdzd centroid values after iteration no  2 ..             -1.29      1.38

No of samples in cluster 3 .....  25                          V         ZR
Stdzd centroid values after iteration no  2 ..              1.02     -0.42


No of alterations made from last iteration ...   4


~~~~~~~~~~~~~ Iteration no 3 ~~~~~~~~~~~~~~~~~~
                                          V        ZR
Sum of stdzd values in cluster 1;      -1.05    -15.70
Sum of stdzd values in cluster 2;     -24.58     26.27
Sum of stdzd values in cluster 3;      25.62    -10.57


No of samples in cluster 1 .....  20                          V         ZR
Stdzd centroid values after iteration no  3 ..             -0.05     -0.78

No of samples in cluster 2 .....  19                          V         ZR
Stdzd centroid values after iteration no  3 ..             -1.29      1.38

No of samples in cluster 3 .....  25                          V         ZR
Stdzd centroid values after iteration no  3 ..              1.02     -0.42


No of alterations made from last iteration ...   0

  3 iterations required for convergence
Summed deviation about seed points =   0.16784773E+02

                -:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-
                -:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-:-


Cluster 1 contains 20 data units
Centroid coordinates
  0.1175E+03  0.1547E+03
Membership list;
Seed point (if used); S-29       GA
S-26      S-31      S-32      S-33      S-34      S-40      S-41
S-42      S-43      S-44      S-45      S-46      S-47      S-48
S-49      S-50      S-87      S-88      S-89


Cluster 2 contains 19 data units
Centroid coordinates
  0.6795E+02  0.3648E+03
Membership list;
Seed point (if used); S-77       SE
S-76      S-80      S-81      S-82      S-83      S-84      S-85
S-86      S-90      S-91      S-94      S-95      S-96      S-97
S-98      S-99      S-91      S-100


Cluster 3 contains 25 data units
Centroid coordinates
  0.1606E+03  0.1898E+03
Membership list;
Seed point (if used); S-104      LL
S-30      S-35      S-36      S-39      S-101     S-105     S-106
S-107     S-108     S-109     S-110     S-111     S-112     S-113
S-114     S-116     S-117     S-118     S-119     S-120     S-121
S-122     S-124     S-125
```

Orientation survey data

This Appendix includes the details of all the analyses which were carried out as part of the initial orientation survey. In order to assist in the location of the data an index of the names of the various data files is provided. This approach and the structure described below is used for all subsequent Appendices containing data taken from RAW-files.

The data described are sub-divided into two parts; the analyses of the rock chips and of the soil samples. The data for individual samples is presented in such a way as to correspond to the traverse line RAW-files which were referred to in the main text of this work. These files were converted into neat listings by a program TAB which was was written by Dr.P.K.Harvey.

All the data shown in the next 4 Appendices were obtained by XRFS at the Geology Department at Nottingham University. In this and subsequent Appendices, all oxide data is expressed in weight percent (Wt%) whilst all trace element data is expressed in parts per million (ppm). Where no analysis for a particular element was carried out the characters "n.a" appear. When no sample could be taken along a fixed spacing traverse a "null" sample is inserted in its place to signify the missing sample.

Rock samples

Traverse line	Sample numbers	Location	No.of samples
NAS103.	R73-93.	St.Keverne Quarry. (U.Landewednack schist)	(22)
NAS104.	R104-118.	W.of England Quarry. (U.gabbro)	(15)
NAS105.	R119-140.	Coverack beach. (L.gabbro)	(22)
NAS106.	R144-165.	Black Head. (Harzburgitic peridotite)	(22)
NAS107.	R170-190.	Lizard lighthouse. (L.Landewednack schist)	(21)
NAS108.	R194-211.	Porthkerris Cove. (U.Landewednack schist)	(18)
NAS109.	R215-239.	Kennack Sands. (Kennack gneiss)	(25)

NAS111.	R268-288.	Kynance Cove. (Lherzolitic peridotite)	(21)
NAS114.	R322-343.	Lizard Point. (Mica schist granulite)	(22)
NAS115.	R362-383.	S.of Coverack. (Harzburgitic peridotite)	(22)
NAS116.	R395-417.	Dean Quarry. (U.gabbro)	(23)

Soil samples

Traverse line	Sample numbers	Location	No.of samples
NAS117.	S1-25.	Near St.Keverne Quarry. (U.Landewednack schist)	(24)
NAS118.	S26-50.	Near West of England Quarries. (U.gabbro)	(21)
NAS119.	S51-74.	N.of Coverack. (L.gabbro)	(21)
NAS120.	S76-99.	Black Head. (Harzburgitic peridotite)	(16)
NAS121.	S101-125.	Lizard lighthouse. (L.Landewednack schist)	(21)
NAS122.	S126-150.	Near Porthkerris Cove. (U.Landewednack schist)	(20)
NAS123.	S151-175.	Thorny Cliff. (Ultrabasic/Kennack gneiss)	(25)
NAS125.	S206-230.	Kynance Cove. (Lherzolitic peridotite)	(21)
NAS127.	S258-280.	Lizard Pt. (Mica schist granulite)	(18)
NAS128.	S305-326.	S.of Coverack. (Harzburgitic peridotite)	(18)
NAS129.	S347-371.	Near Dean Quarry. (U.gabbro)	(21)
NAS135.	S281-331.	Crousa Down/Common. (Crousa gravels)	(21)
NAS136.	S332-346.	Goonhilly Down. (Traverse incl.loess sheet)	(15)
NAS137.	S474-502.	Above Thorny Cliff. (Kennack gneiss)	(28)

	NAS103														
Var.\ID:	R-73	R-74	R-75	R-76	R-77	R-78	R-79	R-80	R-81	R-82	R-83	R-84	R-85	R-86	R-87
SIO2	44.76	45.53	47.23	44.44	44.52	44.26	46.31	48.65	44.11	42.72	42.47	42.61	38.71	38.68	37.66
AL2O3	13.40	12.32	13.90	12.68	11.78	12.98	14.49	15.34	13.08	13.99	13.39	14.14	11.26	11.81	10.41
TIO2	2.01	1.88	1.71	2.44	3.14	2.53	2.70	1.41	3.36	3.14	2.58	2.77	2.61	3.01	3.34
FE2O3	13.07	14.89	11.96	14.71	16.10	14.57	14.65	12.14	14.19	15.23	16.61	20.22	16.93	16.92	17.40
MGO	9.11	10.50	8.24	8.56	8.47	7.95	6.09	7.31	6.76	6.57	7.05	6.42	7.70	6.88	7.10
CAO	10.01	9.14	8.69	9.68	10.35	9.61	8.33	6.96	8.87	8.75	8.79	6.66	10.94	11.99	13.27
NA2O	2.02	1.50	2.23	1.78	1.64	1.96	2.05	2.41	2.54	2.45	1.52	0.97	0.94	0.67	0.00
K2O	0.26	0.50	0.90	0.81	0.74	0.73	1.10	1.64	0.61	0.57	0.12	0.07	0.00	0.00	0.00
MNO	0.21	0.19	0.16	0.19	0.19	0.19	0.15	0.13	0.20	0.20	0.23	0.19	0.29	0.28	0.28
P2O5	0.46	0.34	0.27	0.20	0.18	0.26	0.46	0.31	0.36	0.44	0.96	0.97	1.47	1.76	1.93
BA	80	39	51	35	48	35	38	133	56	36	71	46	46	38	58
CE	31	10	2	42	2	3	8	22	16	10	22	24	28	32	35
CO	48	48	49	56	65	52	46	42	55	51	39	44	37	39	39
CR	107	173	141	125	131	122	88	90	118	50	35	42	46	44	69
CS	4	6	12	13	9	12	22	14	11	8	6	14	0	1	5
CU	36	81	90	96	128	92	119	31	36	55	51	33	41	50	60
GA	17	17	18	18	18	19	16	18	17	19	20	18	17	20	17
LA	16	0	1	6	2	4	13	1	5	9	4	8	12	14	13
NI	87	107	79	76	81	64	67	69	30	25	25	17	23	14	32
NB	6	5	4	3	4	5	7	5	4	4	2	2	3	2	3
PB	17	11	8	6	8	6	9	5	5	11	4	4	3	7	6
RB	7	15	30	26	22	22	39	37	14	15	8	11	4	11	14
SC	38	41	45	53	62	49	53	34	44	40	36	45	39	35	45
SR	213	130	188	167	138	192	174	196	199	250	228	127	196	226	218
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	195	199	224	396	493	359	268	158	333	310	144	167	95	109	152
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	32	29	28	21	26	26	48	23	21	21	29	29	38	39	62
ZN	123	109	76	103	112	94	91	72	96	97	120	135	137	133	152
ZR	119	95	168	64	76	99	115	74	77	67	82	53	64	66	71

						NAS103	NAS104								
Var.\ID:	R-88	R-89	R-90	R-91	R-92	R-93	R-104	R-105	R-106	R-107	R-108	R-109	R-110	R-111	R-112
SIO2	43.56	44.65	40.94	43.61	41.12	42.83	48.79	50.74	47.26	48.55	48.97	46.74	50.16	49.15	46.79
AL2O3	12.78	11.54	12.99	12.45	12.47	13.07	15.26	13.33	12.75	13.88	13.34	12.90	13.68	12.91	12.47
TIO2	2.15	1.62	3.09	2.03	2.69	2.19	0.65	1.17	1.57	1.48	1.66	1.39	1.23	2.13	2.49
FE2O3	14.57	13.51	16.83	15.78	18.04	16.52	7.36	8.80	10.20	9.96	10.21	9.27	9.52	10.32	12.18
MGO	7.69	10.39	5.66	9.02	6.45	6.34	10.35	10.99	8.74	8.76	7.09	8.41	9.53	7.88	7.41
CAO	12.07	12.48	11.34	11.19	10.48	9.82	9.04	7.11	9.78	9.66	8.83	9.43	8.98	8.95	9.73
NA2O	1.23	1.37	1.25	0.97	0.81	1.11	2.65	2.44	3.13	3.01	3.62	3.19	2.86	2.95	2.38
K2O	0.60	0.35	0.19	0.06	0.47	0.63	0.52	1.42	0.38	0.53	0.39	0.31	0.53	0.47	0.29
MNO	0.24	0.25	0.26	0.28	0.27	0.25	0.12	0.14	0.17	0.17	0.18	0.16	0.15	0.17	0.18
P2O5	0.84	0.42	1.36	0.98	1.48	1.26	0.15	0.18	0.35	0.23	0.34	0.29	0.21	0.30	0.54
BA	56	68	76	56	76	60	51	96	14	3	6	69	90	39	21
CE	11	25	35	43	27	16	0	21	39	0	33	15	4	4	20
CO	37	40	30	38	26	39	34	42	37	39	29	31	37	36	38
CR	154	213	43	139	46	90	458	189	215	132	82	243	288	81	322
CS	10	8	7	3	16	25	10	28	12	9	2	4	12	6	5
CU	30	14	76	22	51	31	10	22	27	26	12	22	5	6	8
GA	17	15	21	17	19	23	12	17	17	16	22	16	17	19	20
LA	10	12	24	5	9	13	0	2	3	8	6	6	6	3	5
NI	50	86	25	42	17	29	150	116	102	102	58	108	146	80	80
NB	2	7	3	3	4	2	3	4	4	4	5	2	4	6	6
PB	8	7	13	7	12	6	7	8	3	7	5	0	10	6	13
RB	26	7	14	10	25	31	17	42	11	15	11	7	14	11	14
SC	46	49	40	39	41	42	26	41	40	38	39	37	33	42	41
SR	305	250	261	276	220	261	260	180	203	247	228	162	200	265	219
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	166	165	92	93	110	114	99	165	188	185	192	168	148	227	377
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	32	34	45	40	45	38	16	41	42	35	53	42	42	41	64
ZN	143	134	133	129	142	154	71	160	59	60	55	53	81	84	82
ZR	60	86	62	68	52	73	82	108	146	132	279	105	223	148	598

	NAS104/cont.					NAS104	NAS105								
Var.\ID:	R-113	R-114	R-115	R-116	R-117	R-118	R-119	R-120	R-121	R-122	R-123	R-124	R-125	R-126	R-127
SIO2	47.09	49.23	50.42	40.05	44.12	46.96	52.00	49.95	48.97	49.71	48.30	48.90	49.43	48.84	49.48
AL2O3	13.15	16.84	16.88	9.86	12.63	14.78	13.96	14.59	12.75	15.37	14.32	14.44	14.89	15.17	15.18
TIO2	1.74	0.41	0.44	1.22	3.23	0.76	0.60	0.55	0.64	0.49	0.61	0.46	0.47	0.57	0.44
FE2O3	10.50	5.75	5.46	9.27	10.77	6.90	5.93	7.31	7.19	6.95	6.76	7.28	6.46	6.40	6.38
MGO	9.76	9.53	9.80	12.07	7.22	10.11	9.38	10.28	11.52	10.21	10.11	11.31	10.03	9.82	9.64
CAO	9.73	10.61	10.39	18.78	10.52	12.32	11.82	12.07	11.09	9.49	10.52	9.74	11.66	10.32	10.00
NA2O	2.58	2.18	2.41	1.83	2.35	2.32	2.87	2.44	2.38	2.89	2.63	2.60	2.54	2.94	2.91
K2O	0.23	0.84	0.58	0.69	0.63	0.57	0.24	0.14	0.20	0.27	0.19	0.29	0.22	0.33	0.26
MNO	0.16	0.10	0.10	0.21	0.16	0.14	0.12	0.12	0.14	0.12	0.12	0.12	0.12	0.12	0.11
P2O5	0.19	0.08	0.09	0.07	0.32	0.10	0.00	0.00	0.03	0.07	0.07	0.06	0.02	0.07	0.06
BA	8	57	57	59	23	42	21	30	29	19	33	26	10	26	15
CE	0	0	0	3	24	0	23	43	5	29	0	16	0	2	14
CO	47	25	30	33	44	33	34	29	34	30	31	38	27	36	21
CR	306	530	624	309	330	388	568	438	435	331	363	560	623	489	444
CS	2	22	13	4	14	22	0	0	1	1	2	1	0	1	4
CU	45	27	23	27	19	11	44	32	72	59	38	33	46	46	44
GA	17	13	12	12	18	14	14	14	11	14	14	12	13	13	14
LA	7	8	4	5	2	3	3	0	2	1	0	0	6	0	0
NI	148	152	157	118	131	155	134	161	160	152	144	189	148	132	135
NB	3	0	1	4	7	2	2	1	2	1	3	0	1	2	1
PB	7	9	7	4	3	5	5	7	6	7	4	4	1	7	4
RB	6	24	16	13	14	16	3	3	2	5	3	6	5	7	7
SC	37	24	28	33	43	30	47	41	43	34	37	37	38	37	38
SR	177	250	255	165	178	202	233	180	206	251	229	233	218	258	236
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	247	75	79	156	278	108	132	115	127	105	106	95	110	110	109
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	26	7	8	29	33	14	13	13	15	11	10	11	12	11	9
ZN	66	53	46	53	50	35	38	39	39	37	37	36	31	31	36
ZR	123	32	46	98	152	63	40	40	38	38	38	31	32	36	28

													NAS105	NAS106	
Var.\ID:	R-128	R-129	R-130	R-131	R-132	R-133	R-134	R-135	R-136	R-137	R-138	R-139	R-140	R-144	R-145
SIO2	49.25	50.28	49.00	49.27	49.05	48.78	48.00	48.59	47.81	47.83	48.81	49.26	48.19	42.04	41.46
AL2O3	13.87	16.42	15.06	14.20	14.91	14.42	13.43	14.24	13.26	13.21	14.35	17.76	13.17	1.22	1.69
TIO2	0.58	0.47	0.48	0.61	0.53	0.45	0.50	0.48	0.60	0.61	0.66	0.46	0.65	0.04	0.05
FE2O3	6.67	5.98	6.57	6.39	6.29	6.38	6.75	7.32	6.64	7.01	6.39	4.36	7.08	8.45	8.28
MGO	10.49	8.36	9.57	9.63	9.58	10.89	11.22	11.65	10.97	11.34	9.90	6.93	11.30	40.90	37.84
CAO	10.27	10.08	10.17	11.28	10.34	10.08	10.01	8.30	10.83	10.11	12.63	13.57	10.90	0.64	1.16
NA2O	2.88	3.32	2.84	2.87	3.03	2.81	2.71	2.97	2.62	2.78	2.42	2.62	2.58	0.08	0.14
K2O	0.23	0.22	0.19	0.21	0.25	0.32	0.43	0.47	0.30	0.36	0.20	0.25	0.28	0.05	0.09
MNO	0.13	0.10	0.12	0.12	0.12	0.11	0.13	0.13	0.14	0.14	0.12	0.08	0.14	0.13	0.14
P2O5	0.06	0.07	0.06	0.05	0.07	0.05	0.06	0.10	0.06	0.08	0.03	0.03	0.05	0.04	0.07
BA	23	16	17	44	19	29	19	22	39	29	27	35	39	12	18
CE	1	6	4	25	0	2	19	31	17	11	0	0	10	17	0
CO	36	28	33	30	31	30	34	39	32	35	29	13	35	102	101
CR	436	392	424	542	439	362	396	494	510	593	606	261	971	2078	2316
CS	0	2	1	1	2	2	5	3	1	1	0	5	1	0	3
CU	57	38	51	42	41	10	44	33	53	47	37	12	28	12	13
GA	14	16	14	12	13	12	13	14	15	13	14	13	13	2	2
LA	3	4	7	10	3	0	4	3	4	6	4	6	10	0	3
NI	145	119	142	140	136	159	156	184	142	155	142	109	162	2108	1988
NB	1	1	1	1	1	1	0	0	1	1	3	2	1	1	2
PB	7	6	7	7	8	6	9	3	3	1	2	2	4	7	10
RB	3	3	4	1	5	8	10	11	6	5	6	7	8	0	0
SC	42	33	35	44	38	39	39	32	42	44	40	28	45	13	16
SR	236	266	233	230	236	248	224	287	213	236	257	754	250	2	4
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	120	97	98	124	111	101	111	90	116	124	113	69	128	34	45
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	12	10	11	12	11	11	11	10	12	16	14	9	13	3	1
ZN	37	34	36	47	41	28	38	40	34	34	27	12	32	53	90
ZR	39	35	33	46	38	31	33	31	33	36	43	29	38	15	15

	NAS106/cont.														
Var.\ID:	R-146	R-147	R-148	R-149	R-150	R-151	R-152	R-153	R-154	R-155	R-156	R-157	R-158	R-159	R-160
SIO2	41.47	41.38	42.09	41.12	42.24	42.07	42.82	42.26	43.72	42.04	42.03	41.82	42.48	42.01	40.91
AL2O3	1.66	1.36	1.85	1.65	1.51	1.24	1.03	1.27	1.12	1.54	1.37	1.21	1.60	1.34	1.52
TIO2	0.05	0.05	0.06	0.05	0.05	0.05	0.04	0.05	0.06	0.05	0.04	0.04	0.06	0.04	0.04
FE2O3	8.23	8.46	8.11	8.14	8.98	8.38	8.46	8.51	8.35	8.17	8.49	8.65	9.13	8.36	8.23
MGO	37.76	38.89	36.84	37.84	38.68	38.92	39.40	38.74	38.64	39.10	39.16	39.66	38.55	39.66	38.36
CAO	1.18	0.89	1.72	0.93	1.00	0.75	0.62	1.00	0.94	1.23	0.86	0.34	1.29	0.79	0.84
NA2O	0.13	0.09	0.07	0.19	0.10	0.15	0.09	0.11	0.07	0.12	0.08	0.14	0.07	0.07	0.17
K2O	0.09	0.07	0.09	0.10	0.07	0.09	0.09	0.08	0.10	0.07	0.07	0.08	0.07	0.07	0.09
MNO	0.14	0.13	0.15	0.14	0.15	0.14	0.15	0.14	0.16	0.14	0.13	0.14	0.14	0.13	0.14
P2O5	0.07	0.06	0.06	0.08	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.04	0.05	0.07
BA	2	11	3	0	10	12	9	19	19	3	1	7	10	6	1
CE	2	18	6	10	10	9	10	11	0	7	11	11	4	0	13
CO	99	104	98	99	101	104	106	104	104	102	108	107	103	104	100
CR	2414	2137	2586	2210	2171	2288	2317	2364	2674	2339	2135	2248	1995	2180	2121
CS	2	2	1	0	0	0	1	0	0	1	2	0	2	0	0
CU	9	19	26	18	16	19	18	13	18	23	17	14	24	14	9
GA	1	2	4	2	2	1	2	1	2	2	1	1	1	2	2
LA	13	8	1	2	5	4	5	2	7	14	7	10	2	0	7
NI	2011	2088	1938	1997	2017	2074	2250	2148	2231	2019	2081	2148	2003	2071	2041
NB	1	1	1	1	1	1	1	1	0	1	0	1	2	1	1
PB	5	9	19	11	7	18	11	8	6	8	7	12	7	4	5
RB	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SC	15	14	16	14	16	14	14	15	15	16	14	15	17	14	14
SR	4	3	2	3	3	4	4	2	6	3	3	3	5	4	3
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	40	36	47	41	46	39	35	39	41	44	38	35	43	39	38
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	3	0	2	2	1	1	1	2	1	0	2	2	2	2	0
ZN	64	66	94	65	152	174	194	109	132	79	63	119	67	45	49
ZR	13	14	12	14	15	9	11	12	16	14	13	10	11	10	15

					NAS106	NAS107									
Var.\ID:	R-161	R-162	R-163	R-164	R-165	R-170	R-171	R-172	R-173	R-174	R-175	R-176	R-177	R-178	R-179
SIO2	41.22	41.89	41.26	40.08	40.72	43.42	42.65	42.46	43.80	43.00	42.66	42.46	42.08	42.86	43.30
AL2O3	1.38	1.30	1.74	1.61	1.63	11.27	10.95	11.13	11.71	12.11	12.05	11.95	11.05	11.22	11.46
TIO2	0.03	0.04	0.05	0.05	0.05	2.60	2.60	2.83	2.53	3.42	3.17	3.32	3.31	3.04	2.61
FE2O3	8.29	8.54	8.51	8.92	8.40	13.51	13.02	13.91	12.49	15.09	15.51	15.15	14.76	14.13	13.28
MGO	38.90	39.09	37.97	37.32	37.56	9.13	9.07	9.36	9.25	7.15	7.83	7.57	7.81	8.35	8.71
CAO	0.50	0.79	1.18	0.62	0.94	10.19	11.18	9.09	9.46	10.29	9.74	10.66	9.78	10.06	10.27
NA2O	0.15	0.07	0.16	0.19	0.12	2.44	2.26	2.30	2.64	2.25	1.87	1.87	2.39	2.53	2.50
K2O	0.09	0.08	0.08	0.11	0.10	0.49	0.36	0.56	0.48	0.39	0.56	0.51	0.36	0.58	0.56
MNO	0.14	0.14	0.13	0.15	0.15	0.23	0.24	0.24	0.25	0.25	0.22	0.24	0.25	0.24	0.22
P2O5	0.07	0.06	0.06	0.10	0.09	0.44	0.42	0.49	0.47	0.59	0.55	0.55	0.58	0.49	0.44
BA	23	5	13	5	9	36	18	36	33	23	25	26	34	33	51
CE	4	10	2	0	0	28	37	26	20	36	33	31	20	31	32
CO	96	99	102	104	105	43	46	45	47	50	43	46	49	50	46
CR	2172	2135	2318	2168	2212	256	212	263	237	172	215	123	137	190	238
CS	1	0	2	0	0	0	0	0	0	1	0	0	2	0	0
CU	5	16	16	7	15	78	51	86	68	61	75	70	63	43	45
GA	1	1	2	1	1	19	19	18	18	21	20	24	21	20	19
LA	5	3	5	7	0	16	9	9	17	16	8	26	14	14	9
NI	2132	2062	2025	2071	2083	80	72	74	86	53	68	51	46	60	70
NB	2	0	1	0	1	6	5	8	5	10	7	7	8	6	5
PB	9	7	9	6	13	7	9	12	30	10	11	8	13	15	19
RB	0	0	0	0	0	10	5	8	6	10	16	11	7	10	10
SC	13	15	15	16	15	48	44	50	45	49	49	45	47	52	48
SR	2	4	5	4	4	222	274	185	230	188	163	253	149	215	228
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	36	37	42	42	47	261	259	259	253	295	295	308	299	314	268
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	0	1	2	1	1	41	45	48	42	55	57	56	60	53	47
ZN	58	74	58	72	153	109	100	117	113	149	150	125	144	133	105
ZR	9	16	15	14	15	167	172	189	166	237	234	241	254	196	186

	NAS107/cont.										NAS107	NAS108			
Var.\ID:	R-180	R-181	R-182	R-183	R-184	R-185	R-186	R-187	R-188	R-189	R-190	R-194	R-195	R-196	R-197
SI02	43.32	43.40	44.51	45.09	44.78	44.72	44.30	45.60	43.63	44.92	43.55	43.90	42.08	37.42	49.91
AL203	11.64	11.99	12.52	11.87	12.47	11.71	10.40	12.62	11.60	12.44	11.25	12.74	11.39	10.96	12.84
TI02	2.45	2.38	2.20	1.96	1.81	2.12	2.34	1.81	2.49	2.10	2.50	2.48	3.34	4.48	1.61
FE203	13.48	13.57	12.48	12.52	12.02	12.22	12.50	11.64	13.98	12.41	13.49	14.40	15.35	15.85	13.10
MGO	9.29	8.85	9.29	9.57	9.37	9.34	9.74	9.04	9.07	8.32	8.94	8.07	8.80	5.66	9.50
CAO	10.70	12.10	10.07	10.40	10.02	10.42	12.27	10.26	10.36	10.11	10.21	10.06	10.85	17.71	7.29
NA20	2.17	2.05	2.57	2.60	2.26	2.62	2.22	2.70	2.51	2.93	2.48	2.11	1.59	0.00	2.39
K20	0.47	0.51	0.64	0.62	0.79	0.75	0.48	0.67	0.55	0.70	0.55	0.45	0.43	0.26	1.67
MNO	0.22	0.20	0.22	0.21	0.20	0.24	0.25	0.21	0.24	0.21	0.25	0.21	0.22	0.19	0.22
P205	0.40	0.36	0.37	0.29	0.30	0.34	0.33	0.31	0.38	0.34	0.40	0.45	0.37	0.49	0.27
BA	37	32	51	55	51	99	47	71	52	50	56	96	20	0	99
CE	34	14	11	13	1	30	14	19	20	17	14	26	31	33	0
CO	47	44	47	45	50	47	46	44	53	43	42	37	44	31	47
CR	278	219	244	225	266	235	231	225	157	232	194	120	171	120	139
CS	0	0	0	1	0	0	1	0	0	0	0	7	1	1	11
CU	44	104	40	38	62	45	43	29	61	52	39	57	43	37	109
GA	16	23	18	16	19	17	14	16	20	18	16	20	17	21	17
LA	13	13	5	12	11	3	20	3	11	0	15	18	18	5	8
NI	104	62	81	76	101	80	69	56	58	70	64	50	65	30	59
NB	5	5	5	5	4	5	4	5	7	4	5	5	3	4	3
PB	21	12	4	9	6	13	4	5	9	9	6	22	7	14	3
RB	11	16	12	11	18	16	10	10	9	11	12	13	9	16	30
SC	47	49	46	45	40	47	46	45	50	47	51	46	48	46	48
SR	253	305	254	229	242	260	156	280	225	250	208	340	147	527	166
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	256	287	238	234	197	236	243	217	285	236	284	236	288	361	253
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	42	41	37	35	33	36	39	33	46	39	41	49	31	32	32
ZN	96	92	96	87	87	87	87	80	98	91	99	103	88	83	103
ZR	159	155	148	126	124	141	168	122	157	137	166	240	80	71	96

														NAS108	NAS109
Var.\ID:	R-198	R-199	R-200	R-201	R-202	R-203	R-204	R-205	R-206	R-207	R-208	R-209	R-210	R-211	R-215
SI02	51.24	51.19	56.07	48.34	50.46	50.72	52.92	43.18	38.43	42.51	42.82	34.83	45.87	37.15	64.41
AL203	15.44	15.29	14.71	14.36	15.53	13.02	14.73	13.07	12.77	12.62	13.31	10.91	14.41	10.54	13.92
TI02	1.67	1.84	1.71	1.93	1.68	2.00	1.72	3.79	6.24	3.24	3.78	6.96	1.85	5.83	1.10
FE203	12.38	11.21	10.76	12.16	11.82	12.09	10.84	14.33	17.71	13.85	15.51	19.23	10.39	17.28	6.03
MGO	6.13	5.69	6.20	8.14	6.44	6.32	3.87	5.64	3.58	7.41	6.81	4.97	7.91	7.28	3.25
CAO	4.28	5.24	3.59	7.18	6.49	6.88	3.92	10.99	10.23	11.08	9.77	11.31	9.80	12.28	3.03
NA20	2.70	2.32	1.92	2.55	2.64	3.16	3.99	2.44	2.23	2.12	2.17	1.17	2.74	1.05	3.49
K20	1.37	1.83	4.14	1.00	1.75	1.31	1.48	0.37	0.39	0.33	0.58	0.44	0.32	0.53	3.25
MNO	0.14	0.14	0.13	0.20	0.15	0.19	0.12	0.20	0.22	0.20	0.21	0.25	0.16	0.28	0.08
P205	0.34	0.34	0.34	0.35	0.31	0.47	0.43	0.37	0.38	0.19	0.25	0.43	0.15	0.36	0.28
BA	310	265	135	95	266	55	68	43	39	48	46	21	47	47	609
CE	34	50	29	24	42	47	27	14	21	40	10	20	12	10	21
CO	32	32	34	39	37	35	25	49	59	43	56	61	33	56	12
CR	127	127	116	127	136	119	46	114	80	95	179	90	237	86	37
CS	12	4	8	5	9	6	6	1	0	1	0	0	3	0	5
CU	48	66	40	61	77	27	74	48	95	41	96	81	38	96	36
GA	18	21	19	19	20	16	17	19	18	19	17	20	16	19	17
LA	24	25	12	13	8	25	11	16	18	9	0	0	8	11	11
NI	60	54	50	61	65	34	26	45	69	45	89	79	85	43	21
NB	8	9	6	6	5	4	8	4	3	2	2	2	1	4	8
PB	5	8	11	4	8	6	11	5	4	5	8	8	3	8	24
RB	46	43	39	26	36	18	16	7	6	8	12	7	7	13	88
SC	37	40	40	45	39	43	35	51	54	58	51	57	43	56	19
SR	189	191	147	224	209	187	164	208	152	217	155	174	300	304	259
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	157	180	160	191	179	182	126	339	491	332	408	567	205	545	73
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	35	42	34	39	36	44	46	29	14	16	16	18	12	17	24
ZN	76	89	169	163	110	128	80	82	101	86	139	147	66	105	58
ZR	146	160	165	149	138	173	312	100	52	44	47	69	34	73	163

NAS109/cont.

Var.\ID:	R-216	R-217	R-218	R-219	R-220	R-221	R-222	R-223	R-224	R-225	R-226	R-227	R-228	R-229	R-230
SIO2	60.08	51.38	71.50	58.79	60.11	67.07	48.75	60.19	70.41	51.36	63.60	56.23	52.80	57.07	58.90
AL2O3	13.82	13.34	15.27	13.71	14.13	16.36	14.32	14.37	16.44	13.39	15.39	14.20	13.79	13.62	15.72
TIO2	1.18	1.98	0.44	1.25	1.15	0.42	1.37	0.72	0.34	1.14	0.53	1.46	1.20	1.30	1.10
FE2O3	6.05	9.90	2.52	6.76	5.85	2.82	8.83	4.77	1.90	7.61	3.35	6.67	7.11	6.36	6.24
MGO	4.47	7.48	1.35	4.94	5.65	0.37	9.81	5.44	0.99	11.21	4.77	6.43	8.62	5.43	8.24
CAO	2.99	5.84	1.27	4.45	3.46	3.07	8.45	3.22	0.94	5.94	1.72	3.16	5.96	4.13	1.80
NA2O	4.01	3.52	3.97	3.54	3.80	4.77	2.42	4.15	4.78	2.81	4.60	3.99	2.98	3.32	2.71
K2O	2.46	2.16	5.18	2.51	3.34	2.10	1.87	2.61	4.67	2.46	3.17	2.19	2.72	2.53	4.96
MNO	0.11	0.16	0.04	0.11	0.11	0.05	0.14	0.09	0.03	0.12	0.05	0.10	0.14	0.12	0.06
P2O5	0.33	0.48	0.25	0.30	0.34	0.19	0.28	0.23	0.17	0.25	0.23	0.40	0.28	0.37	0.35
BA	359	173	872	296	451	258	171	373	927	307	437	265	303	478	236
CE	22	27	45	42	28	7	21	48	46	30	37	52	27	61	18
CO	18	32	7	23	21	6	37	15	3	37	8	21	29	21	22
CR	37	53	20	68	88	38	215	128	21	262	52	127	194	71	142
CS	5	1	0	1	2	5	7	2	1	2	89	4	1	6	2
CU	20	38	12	25	54	5	118	45	14	63	16	49	29	29	9
GA	18	18	14	16	17	18	13	15	16	17	16	18	16	18	16
LA	20	21	17	19	18	10	9	16	23	17	24	28	2	23	10
NI	23	40	12	35	44	28	107	52	18	96	29	68	84	34	94
NB	10	10	6	7	8	3	2	4	6	4	4	7	3	6	7
PB	23	12	30	33	80	15	4	41	20	9	22	10	10	16	10
RB	82	87	128	82	95	57	87	89	108	97	88	64	114	82	106
SC	21	35	6	22	21	4	36	16	3	31	8	21	28	20	25
SR	272	283	277	288	253	472	341	351	397	375	262	305	363	372	123
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	81	143	24	94	78	24	123	60	20	116	41	87	111	96	80
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	23	39	14	22	26	8	29	16	15	26	12	30	25	28	27
ZN	58	89	34	61	74	27	67	47	28	114	45	37	60	50	86
ZR	168	226	161	157	166	149	129	114	163	107	132	180	120	188	153

									NAS109	NAS111					
Var.\ID:	R-231	R-232	R-233	R-234	R-235	R-236	R-237	R-238	R-239	R-268	R-269	R-270	R-271	R-272	R-273
SIO2	58.45	48.48	71.51	61.05	54.34	60.56	61.60	54.09	62.97	43.34	43.39	45.64	45.07	42.17	42.52
AL2O3	14.66	15.02	14.95	14.44	13.82	15.68	14.39	13.67	14.10	2.33	2.23	2.89	2.82	2.24	2.34
TIO2	1.08	2.18	0.25	0.75	1.53	0.94	0.74	1.07	0.52	0.09	0.12	0.14	0.13	0.10	0.11
FE2O3	6.10	9.52	1.44	4.56	8.13	4.73	4.08	6.61	3.05	9.46	9.81	11.43	10.07	8.91	8.72
MGO	9.02	15.53	1.21	4.88	7.88	6.00	3.16	6.94	5.04	38.14	37.40	34.94	36.19	38.47	37.28
CAO	2.19	1.95	0.68	2.35	4.09	1.70	2.41	4.45	1.88	1.39	1.94	2.41	2.29	1.36	1.83
NA2O	2.93	1.20	4.43	4.66	2.84	3.99	4.05	3.49	4.12	0.15	0.15	0.17	0.21	0.13	0.19
K2O	3.96	4.60	4.70	2.37	3.14	3.72	2.57	2.18	2.97	0.03	0.06	0.04	0.03	0.05	0.07
MNO	0.06	0.09	0.03	0.08	0.10	0.05	0.07	0.12	0.05	0.13	0.15	0.16	0.14	0.14	0.15
P2O5	0.32	0.44	0.14	0.24	0.38	0.31	0.33	0.28	0.22	0.03	0.02	0.00	0.00	0.05	0.05
BA	424	336	839	172	287	599	289	343	638	10	0	18	13	11	16
CE	31	28	42	38	59	25	22	13	43	13	20	9	9	5	0
CO	21	64	0	16	25	11	12	23	11	108	118	123	121	106	103
CR	160	504	17	75	157	66	43	145	81	2166	2423	3120	2970	2066	2238
CS	0	9	2	4	4	4	4	9	5	1	0	0	0	1	0
CU	12	27	6	38	51	7	6	27	5	6	8	20	13	9	2
GA	18	25	15	15	17	19	17	14	17	3	3	5	2	1	3
LA	23	11	21	16	22	6	17	15	29	0	0	4	4	0	0
NI	55	248	19	38	77	46	28	75	74	2223	2242	2729	2475	2032	1996
NB	6	7	4	4	9	7	4	4	7	1	1	0	1	0	0
PB	18	5	25	7	29	326	15	28	19	10	8	21	13	7	11
RB	100	144	98	73	104	114	94	87	85	1	1	0	1	0	0
SC	24	38	3	16	31	17	7	22	10	16	18	23	20	15	17
SR	213	156	331	322	305	321	322	348	426	7	11	12	11	3	7
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	78	147	20	60	118	69	45	82	33	48	51	66	56	50	47
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	26	15	13	21	34	24	17	22	12	2	3	3	3	3	3
ZN	127	308	20	49	127	71	41	79	34	51	58	131	74	59	80
ZR	169	128	127	125	169	165	207	135	114	15	9	15	13	15	12

	NAS111/cont.														NAS111
Var.\ID:	R-274	R-275	R-276	R-277	R-278	R-279	R-280	R-281	R-282	R-283	R-284	R-285	R-286	R-287	R-288
SIO2	41.86	42.72	44.61	43.05	44.25	41.94	42.20	44.57	42.20	42.43	42.00	41.59	41.23	41.65	41.01
AL2O3	2.38	2.48	2.79	1.75	2.05	2.04	2.19	2.38	2.34	2.13	1.95	2.07	2.33	2.05	2.29
TIO2	0.13	0.10	0.12	0.07	0.11	0.09	0.11	0.13	0.10	0.11	0.09	0.09	0.10	0.09	0.09
FE2O3	8.25	8.81	13.33	8.48	11.58	9.00	8.24	10.47	8.73	8.85	8.75	9.04	8.20	8.66	8.06
MGO	35.34	38.59	37.87	39.28	36.41	38.14	35.95	36.20	38.20	37.47	38.47	36.75	36.61	37.77	36.94
CAO	2.56	1.64	0.80	0.99	1.48	1.71	2.07	2.27	1.53	1.70	1.17	1.27	1.58	1.45	1.56
NA2O	0.21	0.14	0.09	0.11	0.22	0.12	0.16	0.14	0.08	0.13	0.12	0.20	0.18	0.13	0.18
K2O	0.13	0.03	0.00	0.06	0.07	0.06	0.10	0.07	0.04	0.06	0.06	0.09	0.09	0.06	0.08
MNO	0.16	0.13	0.15	0.13	0.16	0.14	0.15	0.18	0.13	0.14	0.14	0.14	0.14	0.14	0.14
P2O5	0.06	0.03	0.00	0.04	0.02	0.05	0.06	0.02	0.05	0.04	0.06	0.07	0.08	0.06	0.08
BA	12	17	22	20	26	11	0	24	3	6	11	18	7	12	3
CE	21	0	6	35	18	4	7	27	21	8	4	17	2	1	22
CO	100	100	113	103	115	109	108	130	100	101	104	104	101	102	100
CR	2275	2233	2541	2483	2287	2116	2382	2727	1915	2321	2275	1969	2190	2134	2079
CS	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1
CU	44	5	12	21	33	14	10	7	6	42	28	4	17	12	5
GA	2	4	5	3	3	2	2	3	3	2	2	1	3	2	1
LA	5	2	0	7	0	0	5	0	6	0	0	6	0	6	0
NI	1937	2041	3520	2248	2917	2130	2179	2593	2010	2088	2041	2263	2042	2132	1945
NB	1	1	1	1	0	2	1	0	1	0	1	0	0	1	1
PB	4	10	37	17	21	5	16	20	13	6	9	11	10	4	6
RB	0	1	0	0	3	0	0	1	0	0	0	0	1	0	1
SC	18	16	21	12	18	14	17	19	17	18	17	15	16	14	15
SR	9	5	15	4	12	3	7	10	4	3	4	5	3	3	2
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	54	48	63	39	56	47	44	59	42	53	44	47	46	40	43
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	4	4	4	4	4	3	3	4	4	4	2	4	4	2	4
ZN	62	59	159	79	243	51	105	121	51	53	55	54	53	50	51
ZR	13	14	12	14	15	12	13	14	12	9	11	11	13	13	12

	NAS114														
Var.\ID:	R-322	R-323	R-324	R-325	R-326	R-327	R-328	R-329	R-330	R-331	R-332	R-333	R-334	R-335	R-336
SIO2	45.21	46.13	47.16	47.38	46.78	46.46	71.56	57.46	56.02	53.77	48.56	46.92	50.91	53.76	49.75
AL2O3	11.46	11.85	11.37	12.41	10.98	10.49	10.51	12.19	14.32	12.84	11.06	12.21	14.18	14.04	16.20
TIO2	1.76	1.57	1.64	1.34	1.82	1.78	0.26	0.85	0.81	0.74	1.66	1.71	1.21	1.43	1.52
FE2O3	12.85	12.60	11.98	11.11	13.13	12.88	5.20	8.92	8.59	10.19	11.81	12.93	11.72	9.14	9.70
MGO	10.82	10.57	10.25	10.58	10.83	10.44	2.50	5.96	6.01	8.08	10.33	9.70	7.65	5.67	6.31
CAO	10.67	11.84	10.56	11.28	11.77	13.97	4.70	7.15	5.11	10.47	10.51	11.57	11.56	8.29	8.55
NA2O	2.36	1.82	2.45	2.32	1.21	1.10	2.88	2.82	4.15	1.26	2.24	2.16	0.69	2.37	2.56
K2O	0.32	0.34	0.31	0.41	0.19	0.37	0.20	0.28	0.27	0.16	0.72	0.36	1.48	0.87	0.69
MNO	0.23	0.24	0.23	0.23	0.25	0.24	0.12	0.19	0.19	0.20	0.22	0.22	0.19	0.18	0.18
P2O5	0.22	0.18	0.17	0.21	0.19	0.14	0.00	0.12	0.20	0.12	0.17	0.19	0.14	0.24	0.28
BA	54	57	27	98	21	15	55	84	96	67	26	53	146	128	78
CE	23	19	39	21	42	13	11	23	28	16	37	21	32	30	73
CO	45	49	44	42	50	42	9	23	20	33	52	39	35	24	33
CR	153	270	147	166	112	117	61	101	66	70	127	216	313	155	144
CS	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0
CU	68	38	57	21	60	52	36	70	69	73	63	53	83	80	69
GA	16	18	16	17	16	19	9	14	18	17	14	17	18	17	22
LA	13	7	0	9	3	0	0	6	3	11	0	0	4	13	25
NI	69	100	71	59	54	54	19	30	21	29	53	64	81	51	55
NB	3	2	3	4	3	2	2	2	2	2	3	2	2	7	11
PB	23	5	10	9	8	15	9	17	34	15	20	9	16	11	8
RB	9	8	8	9	8	8	1	7	4	7	15	10	27	18	19
SC	54	47	49	48	50	49	17	30	37	35	51	51	45	34	34
SR	222	223	222	346	255	287	165	255	292	347	214	223	510	412	476
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	248	246	213	208	241	231	44	129	121	137	220	240	158	151	149
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	32	32	32	29	33	37	25	24	27	22	32	36	31	29	34
ZN	140	123	123	137	124	126	45	89	139	93	144	128	88	68	86
ZR	105	88	103	89	112	114	66	78	90	83	100	100	130	150	157

	NAS114/cont.						NAS114	NAS115							
Var.\ID:	R-337	R-338	R-339	R-340	R-341	R-342	R-343	R-362	R-363	R-364	R-365	R-366	R-367	R-368	R-369
SIO2	51.29	46.40	51.04	53.14	49.79	50.44	54.64	43.28	44.67	42.31	41.87	41.80	42.66	43.94	41.67
AL2O3	12.63	11.64	14.53	15.27	11.94	14.71	16.58	1.96	0.88	1.98	1.25	1.86	3.65	1.54	1.21
TIO2	1.40	1.66	1.45	1.42	1.81	1.73	1.45	0.06	0.08	0.01	0.07	0.05	0.29	0.06	0.04
FE2O3	11.30	12.02	11.85	9.82	10.58	10.94	8.78	8.71	7.65	9.53	7.32	8.59	8.65	9.46	8.15
MGO	8.26	11.78	7.95	6.70	10.10	8.57	4.52	38.57	37.83	40.83	38.41	37.67	36.09	37.23	39.68
CAO	11.26	12.18	8.03	5.70	10.73	8.98	4.56	0.97	2.02	0.52	0.64	1.12	1.59	0.92	0.70
NA2O	0.96	1.34	2.14	1.87	1.23	1.22	2.11	0.15	0.20	0.18	0.21	0.22	0.32	0.16	0.09
K2O	0.36	0.59	1.08	1.35	0.89	0.97	1.73	0.05	0.22	0.01	0.16	0.08	0.08	0.12	0.08
MNO	0.22	0.26	0.19	0.19	0.29	0.25	0.14	0.12	0.23	0.12	0.18	0.14	0.16	0.16	0.14
P2O5	0.26	0.18	0.26	0.33	0.26	0.29	0.35	0.03	0.06	0.03	0.10	0.05	0.10	0.04	0.06
BA	93	54	134	272	77	144	473	0	17	2	14	4	28	4	0
CE	15	22	46	46	31	37	45	10	4	0	27	31	3	23	2
CO	31	52	34	31	38	35	21	95	111	106	98	102	93	113	103
CR	150	197	112	138	112	156	124	2162	2410	1459	2171	2230	2118	2433	2334
CS	1	0	0	1	1	1	4	0	0	2	1	2	0	1	1
CU	52	49	51	100	67	41	89	2	11	31	13	15	46	25	8
GA	18	17	18	21	18	19	18	1	2	0	1	1	4	2	1
LA	7	6	7	20	6	13	22	0	5	1	3	1	10	0	7
NI	56	76	47	55	50	53	42	1996	2354	2178	2096	1986	1876	2884	2192
NB	3	3	3	9	4	7	10	1	1	1	0	1	0	1	1
PB	8	9	13	16	21	16	60	4	4	5	4	4	5	3	2
RB	18	19	23	42	24	33	45	0	0	1	0	0	1	0	1
SC	41	54	42	35	48	46	33	14	19	6	16	15	21	16	14
SR	298	284	241	235	266	299	207	4	11	4	6	7	17	11	3
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	167	221	200	152	212	199	138	42	49	18	42	41	60	46	36
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	43	31	36	28	36	37	31	2	5	1	3	4	7	2	2
ZN	104	214	130	123	156	151	120	43	48	45	43	42	67	73	46
ZR	126	99	120	152	136	123	208	13	10	9	14	15	25	11	11

														NAS115	NAS116
Var.\ID:	R-370	R-371	R-372	R-373	R-374	R-375	R-376	R-377	R-378	R-379	R-380	R-381	R-382	R-383	R-395
SIO2	43.35	39.92	41.54	41.78	42.10	42.58	43.67	42.69	42.45	42.34	42.17	43.62	42.33	41.84	44.99
AL2O3	1.58	0.34	1.06	0.79	1.74	1.90	1.48	1.61	1.78	1.53	2.02	1.42	1.92	2.25	12.19
TIO2	0.07	0.03	0.07	0.05	0.05	0.22	0.07	0.06	0.10	0.05	0.06	0.10	0.05	0.06	2.17
FE2O3	9.99	15.00	10.60	12.35	8.29	8.86	7.87	7.95	7.93	7.72	9.46	9.25	9.14	8.55	11.41
MGO	36.64	40.14	38.76	39.03	37.50	36.98	37.28	38.06	37.46	37.64	35.59	36.43	37.97	36.45	11.82
CAO	0.84	0.00	0.72	0.44	1.21	1.60	2.05	1.22	1.25	1.18	1.22	1.43	0.94	1.58	10.19
NA2O	0.25	0.16	0.16	0.12	0.21	0.23	0.24	0.19	0.16	0.22	0.26	0.20	0.17	0.31	1.83
K2O	0.14	0.08	0.11	0.09	0.11	0.10	0.15	0.11	0.12	0.15	0.12	0.15	0.06	0.12	0.10
MNO	0.16	0.21	0.19	0.19	0.15	0.16	0.18	0.15	0.17	0.17	0.14	0.19	0.13	0.15	0.16
P2O5	0.05	0.05	0.06	0.05	0.06	0.07	0.04	0.06	0.08	0.08	0.06	0.06	0.05	0.07	0.36
BA	7	8	5	8	3	21	3	7	18	17	15	14	8	17	19
CE	18	9	11	0	22	32	21	0	18	15	23	8	0	0	0
CO	120	121	103	112	97	103	98	98	95	99	100	99	100	101	49
CR	2133	1356	2261	1920	2241	2200	2433	2354	1978	2135	2282	2224	2212	2169	213
CS	1	0	4	0	1	0	0	0	3	0	0	1	0	0	3
CU	16	56	15	35	21	16	9	20	33	17	23	41	21	25	78
GA	1	1	2	2	2	2	2	2	2	2	1	2	2	2	14
LA	3	0	0	0	2	0	1	3	2	5	2	0	0	0	6
NI	2679	1932	1990	2244	1977	2096	2013	2035	1947	1984	2121	1985	1989	1953	170
NB	1	2	1	0	0	1	1	0	1	1	1	1	1	0	5
PB	2	2	1	4	2	3	1	2	0	1	2	6	3	8	4
RB	0	1	0	1	0	1	1	1	0	0	0	1	0	1	5
SC	18	7	15	14	16	17	18	15	18	15	15	17	14	15	39
SR	7	4	4	4	6	9	14	16	6	7	6	12	6	45	258
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	44	16	37	36	45	52	45	43	46	41	44	45	40	43	225
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	2	0	2	3	2	5	2	2	4	4	4	5	3	3	28
ZN	52	67	67	64	41	45	47	41	42	39	44	46	40	45	62
ZR	13	12	12	14	14	16	12	14	13	12	12	16	12	18	76

Var.\ID:	NAS116/cont. R-396	R-397	R-398	R-399	R-400	R-401	R-402	R-403	R-404	R-405	R-406	R-407	R-408	R-409	R-410
SIO2	43.18	49.49	44.26	44.36	48.05	48.50	48.59	48.01	48.82	45.91	47.00	47.94	46.96	49.31	48.66
AL2O3	13.36	14.23	13.84	13.43	13.73	13.77	13.78	13.57	13.81	12.99	13.30	13.76	13.10	13.85	14.34
TIO2	2.99	0.82	1.98	2.91	0.94	1.06	0.89	0.92	0.96	1.50	1.25	1.12	1.29	0.87	1.10
FE2O3	11.20	7.39	9.48	9.60	8.02	8.29	7.88	8.09	8.06	9.40	8.99	8.56	8.97	7.81	8.04
MGO	6.56	9.68	10.08	7.85	10.91	10.93	10.98	11.41	11.07	10.63	11.35	11.09	11.21	11.10	10.18
CAO	12.29	11.82	13.85	13.46	9.91	10.19	10.04	9.97	10.04	10.67	10.30	10.36	10.23	10.48	10.47
NA2O	1.98	2.59	1.04	1.97	2.74	2.69	2.82	2.71	2.80	2.19	2.38	2.52	2.31	2.61	2.83
K2O	0.02	0.38	0.00	0.00	0.39	0.37	0.40	0.39	0.37	0.22	0.29	0.36	0.27	0.26	0.28
MNO	0.15	0.12	0.12	0.13	0.14	0.14	0.14	0.14	0.14	0.16	0.15	0.14	0.15	0.14	0.14
P2O5	0.63	0.12	0.37	0.50	0.16	0.17	0.14	0.17	0.15	0.38	0.27	0.22	0.29	0.10	0.10
BA	24	78	8	11	72	78	62	71	76	29	84	79	79	52	51
CE	23	24	21	22	12	29	8	0	11	28	9	8	21	10	8
CO	39	28	44	32	36	42	40	39	39	44	40	38	43	41	41
CR	107	396	188	155	201	210	190	191	188	257	323	291	260	266	237
CS	0	5	1	2	5	5	7	7	9	6	4	5	6	4	3
CU	37	70	19	26	57	51	48	49	53	71	52	38	53	53	55
GA	17	16	16	16	15	13	15	14	14	14	14	14	14	14	15
LA	4	5	6	15	7	4	8	10	8	3	0	13	1	17	19
NI	81	96	162	114	136	130	123	132	130	130	141	135	142	120	126
NB	7	2	7	8	3	4	4	4	3	3	4	5	5	3	3
PB	0	2	0	2	3	2	1	7	0	6	3	4	5	6	4
RB	6	6	5	5	8	9	9	9	8	9	7	9	8	7	9
SC	43	42	42	40	38	38	39	37	40	39	40	40	39	40	37
SR	346	325	323	454	278	262	265	269	264	220	236	256	244	247	240
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	356	178	264	294	145	142	135	139	142	196	180	147	161	138	129
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	38	21	33	34	18	19	18	18	17	27	27	20	25	16	14
ZN	58	36	26	33	54	55	48	55	50	60	57	59	58	43	40
ZR	82	60	119	229	65	60	57	63	65	64	69	72	68	47	60

Var.\ID:	R-411	R-412	R-413	R-414	R-415	R-416	NAS116 R-417
SIO2	48.56	48.35	47.97	47.86	48.08	48.86	45.79
AL2O3	13.89	13.61	13.49	13.55	13.84	13.48	12.90
TIO2	0.94	0.87	0.88	0.80	0.99	0.86	1.52
FE2O3	7.85	7.94	7.97	7.79	8.13	8.20	8.68
MGO	10.34	11.25	11.06	11.02	11.04	11.45	10.40
CAO	10.50	9.87	9.73	10.13	9.78	10.79	10.43
NA2O	2.71	2.67	2.64	2.66	2.79	2.57	2.53
K2O	0.29	0.40	0.40	0.36	0.44	0.21	0.28
MNO	0.14	0.14	0.14	0.15	0.14	0.14	0.15
P2O5	0.11	0.13	0.17	0.13	0.15	0.08	0.18
BA	54	73	53	68	82	48	8
CE	17	12	20	18	15	18	25
CO	39	38	47	40	42	42	39
CR	267	197	167	165	205	228	237
CS	4	6	6	3	6	3	1
CU	44	48	58	48	43	65	54
GA	14	13	13	15	14	13	13
LA	6	14	10	2	10	0	5
NI	108	129	121	120	138	137	127
NB	3	4	3	4	4	3	3
PB	6	0	2	0	0	3	0
RB	8	6	9	9	8	5	5
SC	39	40	40	38	37	40	41
SR	239	296	281	276	292	224	235
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	143	124	132	113	127	129	160
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	15	14	16	15	15	15	17
ZN	47	51	47	52	53	43	46
ZR	63	62	61	64	67	52	67

	NAS117														
Var.\ID:	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S-14	S-15
SIO2	53.59	55.59	60.60	63.93	57.42	63.14	55.25	56.16	55.13	54.69	54.76	55.16	53.64	54.81	53.88
AL2O3	15.36	14.33	14.75	15.68	15.61	16.10	18.73	15.02	15.29	14.88	14.50	15.30	17.48	15.66	15.51
TIO2	1.70	1.66	1.63	1.36	1.55	1.40	1.49	1.61	1.73	1.66	1.68	1.60	1.57	1.49	1.58
FE2O3	10.91	11.29	8.58	8.17	9.78	8.67	11.14	9.95	10.69	10.36	10.38	10.36	11.26	10.04	10.53
MGO	4.24	4.45	3.30	1.38	3.31	2.68	3.40	3.72	3.62	3.87	4.06	3.68	3.36	3.67	3.95
CAO	6.48	5.98	5.45	4.55	5.92	4.78	6.36	5.93	6.02	6.14	6.23	6.24	6.59	6.37	6.64
NA2O	0.30	0.27	0.43	0.47	0.29	1.08	0.66	0.31	0.30	0.19	0.06	0.16	0.57	0.18	0.12
K2O	1.06	1.18	1.45	1.63	1.21	1.55	1.02	1.18	1.15	1.11	1.12	1.10	1.13	1.14	1.10
MNO	0.21	0.22	0.21	0.13	0.19	0.16	0.15	0.19	0.20	0.20	0.21	0.19	0.17	0.18	0.19
P2O5	0.79	0.71	0.49	0.36	0.69	0.25	0.38	0.63	0.67	0.74	0.79	0.79	0.57	0.78	0.80
BA	188	203	234	310	210	302	172	198	199	207	209	202	174	207	192
CE	45	44	51	54	55	65	19	50	30	51	44	40	56	32	38
CO	35	34	23	21	32	29	36	31	31	29	29	34	32	30	36
CR	157	139	117	100	141	120	118	132	140	160	153	153	144	151	141
CS	3	1	3	2	1	5	6	3	3	3	1	4	3	5	3
CU	50	39	35	25	42	41	42	33	43	40	40	47	53	40	44
GA	16	16	14	13	14	15	16	15	16	17	15	14	17	16	15
LA	25	16	23	25	17	9	15	11	19	12	17	13	18	15	13
NI	62	59	41	38	54	47	78	59	58	58	57	64	69	61	66
NB	8	8	11	11	10	9	6	8	7	8	7	7	7	8	8
PB	32	24	17	17	19	10	13	24	21	25	24	26	17	22	20
RB	42	44	52	60	46	50	36	42	43	43	46	44	43	44	41
SC	31	28	25	20	25	27	28	27	29	29	30	30	29	28	29
SR	113	101	102	103	103	108	119	103	113	118	110	116	125	120	121
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	141	123	119	89	118	105	120	121	134	134	131	126	134	123	136
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	31	26	31	28	27	29	26	29	30	29	30	31	28	27	29
ZN	118	101	81	71	99	83	99	92	113	105	102	102	92	95	97
ZR	240	257	324	343	276	331	235	264	235	230	253	234	227	232	233

									NAS117	NAS118					
Var.\ID:	S-16	S-17	S-18	S-20	S-21	S-22	S-23	S-24	S-25	S-26	S-29	S-30	S-31	S-32	S-33
SIO2	59.86	64.43	58.96	55.53	57.78	54.03	53.92	54.08	53.58	55.75	55.74	54.26	55.92	55.30	53.62
AL2O3	14.75	14.69	15.30	15.96	14.33	17.62	14.93	14.98	14.57	23.58	23.47	24.22	23.02	22.70	19.85
TIO2	1.47	1.46	1.49	1.67	1.63	1.41	1.73	1.68	1.70	1.24	1.11	1.12	1.18	1.15	2.17
FE2O3	8.74	8.02	9.22	10.79	9.28	10.52	10.59	10.79	10.76	9.38	9.31	9.17	9.48	9.25	10.81
MGO	3.19	2.18	2.82	3.17	3.59	3.41	3.92	4.31	4.44	2.60	2.95	2.14	2.82	3.30	3.33
CAO	5.60	4.89	5.28	5.98	5.64	6.33	6.32	6.57	6.87	7.44	7.71	8.20	6.90	7.83	7.58
NA2O	0.20	0.43	0.36	0.52	0.37	0.41	0.12	0.03	0.00	0.39	0.38	0.69	0.49	0.47	0.72
K2O	1.37	1.63	1.41	1.22	1.27	1.16	1.10	1.23	1.04	0.51	0.51	0.37	0.65	0.47	0.62
MNO	0.19	0.17	0.17	0.17	0.20	0.17	0.20	0.21	0.22	0.13	0.13	0.11	0.12	0.13	0.16
P2O5	0.63	0.43	0.54	0.57	0.59	0.58	0.75	0.82	0.94	0.32	0.30	0.32	0.32	0.31	0.42
BA	302	331	236	193	213	260	199	193	202	143	143	128	140	150	103
CE	53	60	44	39	35	35	46	21	37	20	16	30	28	7	34
CO	27	23	28	29	25	36	29	33	31	37	37	37	37	38	40
CR	131	107	124	142	130	146	145	155	155	418	422	357	411	439	312
CS	0	0	4	2	0	3	0	5	2	8	8	6	15	9	4
CU	31	28	38	46	35	49	43	45	46	26	28	21	20	33	34
GA	15	15	15	16	14	15	17	15	17	15	15	17	16	17	16
LA	18	16	7	20	16	14	16	14	9	18	11	4	12	6	15
NI	48	41	56	58	48	76	55	61	61	154	171	176	160	167	143
NB	10	12	9	8	8	6	8	6	7	5	3	3	4	3	6
PB	18	21	26	15	22	14	23	30	29	13	8	4	10	65	17
RB	50	58	51	43	47	42	44	49	44	34	34	26	40	32	35
SC	23	21	24	28	26	27	30	32	31	36	35	32	39	37	44
SR	104	106	109	125	108	108	114	117	120	115	129	158	140	136	121
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	111	103	117	130	122	116	132	141	144	124	118	124	129	129	197
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	28	30	30	31	33	26	29	29	32	26	24	24	22	24	34
ZN	81	76	87	95	83	87	105	129	154	59	55	48	55	59	74
ZR	297	344	290	264	274	201	238	223	228	162	128	106	128	130	175

Var.\ID:	NAS118/cont. S-34	S-35	S-36	S-39	S-40	S-41	S-42	S-43	S-44	S-45	S-46	S-47	S-48	S-49	NAS118 S-50
SIO2	55.09	55.28	54.92	53.92	55.92	55.75	55.68	55.60	56.22	55.53	56.47	54.75	55.40	56.33	55.51
AL203	21.22	20.66	20.36	20.70	21.91	21.11	21.87	22.09	22.00	21.53	23.77	21.71	21.11	21.72	21.47
TIO2	1.68	1.56	1.70	1.32	1.34	1.63	1.37	1.44	1.26	1.44	1.18	1.90	1.92	1.33	1.66
FE203	10.58	9.89	10.35	10.15	10.31	9.83	9.56	9.60	9.32	8.97	9.42	9.79	9.77	9.10	9.66
MGO	3.22	3.51	3.50	4.23	3.44	3.24	3.33	2.88	2.99	3.08	2.34	2.44	2.86	3.19	3.03
CAO	7.02	7.20	7.41	7.41	6.82	7.10	7.24	7.31	7.13	7.25	7.12	7.30	7.18	7.26	7.49
NA20	0.61	0.79	0.65	1.20	0.60	0.59	0.48	0.51	0.54	0.69	0.47	0.57	0.61	0.56	0.64
K20	0.59	0.66	0.66	0.60	0.81	0.72	0.62	0.56	0.61	0.62	0.60	0.59	0.68	0.63	0.62
MNO	0.15	0.15	0.15	0.16	0.14	0.15	0.14	0.14	0.14	0.14	0.11	0.14	0.15	0.14	0.15
P205	0.37	0.34	0.34	0.35	0.31	0.34	0.32	0.32	0.32	0.34	0.30	0.38	0.36	0.32	0.34
BA	110	100	95	156	154	108	160	171	159	156	151	94	88	148	88
CE	64	30	11	16	33	27	30	42	42	41	27	21	21	27	28
CO	39	36	38	37	41	39	42	39	34	33	32	39	40	36	35
CR	312	364	343	190	399	370	435	400	365	378	427	360	372	385	355
CS	7	11	6	11	18	12	6	6	7	7	13	8	8	7	7
CU	35	25	26	17	27	24	27	26	26	23	26	31	29	26	27
GA	16	17	17	19	15	14	16	17	17	17	17	18	17	16	16
LA	11	1	11	7	11	17	9	7	16	4	0	9	7	7	9
NI	148	148	148	137	171	153	162	154	144	140	151	142	137	142	135
NB	6	6	8	4	6	6	6	5	6	6	3	6	7	6	6
PB	8	11	10	10	11	7	11	10	9	11	11	15	11	11	12
RB	35	36	36	32	48	39	37	33	34	31	36	33	33	35	30
SC	39	35	39	41	38	37	38	38	37	35	38	39	37	36	38
SR	127	145	145	192	121	118	115	122	122	124	116	118	111	132	127
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	155	146	162	166	142	151	134	141	135	135	118	168	165	135	162
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	28	28	29	31	24	26	24	25	25	26	26	27	28	26	28
ZN	66	61	66	56	59	57	58	57	57	61	56	64	67	61	59
ZR	170	174	176	126	150	175	153	153	163	177	142	162	183	185	157

Var.\ID:	NAS119 S-51	S-53	S-54	S-55	S-56	S-57	S-58	S-59	S-60	S-61	S-63	S-64	S-65	S-66	S-67
SIO2	62.32	71.29	70.59	68.74	65.31	68.36	67.73	67.43	73.20	64.26	59.80	71.92	71.46	73.17	68.42
AL203	15.74	13.83	13.95	13.51	13.79	13.45	14.21	14.34	14.02	14.77	15.89	12.67	12.76	13.69	14.56
TIO2	0.89	0.88	0.90	0.91	0.88	1.04	0.96	0.90	0.96	0.93	0.99	0.85	0.84	0.86	0.91
FE203	5.82	5.59	5.52	4.94	5.29	5.04	5.50	4.85	5.16	5.64	6.29	4.41	5.70	5.33	5.04
MGO	3.84	0.44	0.58	1.54	3.07	2.83	1.50	3.21	0.28	3.05	4.50	0.47	0.63	0.12	1.96
CAO	6.17	3.60	4.07	5.36	6.44	4.72	4.57	5.14	3.39	6.00	6.97	3.56	3.28	3.01	5.49
NA20	0.91	0.63	0.69	0.71	0.71	0.85	0.76	0.78	0.89	0.75	1.03	0.94	0.63	0.76	0.69
K20	1.08	1.69	1.78	1.51	1.33	1.48	1.58	1.40	1.85	1.15	0.91	1.49	1.78	1.87	1.48
MNO	0.14	0.06	0.06	0.08	0.12	0.13	0.08	0.14	0.07	0.12	0.14	0.06	0.06	0.05	0.10
P205	0.25	0.09	0.08	0.09	0.16	0.10	0.14	0.14	0.04	0.15	0.22	0.07	0.04	0.03	0.09
BA	193	306	311	261	240	265	273	247	314	226	192	271	296	337	275
CE	34	38	36	41	31	36	21	36	43	30	32	40	32	46	32
CO	24	10	9	12	21	20	17	26	12	22	31	7	12	11	16
CR	313	154	164	237	262	242	209	285	191	281	328	161	136	135	248
CS	0	1	0	0	0	3	0	3	5	5	1	1	3	4	0
CU	25	14	11	16	18	15	15	20	14	23	25	10	10	11	16
GA	12	11	11	10	10	11	11	9	11	11	12	10	9	9	10
LA	16	16	18	21	13	24	17	18	17	4	3	15	21	28	23
NI	128	61	59	90	121	86	78	98	57	106	124	57	49	45	93
NB	5	13	11	10	9	11	10	8	13	8	6	10	12	13	11
PB	16	17	17	19	18	15	17	16	14	20	13	15	19	17	17
RB	34	63	68	54	46	48	55	47	65	40	31	51	61	65	54
SC	25	11	12	15	18	19	16	20	13	22	27	14	11	11	16
SR	156	114	141	198	232	133	137	139	111	184	182	116	112	100	189
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	81	59	52	53	56	68	64	68	53	75	98	47	50	50	63
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	20	21	22	21	19	25	23	20	23	19	19	23	22	24	22
ZN	40	28	32	34	37	34	39	43	33	35	43	23	24	30	35
ZR	212	400	379	349	273	336	353	283	396	260	177	401	399	472	324

	NAS119/cont.					NAS119	NAS120								
Var.\ID:	S-68	S-69	S-70	S-72	S-73	S-74	S-76	S-77	S-80	S-81	S-82	S-83	S-84	S-85	S-86
SIO2	70.85	70.37	63.59	69.38	70.03	62.96	73.57	72.64	73.74	74.78	77.16	73.38	67.70	73.67	73.49
AL2O3	13.29	13.39	13.95	13.72	16.47	15.72	9.32	13.19	9.60	11.39	12.60	11.26	8.34	10.11	9.78
TIO2	1.12	0.89	0.96	0.93	0.88	0.96	0.89	0.83	0.82	0.89	0.90	0.83	0.89	0.87	0.89
FE2O3	4.56	5.32	5.62	5.69	6.51	6.15	6.61	6.07	4.58	6.05	4.95	6.51	7.82	5.66	6.08
MGO	1.59	1.67	4.34	1.17	0.00	4.28	3.93	1.61	4.09	0.34	0.00	1.37	7.42	2.72	3.88
CAO	4.41	3.90	5.71	4.18	3.32	6.05	2.38	2.45	2.43	2.02	2.13	2.15	2.64	2.17	2.41
NA2O	0.77	0.87	1.11	0.84	0.71	0.93	0.47	0.55	0.54	0.64	0.68	0.61	0.27	0.64	0.62
K2O	1.65	1.71	1.30	1.51	1.87	1.14	2.02	2.15	2.09	2.08	2.18	2.04	1.76	2.09	2.08
MNO	0.11	0.09	0.14	0.07	0.04	0.15	0.17	0.11	0.19	0.06	0.03	0.09	0.23	0.13	0.16
P2O5	0.08	0.06	0.11	0.07	0.06	0.16	0.06	0.06	0.06	0.02	0.00	0.04	0.13	0.04	0.04
BA	285	294	226	256	337	211	341	356	331	363	365	357	306	341	352
CE	30	29	27	23	42	25	73	50	49	47	41	37	43	53	52
CO	14	18	29	15	13	33	81	59	65	20	11	36	96	59	87
CR	191	171	282	185	138	307	1057	597	748	465	344	592	1958	780	1103
CS	1	2	2	6	7	4	2	6	3	5	3	5	6	2	2
CU	14	12	22	15	13	25	10	12	8	9	6	8	29	9	13
GA	9	10	12	12	11	12	8	10	8	9	9	8	10	9	8
LA	24	12	13	16	21	12	12	16	18	20	22	22	18	18	21
NI	73	63	101	58	47	120	193	224	213	104	86	133	695	223	317
NB	11	11	8	10	13	7	12	11	12	13	14	12	10	13	14
PB	17	15	12	17	19	15	33	22	22	19	15	23	41	24	17
RB	59	57	38	51	68	34	63	78	64	71	77	68	59	70	65
SC	15	14	24	18	16	30	9	14	7	7	7	8	15	9	12
SR	146	124	157	132	110	163	71	72	71	71	76	70	65	73	76
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	59	54	85	67	60	87	52	48	53	46	46	49	59	47	47
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	23	23	19	23	25	20	26	23	22	23	25	22	21	25	25
ZN	34	30	41	29	32	41	51	56	45	34	24	34	115	45	46
ZR	384	354	236	348	381	236	386	381	415	412	418	394	315	396	389

							NAS120	NAS121							
Var.\ID:	S-90	S-94	S-95	S-96	S-97	S-98	S-99	S-101	S-104	S-105	S-106	S-107	S-108	S-109	S-110
SIO2	62.33	75.61	72.43	74.60	74.97	70.31	76.04	50.67	48.15	50.30	50.42	48.61	49.52	49.19	50.06
AL2O3	7.34	10.24	12.24	10.40	10.72	8.58	10.38	12.98	14.08	13.09	12.95	12.97	12.75	13.10	12.97
TIO2	0.68	0.84	0.86	0.80	0.87	0.81	0.84	2.28	2.29	2.35	2.53	2.44	2.50	2.57	2.54
FE2O3	8.16	5.39	6.60	6.40	6.20	7.22	3.94	12.53	13.21	12.82	13.07	13.11	13.00	13.30	13.15
MGO	12.70	2.49	1.86	1.72	1.17	7.09	2.41	6.58	6.81	6.35	6.10	6.43	5.74	5.53	5.41
CAO	2.39	2.25	2.33	1.97	1.98	2.62	2.31	7.72	8.84	7.72	7.72	8.00	7.53	7.59	7.46
NA2O	0.35	0.66	0.60	0.74	0.75	0.43	0.73	1.00	1.75	1.17	1.21	1.39	1.13	1.07	0.99
K2O	1.63	2.05	2.11	1.98	2.12	2.00	2.20	1.09	0.82	1.09	1.08	1.03	1.05	1.04	1.12
MNO	0.23	0.12	0.11	0.09	0.09	0.27	0.15	0.22	0.21	0.22	0.22	0.22	0.21	0.22	0.21
P2O5	0.13	0.00	0.05	0.00	0.00	0.09	0.03	0.45	0.36	0.43	0.44	0.44	0.48	0.51	0.49
BA	272	352	355	341	360	326	348	106	63	107	116	86	108	110	117
CE	42	47	47	46	44	67	54	41	24	21	36	24	14	60	24
CO	111	52	54	24	35	129	50	51	41	41	44	41	48	41	41
CR	2128	1012	654	715	571	1431	556	355	292	334	329	307	310	315	346
CS	2	3	6	3	4	3	3	1	3	5	2	1	4	0	4
CU	10	9	10	6	7	12	6	70	65	66	67	75	66	71	63
GA	7	10	10	8	9	8	7	19	18	17	17	19	19	18	18
LA	19	19	17	19	19	23	18	21	17	13	4	11	18	14	9
NI	750	224	231	200	132	320	151	146	122	121	118	116	107	109	114
NB	8	13	13	12	12	10	13	7	5	6	7	6	7	5	8
PB	21	21	22	19	19	25	20	45	17	25	28	41	40	32	60
RB	48	65	76	65	69	58	70	32	23	32	33	27	31	31	35
SC	14	8	11	8	9	11	9	39	43	41	42	43	38	39	38
SR	58	73	73	71	72	64	76	162	180	163	161	155	158	159	152
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	60	47	50	41	46	57	40	213	235	229	233	233	224	220	222
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	17	23	23	22	23	20	23	36	37	37	38	41	37	38	37
ZN	92	44	47	42	37	57	40	124	120	121	126	133	120	119	124
ZR	265	389	387	396	414	358	457	188	166	195	205	198	205	209	210

	NAS121/cont.												NAS121	NAS122	
Var.\ID:	S-111	S-112	*-113	S-114	S-116	S-117	S-118	S-119	S-120	S-121	S-122	S-124	S-125	S-126	S-130
SIO2	50.47	48.25	48.43	49.81	48.72	50.60	50.66	50.30	51.18	51.03	50.70	49.33	50.54	58.02	56.41
AL2O3	12.84	13.75	13.17	13.56	13.67	12.84	12.92	12.82	13.48	12.96	13.12	13.11	13.26	22.52	16.85
TIO2	2.30	2.58	2.42	2.70	2.59	2.34	2.50	2.41	2.45	2.42	2.47	2.35	2.23	1.45	1.83
FE2O3	12.23	13.78	12.88	13.67	13.79	12.55	13.19	12.66	12.80	12.58	12.97	13.03	12.55	12.63	11.47
MGO	6.11	5.54	5.67	5.57	5.42	5.70	5.46	5.61	5.76	6.23	6.24	6.79	6.81	1.58	4.83
CAO	7.43	8.09	7.60	8.13	8.03	7.31	7.41	7.25	7.14	7.50	7.73	8.56	8.08	4.97	5.69
NA2O	0.94	1.29	0.91	1.16	1.19	0.90	0.99	1.07	1.09	1.17	1.14	1.24	1.22	0.13	0.74
K2O	1.13	1.02	1.21	0.99	1.04	1.17	1.15	1.10	1.18	1.10	1.10	0.95	1.08	1.84	2.12
MNO	0.21	0.21	0.21	0.22	0.21	0.21	0.21	0.21	0.20	0.22	0.22	0.22	0.22	0.14	0.21
P2O5	0.44	0.44	0.52	0.44	0.50	0.51	0.47	0.47	0.45	0.44	0.44	0.41	0.39	0.36	0.39
BA	114	96	196	83	98	116	129	125	124	96	90	90	104	219	163
CE	35	61	30	32	41	19	44	38	45	23	51	21	40	48	25
CO	49	49	61	43	39	47	43	46	45	56	47	49	51	29	41
CR	358	249	272	299	291	338	332	324	313	335	317	304	347	143	236
CS	1	3	5	3	3	4	4	3	2	3	5	1	2	8	11
CU	68	71	77	72	67	62	65	69	71	66	61	66	65	74	39
GA	18	17	19	19	19	18	18	20	18	18	19	18	18	21	16
LA	18	17	15	22	13	4	14	15	11	25	5	10	10	9	5
NI	139	95	110	106	102	126	118	127	128	131	113	112	134	70	91
NB	7	5	7	6	7	6	8	7	6	5	6	6	5	8	6
PB	113	45	218	48	48	70	30	50	44	38	21	22	34	19	19
RB	34	29	33	31	31	36	37	33	34	33	32	30	35	43	55
SC	38	40	39	41	40	39	39	39	37	40	40	44	41	37	37
SR	170	167	164	156	158	147	155	161	141	155	159	173	177	74	109
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	207	239	221	229	231	200	212	219	209	219	233	226	210	152	171
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	37	40	36	42	39	36	37	34	38	35	35	36	35	25	22
ZN	138	120	151	125	125	129	117	127	133	128	126	121	120	219	210
ZR	198	193	197	213	201	214	209	212	212	196	188	172	181	149	170

Var.\ID:	S-131	S-132	S-133	S-134	S-135	S-136	S-139	S-140	S-141	S-142	S-143	S-144	S-145	S-146	S-147
SIO2	53.01	52.43	56.11	60.19	53.17	37.52	59.11	57.71	57.99	56.19	54.33	56.63	58.05	55.74	56.51
AL2O3	16.54	16.13	15.31	15.91	17.86	15.85	15.85	15.62	15.26	15.76	18.04	16.00	15.69	14.69	15.25
TIO2	2.02	2.06	1.81	1.60	2.11	1.69	1.68	1.70	1.76	1.72	2.12	1.82	1.76	1.63	1.75
FE2O3	11.79	12.49	10.75	9.56	12.64	10.02	9.56	9.91	9.59	10.30	12.94	10.36	9.71	9.72	9.93
MGO	5.65	5.48	5.28	4.18	4.76	4.63	4.22	4.64	4.71	4.99	4.51	4.80	4.58	5.98	5.77
CAO	6.97	6.63	6.81	5.70	6.58	5.97	5.73	5.98	6.12	6.25	5.43	6.25	5.82	6.27	6.48
NA2O	1.19	1.07	0.00	0.55	0.74	0.63	0.55	0.65	0.53	0.55	1.00	0.72	0.60	0.46	0.58
K2O	1.26	1.29	1.42	1.73	1.35	1.60	1.67	1.59	1.61	1.50	1.96	1.53	1.69	1.53	1.63
MNO	0.25	0.23	0.23	0.21	0.21	0.21	0.22	0.22	0.24	0.23	0.20	0.23	0.23	0.25	0.26
P2O5	0.44	0.48	0.46	0.34	0.39	0.42	0.38	0.43	0.43	0.45	0.39	0.43	0.41	0.51	0.44
BA	154	163	173	211	166	205	220	223	206	209	204	182	189	203	180
CE	18	29	42	63	45	40	30	44	41	26	39	50	32	47	42
CO	40	41	35	35	43	35	32	31	33	37	40	38	38	37	38
CR	186	220	212	191	218	196	179	193	173	211	157	172	191	237	237
CS	4	8	4	4	0	1	0	0	0	0	3	0	0	5	1
CU	61	65	37	36	52	41	34	35	36	41	74	43	35	38	38
GA	19	16	16	15	18	17	17	16	16	17	18	18	16	16	16
LA	12	11	25	6	19	17	13	17	14	13	12	16	18	15	10
NI	90	108	102	82	76	84	72	86	67	92	73	75	83	108	97
NB	4	5	6	8	5	8	7	7	8	7	7	8	7	7	7
PB	16	20	21	18	25	18	19	21	19	18	12	19	20	21	20
RB	34	36	47	55	44	51	53	52	51	48	46	49	54	50	48
SC	40	40	34	31	42	31	30	30	30	31	39	32	31	31	33
SR	123	135	127	118	119	127	126	128	133	136	126	128	122	117	130
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	195	190	161	133	176	142	139	139	140	155	188	147	152	153	166
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	29	22	26	25	24	27	26	28	29	24	26	27	25	23	24
ZN	170	171	151	132	181	137	127	128	134	141	191	160	153	153	151
ZR	156	157	179	230	180	219	247	226	243	203	176	212	230	185	196

	NAS122/cont.		NAS122	NAS123											
Var.\ID:	S-148	S-149	S-150	S-151	*-152	S-153	S-154	S-155	S-156	S-157	S-158	S-159	S-160	S-161	S-162
SIO2	56.20	55.69	53.82	51.82	49.00	55.48	56.64	59.12	58.45	57.99	55.72	55.13	53.82	54.15	53.10
AL2O3	15.65	15.43	15.40	12.61	1.58	7.61	8.44	9.98	8.99	9.05	9.24	10.77	9.60	8.15	6.61
TIO2	1.73	1.76	1.71	2.10	0.36	0.88	0.95	0.98	0.97	0.99	1.03	1.27	1.18	0.94	0.79
FE2O3	10.09	10.49	10.72	10.21	10.98	8.41	9.36	8.93	8.29	8.64	8.89	8.73	9.11	8.72	9.20
MGO	5.22	5.68	6.04	8.04	36.52	17.16	14.64	11.16	12.44	12.52	14.36	11.62	13.95	15.83	20.39
CAO	6.54	7.04	6.99	5.09	1.47	3.44	3.44	3.58	3.73	3.64	3.94	4.02	4.14	3.66	3.55
NA2O	0.41	0.48	0.25	1.43	0.00	0.65	0.63	0.79	0.78	0.68	0.69	0.95	0.82	0.60	0.34
K2O	1.69	1.66	1.54	1.92	0.39	1.33	1.20	1.26	1.42	1.31	1.45	1.98	1.48	1.29	0.92
MNO	0.24	0.25	0.26	0.16	0.25	0.20	0.16	0.12	0.18	0.15	0.19	0.16	0.19	0.19	0.20
P2O5	0.46	0.41	0.64	0.43	0.08	0.18	0.16	0.11	0.16	0.18	0.22	0.28	0.26	0.26	0.18
BA	183	165	179	241	67	238	233	276	287	234	249	299	253	233	173
CE	22	33	36	63	39	33	42	37	38	29	46	40	46	26	32
CO	39	43	40	48	168	79	76	68	61	66	70	52	68	74	89
CR	237	246	256	525	3584	1735	1796	1697	1404	1605	1531	1140	1358	1621	1903
CS	3	5	8	13	3	10	13	18	20	13	9	10	8	5	6
CU	35	41	39	23	49	25	25	21	21	26	25	21	25	22	25
GA	17	18	16	19	5	11	11	13	12	12	11	14	12	11	9
LA	11	12	3	21	14	9	13	11	15	8	18	17	19	8	6
NI	98	104	111	347	2509	1066	1037	895	777	921	916	733	839	1016	1392
NB	6	6	6	9	1	5	6	6	6	5	7	6	5	4	4
PB	18	21	20	18	215	25	24	19	16	22	25	17	24	29	38
RB	52	48	51	65	17	53	50	52	56	52	55	72	60	50	38
SC	31	34	35	24	22	22	23	24	22	22	22	23	24	22	22
SR	128	141	124	298	55	169	159	173	189	156	163	172	182	151	126
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	162	171	177	119	51	72	66	74	70	80	72	80	81	64	65
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	24	24	23	29	5	16	18	18	20	16	14	20	17	17	11
ZN	160	160	159	105	568	103	103	91	80	95	92	98	96	104	95
ZR	193	180	164	249	50	141	153	174	179	165	154	173	157	138	117

													NAS123	NAS125	
Var.\ID:	S-163	S-164	S-165	S-166	S-167	S-168	S-169	S-170	S-171	S-172	S-173	S-174	S-175	S-206	S-207
SIO2	53.92	54.57	54.91	54.58	54.32	54.00	55.68	53.63	54.26	55.83	52.75	55.12	53.58	44.70	45.11
AL2O3	7.89	8.86	9.21	8.87	8.91	8.61	10.42	7.46	7.78	7.98	6.67	8.02	8.63	7.03	7.06
TIO2	0.91	1.02	1.01	1.00	1.11	0.98	0.99	0.85	0.93	0.90	0.81	0.94	1.06	0.45	0.84
FE2O3	9.12	9.54	8.68	9.18	9.01	9.26	7.19	8.81	8.90	8.86	9.43	8.79	8.80	10.49	12.07
MGO	17.27	14.62	14.13	14.81	13.97	15.16	10.84	17.31	15.73	15.24	20.56	15.11	15.27	30.53	25.01
CAO	3.66	4.04	4.19	3.98	3.99	4.02	3.74	3.78	3.93	3.81	3.68	3.76	4.38	2.09	3.76
NA2O	0.63	0.57	0.89	0.66	0.81	0.71	1.45	0.51	0.60	0.53	0.51	0.58	0.96	0.05	0.42
K2O	1.14	1.20	1.38	1.28	1.36	1.29	1.53	1.13	1.21	1.20	0.95	1.26	1.31	0.06	0.61
MNO	0.19	0.20	0.21	0.20	0.20	0.21	0.16	0.20	0.24	0.21	0.22	0.21	0.23	0.15	0.21
P2O5	0.22	0.24	0.25	0.24	0.27	0.26	0.28	0.27	0.26	0.24	0.16	0.26	0.25	0.14	0.19
BA	232	235	269	246	280	256	293	229	247	230	204	252	254	30	80
CE	36	26	30	29	30	7	34	30	24	40	38	30	38	20	0
CO	80	77	77	71	70	81	55	83	85	79	99	76	90	100	102
CR	1649	1620	1516	1618	1547	1709	1081	1828	1939	1864	2181	1719	1553	2128	1776
CS	6	9	11	9	6	8	8	9	10	10	8	12	8	5	9
CU	23	27	23	23	26	25	20	25	27	27	26	27	26	14	29
GA	11	10	11	12	13	11	14	10	11	10	11	10	13	6	9
LA	13	13	11	17	6	8	17	10	15	12	13	11	3	5	2
NI	1146	1107	944	1020	942	1023	627	1132	1005	1040	1250	1040	899	1541	1109
NB	5	5	6	4	6	6	5	5	5	6	5	6	6	1	2
PB	27	26	23	24	20	26	24	24	28	27	22	31	23	16	26
RB	47	49	56	54	58	54	55	45	48	47	38	51	50	4	19
SC	22	23	22	21	23	22	19	21	22	22	22	22	22	24	24
SR	160	164	201	189	197	187	273	149	165	155	163	171	191	33	75
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	68	70	73	74	77	76	64	70	71	77	69	66	92	54	76
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	14	17	18	15	17	17	15	16	15	18	14	16	18	5	13
ZN	99	110	102	118	104	103	78	104	97	103	89	103	92	179	168
ZR	141	153	151	149	160	158	154	139	158	158	129	153	148	46	79

	NAS125/cont.														
Var.\ID:	S-208	S-209	S-210	S-211	S-213	S-214	S-215	S-216	S-217	S-219	S-220	S-222	S-224	S-225	S-226
SIO2	44.61	43.99	46.30	44.50	49.84	53.11	50.13	47.59	52.53	59.93	49.39	50.97	48.76	49.29	51.17
AL2O3	6.58	4.03	6.09	6.37	8.55	8.38	6.11	6.06	7.00	7.49	4.91	6.45	6.15	6.75	6.51
TIO2	0.80	0.56	0.63	0.63	0.74	0.73	0.66	0.62	0.74	0.72	0.53	0.70	0.58	0.63	0.58
FE2O3	10.58	10.92	14.70	14.61	13.09	12.63	11.83	13.58	10.83	9.79	10.99	12.29	10.52	10.92	11.50
MGO	26.99	30.39	21.93	17.96	11.39	12.30	17.58	20.09	17.08	13.63	26.02	17.14	21.90	19.19	17.40
CAO	3.24	3.69	3.55	3.48	3.22	3.23	3.97	3.43	3.80	3.13	3.20	3.67	4.41	3.67	3.32
NA2O	0.20	0.02	0.22	0.24	0.50	0.55	0.35	0.26	0.49	0.51	0.21	0.45	0.36	0.36	0.46
K2O	0.37	0.26	0.76	0.76	1.04	1.16	1.02	0.82	1.20	1.28	0.64	1.00	0.68	0.90	0.92
MNO	0.20	0.28	0.29	0.26	0.15	0.18	0.32	0.26	0.28	0.19	0.31	0.28	0.25	0.23	0.19
P2O5	0.23	0.18	0.22	0.32	0.25	0.17	0.21	0.21	0.19	0.06	0.14	0.19	0.15	0.20	0.14
BA	85	82	141	138	186	201	149	148	191	232	125	178	117	187	139
CE	10	9	11	7	0	27	43	15	39	22	13	41	33	16	29
CO	98	135	152	117	84	79	153	134	111	95	157	129	124	96	93
CR	1634	3609	3213	2870	2665	3282	3176	3720	3173	2833	3434	3223	3523	2844	3388
CS	3	0	3	5	10	6	7	1	6	8	0	5	1	3	3
CU	22	13	20	12	15	17	20	16	17	15	17	15	10	21	12
GA	7	6	5	8	8	9	6	7	8	7	8	6	6	7	5
LA	11	4	6	0	10	6	5	0	10	8	15	13	4	15	6
NI	1137	1738	1452	820	698	937	1068	1058	820	892	1591	1205	1030	1215	1021
NB	2	0	4	4	6	7	5	5	6	7	3	6	3	5	4
PB	23	16	18	25	25	24	32	29	27	25	35	29	22	45	27
RB	11	7	22	22	30	38	28	25	36	36	17	28	22	26	27
SC	27	28	30	23	20	20	24	21	21	19	23	23	23	24	21
SR	55	37	67	59	66	80	63	59	68	72	49	69	54	80	64
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	58	79	78	80	76	83	85	82	90	79	75	89	95	78	83
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	11	6	9	8	10	11	10	9	12	16	7	13	8	13	10
ZN	145	83	97	126	112	127	125	122	128	111	248	153	141	208	158
ZR	77	35	98	84	130	155	123	105	152	213	93	148	107	120	130

				NAS125	NAS127										
Var.\ID:	S-227	S-228	S-229	S-230	S-258	S-261	S-262	S-263	S-264	S-265	S-266	S-267	S-268	S-269	S-270
SIO2	52.71	45.31	46.79	50.22	53.07	52.87	52.10	53.43	56.24	56.09	57.21	55.14	53.45	54.52	52.77
AL2O3	7.74	3.41	3.20	5.89	13.57	14.16	12.94	13.18	15.77	13.90	15.03	16.21	14.74	15.52	14.82
TIO2	0.69	0.35	0.18	0.62	1.91	1.84	1.76	1.72	1.52	1.77	1.64	1.61	1.86	1.78	1.77
FE2O3	10.70	11.19	12.82	10.36	10.06	10.86	9.55	9.36	8.63	9.00	8.75	9.45	10.13	10.02	10.84
MGO	16.56	30.86	31.94	19.96	7.63	7.27	8.11	7.89	5.21	6.73	5.72	4.98	6.94	6.16	6.81
CAO	2.96	2.17	1.43	2.61	7.11	7.49	7.32	6.83	4.68	6.14	5.28	4.40	6.04	5.07	5.83
NA2O	0.39	0.01	0.00	0.35	1.15	1.02	1.30	1.36	1.44	1.23	1.13	1.28	1.01	0.97	0.92
K2O	0.97	0.40	0.13	0.90	1.75	1.69	1.72	1.80	2.59	2.15	2.43	2.35	1.94	2.25	2.31
MNO	0.19	0.31	0.20	0.25	0.25	0.24	0.27	0.27	0.19	0.26	0.23	0.19	0.24	0.23	0.23
P2O5	0.16	0.20	0.05	0.20	0.32	0.32	0.34	0.34	0.36	0.34	0.35	0.37	0.37	0.40	0.38
BA	191	69	43	164	170	187	184	193	303	244	265	300	189	254	201
CE	37	21	24	46	34	42	40	27	34	26	48	41	36	29	42
CO	102	154	157	111	31	35	37	33	23	32	27	29	33	36	31
CR	2483	3966	3103	2972	228	181	182	193	169	172	167	170	233	183	187
CS	10	2	2	10	4	5	3	7	8	10	10	9	8	9	12
CU	16	16	19	13	37	50	38	34	29	33	33	39	38	43	42
GA	9	5	2	6	18	19	16	18	20	18	17	19	19	19	20
LA	13	5	4	8	13	6	11	8	10	23	13	14	7	22	12
NI	1125	1878	2499	1253	91	72	73	80	68	67	63	63	86	65	68
NB	7	2	1	4	7	8	7	8	10	9	9	10	8	11	8
PB	40	39	28	39	18	16	31	17	16	16	20	16	20	18	20
RB	30	8	3	24	53	47	47	51	73	66	72	64	57	66	65
SC	25	26	23	23	33	38	34	34	27	30	29	27	34	32	35
SR	66	36	22	50	230	224	213	202	144	171	156	153	186	172	157
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	81	75	52	73	142	158	148	145	115	135	126	131	143	130	148
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	14	4	1	10	31	31	28	26	24	28	25	24	27	26	25
ZN	158	273	359	213	106	108	119	112	91	113	106	98	135	130	145
ZR	153	49	22	126	193	172	160	173	207	216	213	186	187	197	175

	NAS127/cont.						NAS127	NAS128							
Var.\ID:	S-271	S-272	S-276	S-277	S-278	S-279	S-280	S-305	S-308	S-309	S-310	S-311	S-312	S-313	S-314
SIO2	51.57	52.31	53.17	51.72	49.63	51.58	51.96	63.54	64.78	66.03	70.44	71.97	72.18	74.81	74.64
AL2O3	13.62	13.43	14.28	14.76	13.40	14.29	13.87	10.85	12.82	14.35	14.18	13.83	13.34	9.86	8.82
TIO2	1.79	1.80	1.67	1.68	1.70	1.87	1.86	0.89	0.92	0.85	0.88	0.92	0.92	0.90	0.99
FE2O3	10.79	9.85	10.00	10.83	10.13	11.83	11.73	10.35	8.77	9.35	6.92	5.76	6.80	4.86	3.10
MGO	6.84	6.32	5.43	5.90	6.14	6.67	6.95	8.15	5.93	3.18	0.90	1.66	1.53	2.51	5.18
CAO	5.34	4.59	4.36	5.24	4.80	5.99	5.83	3.44	3.44	2.96	2.69	2.97	2.78	2.77	3.53
NA2O	0.88	0.85	1.09	1.05	1.12	0.87	0.84	0.37	0.36	0.36	0.46	0.43	0.41	0.46	0.22
K2O	2.04	2.46	2.30	1.92	2.03	1.95	1.97	1.67	1.77	1.92	1.92	2.02	1.99	1.71	1.85
MNO	0.24	0.23	0.19	0.19	0.19	0.20	0.21	0.25	0.19	0.12	0.06	0.12	0.10	0.13	0.27
P2O5	0.42	0.47	0.43	0.40	0.46	0.38	0.40	0.13	0.14	0.11	0.09	0.10	0.07	0.04	0.11
BA	208	243	252	222	220	159	140	316	333	345	365	364	367	319	356
CE	19	46	30	52	53	34	34	58	79	95	40	46	45	39	64
CO	30	30	28	30	35	35	35	110	97	49	24	39	26	32	46
CR	178	189	183	200	206	262	267	1786	1682	1022	468	418	501	604	577
CS	13	14	13	10	15	14	18	9	7	9	6	9	6	6	8
CU	40	32	39	50	34	58	66	42	37	30	18	22	20	19	21
GA	19	18	17	18	16	18	18	10	11	10	11	11	9	7	9
LA	17	14	23	12	18	13	17	21	26	24	18	18	23	17	26
NI	59	63	61	66	67	75	79	1280	795	704	215	215	209	223	266
NB	6	10	10	7	8	7	6	11	13	12	15	13	14	13	13
PB	29	20	18	27	18	47	20	20	21	20	18	20	23	20	23
RB	56	68	64	55	54	55	59	59	65	74	76	81	77	61	64
SC	34	27	28	33	30	36	35	22	21	20	11	12	11	9	11
SR	158	136	135	172	149	185	186	98	99	92	88	91	90	89	99
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	133	117	106	137	111	143	140	68	70	59	48	44	49	41	42
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	26	22	24	24	22	26	25	24	28	30	24	23	24	23	24
ZN	142	116	110	120	113	132	153	132	98	85	59	62	62	56	69
ZR	168	188	201	175	177	172	169	259	321	333	413	419	419	446	411

										NAS128	NAS129				
Var.\ID:	S-315	S-318	S-319	S-320	S-321	S-322	S-323	S-324	S-325	S-326	S-347	S-348	S-349	S-350	S-351
SIO2	76.73	74.83	73.53	69.91	69.60	73.30	68.29	70.11	66.88	67.98	55.51	58.00	59.65	59.11	59.17
AL2O3	10.30	9.89	10.80	13.70	14.69	11.83	12.44	12.46	14.29	13.00	19.44	17.51	17.61	17.92	17.83
TIO2	1.01	0.90	0.96	0.92	0.94	0.92	0.87	0.82	0.83	0.89	1.02	1.30	1.23	1.25	1.42
FE2O3	4.43	5.70	6.16	7.26	7.82	5.98	7.07	6.22	6.19	6.86	9.31	7.27	7.64	7.68	7.57
MGO	2.10	1.94	2.63	1.08	0.90	2.34	3.47	2.95	3.69	3.61	5.14	5.07	3.88	3.61	3.92
CAO	2.88	3.08	2.89	2.69	2.78	2.96	3.28	3.19	3.74	3.67	7.39	6.94	6.48	6.49	6.66
NA2O	0.39	0.43	0.31	0.54	0.51	0.45	0.37	0.41	0.38	0.37	0.71	0.81	0.69	0.86	0.75
K2O	1.84	1.55	1.68	1.84	1.87	1.99	1.70	1.71	1.63	1.68	0.47	0.81	0.93	0.90	0.90
MNO	0.15	0.09	0.14	0.06	0.06	0.13	0.13	0.12	0.14	0.14	0.14	0.19	0.14	0.14	0.16
P2O5	0.04	0.03	0.05	0.08	0.07	0.06	0.12	0.11	0.17	0.13	0.23	0.27	0.25	0.26	0.29
BA	350	300	324	365	362	371	301	327	317	311	122	167	210	196	195
CE	51	61	52	35	61	59	51	50	39	36	0	22	43	33	37
CO	23	24	35	23	26	49	62	43	57	64	41	44	30	36	36
CR	569	688	700	632	872	588	941	669	743	1021	305	230	222	230	241
CS	14	3	12	9	13	10	10	8	8	10	0	0	0	0	0
CU	17	23	23	18	20	17	27	22	27	30	61	47	44	44	43
GA	9	7	9	9	10	7	10	9	10	11	13	14	13	14	14
LA	21	24	17	21	22	29	21	25	18	22	4	11	16	16	15
NI	182	229	230	242	268	285	338	305	524	368	145	113	101	102	100
NB	15	13	13	14	14	13	12	11	11	11	4	5	6	7	7
PB	21	22	19	18	21	23	27	21	22	20	12	12	13	12	14
RB	69	56	65	70	67	72	61	61	59	60	25	31	35	35	34
SC	9	10	11	13	13	10	15	10	12	14	43	37	35	36	37
SR	87	108	86	89	91	97	99	98	113	116	144	140	132	131	132
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	39	40	49	50	50	49	46	50	52	57	122	125	114	112	125
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	24	23	23	25	23	25	24	21	21	22	17	20	20	20	21
ZN	54	59	66	56	54	54	65	66	71	75	63	73	66	73	69
ZR	447	431	414	406	387	401	369	392	340	379	122	175	211	204	213

	NAS129/cont.														
Var.\ID:	S-352	S-353	S-354	*-355	S-358	S-359	S-360	S-361	S-362	S-363	S-364	S-365	S-368	S-369	S-370
SI02	58.90	58.69	58.89	57.17	57.51	57.57	60.66	57.90	58.00	59.56	58.61	60.16	60.50	61.83	62.32
AL203	18.34	18.07	17.65	17.51	17.50	18.14	17.26	18.38	18.18	17.09	16.34	16.33	16.35	15.10	16.67
TI02	1.32	1.37	1.38	1.52	1.42	1.42	1.38	1.20	1.28	1.42	1.48	1.60	1.76	1.81	1.62
FE203	7.58	7.75	7.44	8.06	8.07	8.41	7.59	8.20	8.14	7.52	7.54	7.47	7.96	7.60	7.59
MGO	3.70	4.16	4.19	4.00	3.67	3.68	2.48	3.44	3.66	3.14	4.26	3.93	2.70	3.29	1.90
CAO	6.78	6.84	6.81	6.92	6.75	6.97	5.51	6.65	6.71	6.17	6.57	6.51	6.34	5.97	5.73
NA20	0.68	0.77	0.79	0.69	0.64	0.70	0.59	0.76	0.66	0.64	0.80	0.89	0.93	0.88	0.92
K20	0.89	0.88	0.87	0.76	0.87	0.75	1.20	0.83	0.77	0.95	0.86	0.92	0.89	1.00	0.99
MNO	0.15	0.17	0.17	0.16	0.15	0.15	0.13	0.13	0.14	0.14	0.16	0.16	0.11	0.14	0.09
P205	0.29	0.29	0.30	0.33	0.32	0.31	0.29	0.28	0.30	0.33	0.28	0.23	0.21	0.19	0.18
BA	196	206	213	124	217	188	272	190	191	227	140	139	133	163	163
CE	12	0	20	17	1	30	26	32	29	37	30	35	30	43	37
CO	33	38	35	32	29	36	31	34	37	37	36	36	34	33	26
CR	226	223	248	248	229	257	198	246	277	251	292	282	282	269	272
CS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
CU	44	43	45	42	43	45	37	47	41	38	43	38	54	32	28
GA	13	14	14	15	14	15	13	14	13	13	13	14	12	12	12
LA	11	11	8	8	10	12	15	8	2	18	11	17	20	19	14
NI	106	101	106	108	105	113	110	113	109	98	108	99	97	88	84
NB	7	6	7	8	7	5	8	6	7	8	7	8	8	9	10
PB	13	13	15	325	14	11	18	13	14	18	16	16	13	15	11
RB	37	35	37	33	35	33	47	34	35	37	32	35	34	34	42
SC	36	37	37	38	36	40	30	34	36	33	38	38	36	33	33
SR	138	133	142	140	141	142	109	140	139	122	129	137	136	131	124
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	115	123	118	125	129	128	107	119	123	114	129	138	140	152	129
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	22	20	21	20	22	23	22	20	21	23	23	24	22	24	26
ZN	75	79	79	72	68	68	64	64	65	67	65	57	63	54	54
ZR	203	194	195	181	201	190	269	186	203	245	230	246	261	298	302

	NAS129	NAS135													
Var.\ID:	S-371	S-281	S-282	S-283	S-284	S-285	S-286	S-287	S-288	S-289	S-293	S-294	S-295	S-296	S-297
SI02	60.41	62.18	64.03	65.27	59.06	54.93	59.46	60.04	61.79	65.57	67.52	64.50	64.25	66.36	69.44
AL203	16.69	20.87	20.63	20.00	21.21	23.33	22.15	19.22	20.35	20.57	19.10	21.35	23.06	16.40	17.05
TI02	1.51	1.43	1.37	1.30	1.05	0.97	1.04	1.05	0.90	0.97	1.15	1.06	1.13	0.89	0.95
FE203	8.15	7.69	7.79	7.67	9.15	11.70	8.43	5.51	6.85	6.45	7.21	8.98	8.47	7.27	7.41
MGO	2.98	0.00	0.00	0.00	0.26	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	6.13	4.21	4.15	3.61	4.63	4.68	4.47	4.25	4.15	4.18	3.54	3.72	4.00	2.34	2.50
NA20	0.69	0.61	0.63	0.62	0.69	0.46	0.62	0.66	0.79	0.88	0.54	0.54	0.67	0.33	0.38
K20	0.88	1.20	1.29	1.53	1.11	0.90	1.31	1.23	1.41	1.48	1.28	1.23	1.13	1.67	1.94
MNO	0.13	0.04	0.04	0.03	0.07	0.08	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.03	0.02
P205	0.24	0.21	0.17	0.15	0.22	0.26	0.24	0.28	0.23	0.15	0.11	0.14	0.15	0.14	0.10
BA	163	216	251	320	227	213	252	242	287	286	268	256	275	299	354
CE	22	0	24	45	32	11	40	47	33	27	7	21	28	34	21
CO	26	19	18	19	27	32	30	16	16	17	11	18	15	5	10
CR	289	241	255	227	289	328	263	213	214	217	220	255	290	89	97
CS	0	7	6	7	7	6	5	12	10	5	7	6	6	5	6
CU	34	18	22	22	21	27	23	28	27	22	16	23	27	8	8
GA	14	12	11	13	13	15	13	11	12	12	10	11	13	9	11
LA	11	10	6	20	7	18	11	7	22	13	13	7	14	22	20
NI	95	83	77	70	111	147	117	69	75	66	57	69	85	23	28
NB	9	11	11	12	10	9	9	9	11	10	10	10	10	11	13
PB	21	15	14	15	15	14	15	15	14	16	14	15	14	18	19
RB	38	52	50	59	52	47	52	43	50	53	47	48	46	57	70
SC	37	19	19	21	22	25	20	17	16	15	17	23	30	10	10
SR	129	68	74	72	83	80	101	98	114	126	57	62	73	41	50
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	143	78	79	73	82	89	80	71	66	67	67	73	68	63	57
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	25	17	15	19	15	14	17	16	17	17	13	17	18	16	18
ZN	62	40	41	40	57	66	64	41	40	32	31	34	33	26	32
ZR	264	260	268	323	233	171	239	241	256	258	244	246	221	247	318

	NAS135/cont.						NAS135	NAS136							
Var.\ID:	S-298	S-299	S-300	S-301	S-328	S-330	S-331	S-332	S-333	S-334	S-335	S-336	S-337	S-338	S-339
SIO2	70.04	71.03	71.72	71.82	68.04	66.52	70.49	68.44	60.84	70.89	68.02	69.11	65.40	70.11	67.96
AL2O3	18.29	17.45	17.88	16.98	17.99	21.18	17.78	12.03	9.85	14.60	15.33	14.66	15.91	15.81	15.47
TIO2	1.06	1.20	1.26	1.26	1.10	1.23	1.06	0.73	0.74	0.90	0.79	0.77	0.85	0.91	0.89
FE2O3	7.67	7.16	6.85	6.72	7.61	8.58	6.66	9.71	10.98	7.37	8.04	6.26	7.75	6.82	7.48
MGO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.53	10.93	0.05	0.00	0.00	0.00	0.00	0.00
CAO	2.79	2.98	3.04	2.92	3.26	3.84	2.81	2.02	2.84	2.28	2.19	2.05	2.13	2.33	2.18
NA2O	0.34	0.21	0.20	0.23	0.20	0.03	0.44	0.58	0.36	0.55	0.62	0.65	0.52	0.53	0.51
K2O	1.82	1.38	1.35	1.36	1.41	0.73	1.75	1.52	1.26	1.95	1.88	2.03	1.97	2.06	1.98
MNO	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.08	0.21	0.05	0.04	0.03	0.03	0.03	0.03
P2O5	0.09	0.08	0.07	0.07	0.14	0.17	0.09	0.04	0.09	0.05	0.09	0.10	0.15	0.11	0.12
BA	331	292	279	265	297	211	320	294	270	368	334	331	347	364	355
CE	44	43	36	15	39	27	39	35	52	36	39	46	39	32	33
CO	7	12	11	8	7	9	11	33	95	24	16	11	14	12	12
CR	128	157	161	160	156	197	110	1009	2222	459	436	143	171	182	160
CS	7	6	6	5	7	7	9	4	2	4	5	8	7	5	6
CU	12	12	15	14	17	22	9	10	17	11	11	8	5	11	8
GA	10	11	10	10	11	11	12	9	8	10	9	10	9	12	11
LA	20	19	15	20	20	14	21	25	16	22	18	24	25	17	20
NI	35	44	37	38	62	54	32	263	930	241	174	59	50	62	52
NB	14	12	13	13	13	8	14	12	8	14	13	13	14	16	16
PB	20	20	16	15	22	14	23	24	29	23	23	20	20	19	22
RB	70	52	48	47	60	34	71	52	43	75	68	76	74	84	78
SC	13	14	19	19	17	30	13	9	24	11	10	8	9	10	9
SR	46	39	36	36	66	38	55	59	49	68	64	63	62	64	62
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	62	67	66	65	66	87	58	44	77	53	48	39	45	44	48
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	19	16	17	17	19	19	21	18	18	25	23	21	22	24	23
ZN	32	32	24	26	25	36	33	47	113	45	41	35	36	40	34
ZR	303	265	248	243	285	195	355	354	274	420	402	442	409	438	428

							NAS136	NAS137							
Var.\ID:	S-340	S-341	S-342	S-343	S-344	S-345	S-346	S-474	S-476	S-477	S-478	S-479	S-480	S-481	S-482
SIO2	71.38	69.41	70.50	63.29	60.58	57.99	63.37	58.52	54.90	54.22	53.74	54.69	53.79	54.15	53.49
AL2O3	15.15	15.19	14.44	15.71	11.15	4.96	11.30	13.06	11.62	11.67	11.45	12.43	12.42	12.62	11.42
TIO2	0.92	0.91	0.94	0.87	0.68	0.70	0.80	1.21	1.25	1.32	1.36	1.33	1.34	1.35	1.34
FE2O3	6.58	7.43	7.80	13.54	15.54	11.83	13.40	7.11	8.28	8.43	8.45	8.71	8.50	8.41	8.48
MGO	0.00	0.00	0.57	1.31	8.28	20.33	6.95	5.99	9.84	9.84	10.13	9.86	10.01	10.06	10.02
CAO	2.37	2.17	2.36	2.14	2.14	3.38	2.43	2.31	3.70	3.40	3.23	3.52	3.47	3.27	3.88
NA2O	0.45	0.54	0.48	0.41	0.30	0.00	0.39	1.13	0.71	0.77	0.92	1.04	0.98	1.10	0.68
K2O	2.14	1.96	2.04	1.66	1.43	1.15	1.23	3.98	2.38	2.57	2.56	2.42	2.54	2.44	2.09
MNO	0.05	0.03	0.07	0.05	0.19	0.56	0.11	0.11	0.15	0.15	0.15	0.14	0.14	0.14	0.16
P2O5	0.09	0.09	0.07	0.08	0.07	0.19	0.02	0.48	0.51	0.52	0.48	0.44	0.46	0.41	0.47
BA	359	339	360	318	313	323	273	343	300	295	280	280	298	308	295
CE	39	29	37	24	18	25	24	50	42	43	43	47	47	25	37
CO	15	14	36	28	89	150	59	29	45	41	41	40	46	46	45
CR	160	227	634	1405	2324	3919	2977	518	895	755	769	665	714	682	791
CS	4	6	5	6	6	9	5	13	8	9	9	11	8	7	4
CU	14	6	12	17	16	16	14	14	27	22	21	23	22	20	21
GA	11	11	10	10	10	8	9	16	13	14	13	14	14	14	13
LA	22	22	18	26	10	13	16	18	12	11	11	11	19	17	17
NI	68	52	207	502	1585	2509	1321	222	479	470	459	420	447	475	515
NB	15	15	15	13	8	6	9	8	8	7	8	6	6	6	8
PB	23	17	20	28	30	39	33	28	25	23	26	22	24	21	27
RB	85	80	80	68	57	32	43	96	80	82	81	78	79	84	74
SC	10	8	15	19	26	33	23	19	23	22	23	23	23	22	22
SR	66	61	66	54	44	32	46	144	180	173	169	180	180	186	183
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	46	50	53	73	81	92	82	70	77	81	79	79	80	73	72
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	23	21	24	19	19	13	19	13	15	16	17	16	17	15	15
ZN	47	34	54	88	167	322	177	87	125	128	128	133	135	138	142
ZR	435	412	418	300	190	144	270	156	162	156	158	150	150	147	158

NAS137/cont.

Var.\ID:	S-483	S-484	S-485	S-486	S-487	S-488	S-489	S-490	S-491	S-492	S-493	S-494	S-495	S-496	S-497
SI02	54.29	54.40	53.83	54.96	58.90	54.45	61.59	54.29	53.03	54.62	54.90	54.11	53.25	53.70	52.13
AL203	11.76	11.88	11.49	13.49	15.77	14.27	16.52	12.50	12.04	13.41	13.26	13.26	13.91	14.55	13.83
TI02	1.31	1.32	1.06	1.39	1.22	1.53	0.92	1.16	1.37	1.46	1.30	1.47	1.62	1.56	1.56
FE203	8.30	8.45	7.16	7.62	7.11	8.63	5.09	7.04	7.74	7.49	6.93	7.91	8.05	7.90	8.15
MGO	9.91	10.03	10.45	7.94	5.83	7.60	3.89	9.22	9.03	7.33	7.04	7.35	6.76	6.54	7.42
CAO	3.52	3.25	3.53	4.15	2.43	3.96	2.14	3.37	3.91	4.04	3.58	4.08	4.34	4.08	4.51
NA20	0.84	0.90	1.17	1.50	1.61	1.35	1.99	1.45	1.22	1.46	1.97	1.59	1.69	1.81	1.58
K20	2.29	2.42	2.53	2.68	4.26	2.70	4.56	2.48	2.19	2.21	2.38	2.08	2.14	1.89	1.89
MNO	0.15	0.14	0.13	0.13	0.09	0.13	0.06	0.14	0.15	0.16	0.13	0.15	0.14	0.13	0.15
P205	0.47	0.46	0.41	0.43	0.38	0.43	0.27	0.36	0.42	0.40	0.38	0.38	0.40	0.39	0.42
BA	308	298	278	294	351	246	371	298	302	335	366	228	228	278	239
CE	40	36	27	33	33	39	31	32	35	33	32	42	26	36	34
CO	49	48	46	37	33	39	25	41	40	35	33	32	34	30	40
CR	784	757	740	495	338	488	200	675	633	485	443	505	401	417	468
CS	7	8	7	4	7	8	8	9	7	9	5	9	6	7	3
CU	19	21	20	29	25	27	19	17	19	24	21	27	39	23	31
GA	14	15	11	14	15	15	16	15	14	15	15	15	14	15	15
LA	13	10	14	13	16	12	13	14	13	18	10	17	17	12	15
NI	505	495	514	350	238	326	158	426	391	299	271	269	227	257	321
NB	6	7	6	7	6	8	7	5	7	7	7	8	8	7	6
PB	27	28	27	19	31	19	21	21	23	23	23	23	21	26	31
RB	79	79	76	76	108	90	97	89	78	78	81	73	78	67	69
SC	21	24	20	25	23	25	18	23	22	21	20	22	23	21	23
SR	186	178	183	209	161	206	171	239	216	224	239	212	247	298	233
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	76	74	67	86	75	90	56	71	69	77	74	77	86	87	96
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	15	15	15	17	14	18	13	13	16	18	15	17	16	14	16
ZN	133	137	109	102	97	108	77	114	106	90	79	83	83	85	83
ZR	161	154	128	151	126	165	125	130	154	174	152	161	159	173	153

					NAS137
Var.\ID:	S-498	S-499	S-500	S-501	S-502
SI02	51.84	54.35	51.79	53.73	53.96
AL203	14.35	12.47	13.24	12.75	11.47
TI02	1.51	1.30	1.68	1.56	1.28
FE203	8.78	7.64	8.40	8.57	7.80
MGO	7.64	8.72	6.65	7.81	8.90
CAO	5.65	4.54	4.53	4.38	4.10
NA20	1.33	1.26	1.46	1.16	1.04
K20	1.73	1.85	2.05	1.91	1.88
MNO	0.14	0.15	0.14	0.14	0.14
P205	0.39	0.41	0.49	0.40	0.38
BA	167	270	253	210	248
CE	35	31	27	38	14
CO	41	47	34	41	41
CR	559	673	457	577	720
CS	3	8	6	9	17
CU	30	29	28	40	25
GA	13	14	16	14	13
LA	13	15	17	13	12
NI	342	434	269	355	408
NB	5	6	8	7	8
PB	18	29	23	25	28
RB	78	69	79	75	73
SC	28	22	22	22	21
SR	193	224	281	202	180
S	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a
V	91	76	100	83	70
W	n.a	n.a	n.a	n.a	n.a
Y	20	18	20	19	15
ZN	82	89	88	105	108
ZR	153	148	173	162	152

<u>Power auger programme data</u>

Data in this Appendix are again presented as a series of list files taken direct from the traverse line RAW-files. Attention is drawn in this instance to the sample names. A prefix "BXS" describes a sample which which was taken at one metre depth. Samples which are prefixed "BXB" originate from the base of the power auger hole.

Although this Appendix ostensibly contains only data collected with the aid of the Minuteman power auger, it was found necessary to extend some of these traverse lines at a later stage by hand augering. These extensions consist only of shallow samples as no basal samples could be collected.

Following the listing of all the traverse line data relevant to the power auger programme, some of the data from individual soil profiles are presented. A "BXS" prefix is retained with the sample number and the depth in the profile is described by the final character in the sample name. The traverse line number along which these profiles were taken are shown immediately above the Identity code (ID) for each particular sample.

BXS3000 = 1 metre depth		BXS3000	= Shallowest sample
BXS3000B = 2 metre depth	or	BXS3000b	= :
BXS3000C = 3 metre depth		BXS3000c	= :
BXB3000 = Basal sample		BXB3000	= Basal sample

<u>List of abbreviations used periodically in Appendices</u>

UB .... Ultrabasic
LH .... Lherzolitic peridotite
HA .... Harzburgitic peridotite
KE .... Kennack gneiss
GA .... Gabbro
LG .... Lower gabbro
UG .... Upper gabbro
UL .... Upper Landewednack hornblende schist
GR .... Crousa gravel
LL .... Lower Landewednack hornblende schist

MS .... Mica schist granulite (Old Lizard Head Series)
CUM ... Cumulate zone
TQ .... Treleague quartzite

Traverse line	Sample numbers	Location	No. of samples
NAS143.	BXS3000-3028.	East of Trelan Farm (N-S).	(29)
NAS144.	BXB3000-3028.	Basal samples.	(29)
NAS145.	S1315-1300. S927-939. BXS3099-3091. BXS3079-3072. BXS3041-3029. BXS3080-3090. BXS3100-3114.	Arrowan Common (S) to Trelanvean (N).	(85)
NAS146.	BXB3099-3091. BXB3079-3072. BXB3041-3029. BXB3080-3090. BXB3100-3114.	Basal samples.	(69)
NAS147.	BXS3127-1324. BXS3071-3042. S1184-1206.	Trelan Gate (N) to Little Pednavounder (S).	(58)
NAS148.	BXB3127-3123. BXB3071-3042.	Basal samples.	(35)
NAS149.	BXS3128-3136.	Seaview traverse.	(9)
NAS150.	BXB3128-3136.	Basal samples.	(9)
NAS151.	BXS4000-4028.	South of Trelan Farm (N-S).	(29)
NAS152.	BXB4000-4027.	Basal samples.	(29)
NAS153.	BXS4029-4055.	South of Trelan Farm (S-N).	(27)
NAS154.	BXB4029-4055.	Basal samples.	(27)
NAS155.	BXS4056-4082.	North of Trelan Farm (S-N).	(27)
NAS156.	BXB4056-4082.	Basal samples.	(27)
NAS157.	BXS3122-3115. S731-747.	Roscrowgey to Fox Covert (N-S).	(25)
NAS158.	BXB3122-3115.	Basal samples.	(8)
NAS159.	BXS3137-3151.	Southwest of Rosuic (SW-NE).	(15)
NAS160.	BXB3137-3150.	Basal samples.	(15)

Var.\ID:	NAS143 BXS3000	BXS3001	BXS3002	BXS3003	BXS3004	BXS3005	BXS3006	BXS3007	BXS3008	BXS3009	BXS3010	BXS3011
SIO2	62.65	65.21	67.61	61.20	62.89	62.23	59.72	59.26	53.02	52.53	51.42	55.52
AL2O3	13.56	13.19	14.17	13.71	13.80	14.99	16.49	15.61	15.74	17.17	17.34	17.77
TIO2	2.84	2.38	2.49	3.04	2.83	3.02	2.85	3.38	4.01	4.16	2.77	2.54
FE2O3	8.53	8.86	7.27	9.12	8.37	9.71	8.92	11.89	12.34	13.23	15.33	11.88
MGO	0.05	1.12	0.00	0.79	0.00	0.00	1.42	0.00	0.00	0.00	2.32	1.08
CAO	4.03	4.03	3.99	4.75	4.07	4.46	5.42	4.75	5.61	6.05	5.96	4.98
NA2O	1.16	1.05	0.91	1.20	1.30	1.02	1.05	0.99	1.25	1.39	1.20	1.24
K2O	1.63	1.61	1.68	1.42	1.63	1.40	1.26	1.19	0.93	0.75	0.58	1.03
MNO	0.10	0.14	0.09	0.12	0.09	0.08	0.19	0.08	0.10	0.09	0.12	0.11
P2O5	0.18	0.15	0.14	0.21	0.19	0.18	0.25	0.22	0.30	0.30	0.24	0.25
BA	249	248	257	186	219	221	192	195	134	135	100	158
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	30	24	14	23	26	24	39	25	34	29	45	39
CR	241	201	214	257	230	243	248	246	267	203	414	306
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	17	18	14	23	18	21	24	25	46	29	33	23
GA	14	13	12	15	15	13	17	16	17	19	16	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	88	83	72	112	73	87	104	96	100	124	239	193
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	14	15	12	18	16	13	15	14	12	7	14
RB	48	47	53	41	46	43	39	38	27	23	22	33
SC	26	24	23	37	25	28	46	39	46	59	55	50
SR	186	159	149	183	174	174	190	165	189	222	201	199
S	118	169	168	172	88	177	164	273	226	250	161	266
SN	0	5	3	6	2	1	0	0	0	3	1	6
V	244	207	177	264	240	251	261	329	385	359	265	208
W	5	0	3	0	2	2	0	0	2	0	6	5
Y	27	27	28	25	28	28	25	29	23	25	29	28
ZN	43	41	43	42	41	47	48	50	47	47	65	57
ZR	299	321	337	262	308	270	214	243	185	179	132	169

Var.\ID:	BXS3012	BXS3013	BXS3014	BXS3015	BXS3016	BXS3017	BXS3018	*XS3019	BXS3020	BXS3021	BXS3022	BXS3023
SIO2	56.57	54.65	51.64	47.96	52.86	54.43	54.91	45.10	51.58	55.52	62.27	59.25
AL2O3	17.79	18.88	18.03	17.43	15.66	17.88	19.49	13.18	14.83	15.47	14.69	15.84
TIO2	2.14	1.94	1.51	4.80	2.08	1.52	1.37	4.23	2.43	2.96	2.50	3.70
FE2O3	11.47	12.95	12.38	19.31	11.77	10.37	10.82	18.54	13.50	12.23	8.94	11.15
MGO	1.02	1.80	5.45	0.00	5.15	3.51	2.49	3.64	2.85	1.58	0.00	0.00
CAO	4.95	5.48	6.38	4.41	5.90	6.70	6.58	6.04	5.23	5.81	3.91	4.61
NA2O	1.32	1.16	1.06	1.29	1.07	1.11	1.18	1.37	1.31	1.26	1.15	1.13
K2O	0.89	0.63	0.37	0.85	0.56	0.50	0.40	0.44	0.56	0.77	1.65	1.31
MNO	0.08	0.09	0.11	0.10	0.15	0.12	0.09	0.21	0.13	0.15	0.08	0.09
P2O5	0.21	0.21	0.20	0.35	0.26	0.20	0.17	0.36	0.29	0.24	0.19	0.25
BA	118	110	55	136	90	72	134	79	86	113	251	214
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	41	43	63	41	45	34	27	67	38	23	20	32
CR	212	228	450	315	561	323	244	144	209	206	176	207
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	36	17	31	23	23	24	195	21	37	23	18
GA	17	16	15	18	16	14	15	22	17	17	14	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	162	175	344	190	378	171	125	92	82	90	76	74
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	8	12	9	23	10	13	6	13	9	7	14	14
RB	29	27	17	30	20	20	19	15	18	25	50	42
SC	50	57	54	66	47	40	42	98	50	50	29	34
SR	204	197	160	119	180	222	260	184	203	219	160	149
S	333	336	388	313	594	465	316	178	238	207	42	212
SN	3	1	0	0	1	0	0	1	1	0	4	4
V	166	205	195	405	198	165	142	666	264	295	183	232
W	4	4	5	3	8	4	4	2	0	4	4	0
Y	18	22	16	16	19	18	13	34	28	28	37	35
ZN	51	57	70	140	90	45	42	136	60	50	45	46
ZR	155	129	84	142	105	109	80	126	144	151	322	318

	NAS143/cont.				NAS143	NAS144						
Var.\ID:	BXS3024	BXS3025	BXS3026	BXS3027	BXS3028	BXB3000	BXB3001	BXB3002	BXB3003	BXB3004	BXB3005	BXB3006
SIO2	54.26	49.48	63.05	61.14	49.96	42.93	51.24	43.88	51.03	52.51	55.32	44.92
AL203	16.73	18.41	15.76	14.93	18.81	12.00	5.51	12.28	13.98	13.76	15.94	13.29
TIO2	4.59	5.46	1.98	2.19	3.69	7.25	0.69	5.11	4.32	4.14	4.35	4.50
FE203	12.35	15.13	9.11	9.32	16.88	17.34	11.75	14.33	12.73	12.35	12.71	13.93
MGO	0.00	0.00	0.00	1.71	0.40	3.43	23.71	7.06	2.21	3.10	0.00	4.46
CAO	5.82	5.82	3.56	4.92	5.97	7.06	5.44	8.78	6.93	7.26	6.10	8.29
NA20	1.40	1.66	0.74	0.71	0.21	1.85	0.09	1.15	1.50	2.03	1.51	2.13
K20	0.73	0.60	1.68	1.24	0.56	0.78	0.00	0.08	0.77	0.94	0.99	0.45
MNO	0.09	0.09	0.09	0.17	0.19	0.17	0.11	0.14	0.13	0.11	0.10	0.14
P205	0.32	0.41	0.23	0.40	0.70	0.45	0.00	0.31	0.28	0.23	0.26	0.29
BA	134	101	282	202	143	30	33	13	82	59	121	14
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	41	37	27	36	58	77	91	65	52	49	40	56
CR	190	160	144	151	163	143	2086	330	164	282	279	122
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	23	34	20	27	36	72	24	38	46	40	43	72
GA	19	21	14	16	23	17	7	14	15	14	16	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	72	76	58	68	90	245	1550	709	130	159	120	153
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	13	8	15	15	13	11	9	6	10	9	13	9
RB	25	23	61	48	34	14	3	5	25	28	32	15
SC	57	74	24	28	57	86	26	65	63	55	53	73
SR	176	173	100	115	97	223	37	140	258	343	219	251
S	302	225	200	524	336	28	44	23	487	142	180	53
SN	0	2	2	7	4	1	1	5	2	0	0	0
V	445	495	152	176	339	444	113	404	365	364	354	422
W	5	4	1	4	0	3	7	1	2	2	1	0
Y	31	38	38	35	67	20	9	18	25	21	25	18
ZN	43	60	59	82	99	143	62	63	52	53	61	61
ZR	235	192	367	301	254	96	38	103	160	137	173	86

Var.\ID:	BXB3007	BXB3008	BXB3009	BXB3010	BXB3011	BXB3012	BXB3013	BXB3014	$XB3015	BXB3016	BXB3017	BXB3018
SIO2	50.33	51.89	43.05	50.07	50.67	51.32	51.45	53.86	46.58	46.60	51.54	54.49
AL203	15.37	14.72	13.70	14.47	14.16	15.05	14.73	17.48	5.97	13.35	16.09	19.09
TIO2	1.72	2.36	5.93	2.56	1.38	1.86	1.05	0.82	1.16	4.25	1.18	0.62
FE203	10.82	12.26	15.89	13.38	10.77	12.12	8.89	8.54	11.21	15.31	9.41	7.60
MGO	7.14	8.32	1.76	7.34	8.24	7.68	7.91	6.90	24.68	6.15	7.69	5.77
CAO	8.35	5.23	9.87	7.46	8.03	7.36	8.40	8.20	3.81	8.47	9.57	8.16
NA20	1.68	1.43	2.26	1.80	1.93	1.50	2.63	2.03	0.43	1.46	1.50	1.98
K20	0.23	1.30	0.41	0.54	0.56	0.49	0.55	0.48	0.23	0.34	0.46	0.50
MNO	0.14	0.14	0.15	0.18	0.17	0.22	0.12	0.11	0.27	0.19	0.12	0.10
P205	0.15	0.22	0.44	0.25	0.26	0.31	0.16	0.10	0.16	0.29	0.10	0.11
BA	15	36	27	21	92	42	74	60	68	8	67	81
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	42	52	57	52	42	55	41	35	222	51	46	34
CR	195	380	60	109	133	364	86	144	2071	127	217	259
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	37	44	17	13	18	17	32	25	83	10	5
GA	15	15	19	16	17	18	16	15	13	22	14	14
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	135	148	136	187	166	298	142	147	1650	254	167	115
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	9	19	8	12	6	8	9	7	27	10	9	9
RB	9	34	15	17	17	17	15	17	5	11	24	23
SC	49	65	80	47	49	51	53	57	39	71	46	41
SR	228	237	280	193	352	305	330	247	87	267	357	553
S	6	5	20	3	16	20	0	66	0	0	0	0
SN	0	2	0	2	0	1	0	0	2	0	0	0
V	232	224	655	275	192	187	140	135	209	552	189	106
W	2	8	0	3	5	6	0	4	17	5	5	4
Y	20	17	33	26	33	35	21	15	25	24	17	19
ZN	49	239	52	78	41	77	42	54	574	106	29	23
ZR	53	64	145	99	93	96	69	45	50	87	58	166

	NAS144/cont.									NAS144	NAS145	
Var.\ID:	BXB3019	BXB3020	BXB3021	BXB3022	BXB3023	BXB3024	BXB3025	BXB3026	BXB3027	BXB3028	S-1315	S-1314
SIO2	52.68	47.73	52.64	54.84	46.94	48.45	43.79	51.50	42.13	48.81	67.81	62.24
AL203	14.62	13.35	13.08	16.67	15.02	12.65	15.35	17.09	17.20	17.60	13.34	13.78
TIO2	0.89	2.56	1.10	1.20	5.10	2.18	5.89	2.16	8.14	2.70	0.96	1.04
FE203	9.51	15.23	10.85	8.34	15.27	10.16	20.02	11.84	18.73	15.88	8.37	12.42
MGO	8.84	6.13	9.45	6.09	2.87	8.15	0.62	5.47	0.00	5.02	1.52	2.47
CAO	8.20	6.08	6.64	7.85	4.99	8.36	7.16	7.00	8.77	6.82	2.60	2.60
NA20	1.66	1.67	2.04	2.13	1.55	2.04	2.05	1.87	1.49	1.29	0.52	0.51
K20	0.46	0.31	0.53	0.53	1.78	0.25	0.39	0.34	0.41	0.28	1.93	1.68
MNO	0.16	0.17	0.16	0.11	0.10	0.20	0.15	0.21	0.20	0.22	0.07	0.06
P205	0.11	0.27	0.14	0.14	0.42	0.26	0.48	0.31	0.72	0.47	0.14	0.13
BA	72	39	65	128	43	29	60	61	85	62	364	344
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	40	53	41	35	61	53	64	53	69	51	30	31
CR	90	90	125	128	509	83	96	71	133	92	589	1165
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	61	51	18	31	48	144	24	51	21	16	18
GA	15	18	16	15	16	16	24	19	21	21	9	13
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	90	76	73	139	177	84	100	71	107	116	239	399
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	10	4	7	8	13	6	6	8	15	11	26	23
RB	15	12	22	20	45	5	22	13	17	14	72	65
SC	60	82	64	44	83	76	98	55	102	71	8	16
SR	276	247	296	293	239	245	186	203	149	172	89	87
S	0	4	0	63	4	15	33	34	76	76	n.a	n.a
SN	0	1	0	2	4	0	4	0	0	2	n.a	n.a
V	153	388	146	122	324	296	897	249	665	345	64	86
W	6	3	5	4	1	14	9	4	6	3	n.a	n.a
Y	20	25	19	21	24	25	31	39	40	41	26	21
ZN	50	83	64	33	153	38	77	74	78	108	59	73
ZR	52	77	62	102	100	215	107	177	137	108	377	342

Var.\ID:	S-1313	S-1312	S-1311	S-1310	S-1309	S-1308	S-1307	S-1306	S-1305	S-1304	S-1303	S-1302
SIO2	71.11	66.71	70.63	69.19	65.67	68.29	69.39	67.79	67.30	62.66	60.02	65.02
AL203	12.72	13.79	10.10	13.81	14.31	14.31	13.06	14.77	14.29	13.07	13.00	16.45
TIO2	1.03	1.04	1.33	0.99	1.28	1.01	1.35	1.26	1.08	1.32	1.40	1.37
FE203	7.28	6.75	8.70	7.60	8.86	7.78	8.77	8.18	9.29	12.65	13.65	8.64
MGO	1.18	3.28	2.06	1.80	1.73	0.41	1.38	0.56	0.92	3.85	5.14	0.00
CAO	2.51	3.00	2.31	2.75	3.07	2.56	2.98	3.08	2.58	2.77	2.80	2.69
NA20	0.54	0.54	0.61	0.48	0.41	0.54	0.44	0.62	0.48	0.55	0.50	0.67
K20	1.94	2.05	1.58	1.91	1.84	1.92	1.63	1.94	1.81	1.26	1.41	1.94
MNO	0.08	0.17	0.07	0.11	0.09	0.05	0.10	0.05	0.05	0.09	0.11	0.04
P205	0.08	0.15	0.07	0.13	0.22	0.16	0.10	0.09	0.12	0.07	0.11	0.13
BA	365	384	340	352	354	369	384	354	338	330	356	397
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	38	100	29	42	49	16	30	22	18	45	51	21
CR	521	710	941	613	759	337	687	834	593	1437	1239	508
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	14	23	11	15	17	12	10	20	14	13	20	14
GA	12	11	8	12	12	11	12	12	10	12	12	12
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	192	361	247	217	232	114	218	240	195	694	635	182
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	25	23	18	25	24	22	26	17	22	16	17	18
RB	74	74	57	74	70	75	71	72	68	51	51	71
SC	8	18	7	11	14	10	13	19	12	19	25	16
SR	89	92	79	71	83	79	84	103	74	75	75	76
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	60	79	57	64	72	60	78	75	69	99	134	87
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	27	29	25	23	26	23	26	28	24	25	29	24
ZN	49	63	48	52	59	45	51	58	52	53	50	39
ZR	412	402	383	383	370	406	353	377	374	275	255	306

NAS145/cont.

Var.\ID:	S-1301	S-1300	S-939	S-938	S-937	S-936	S-935	S-934	S-933	S-932	S-931	S-930
SIO2	63.60	54.32	56.53	51.72	54.14	56.61	55.87	44.17	51.77	52.78	54.79	50.57
AL2O3	12.92	13.05	10.07	14.43	9.44	15.23	14.65	16.34	12.62	11.52	13.82	12.98
TIO2	1.37	2.73	1.87	2.22	1.50	2.08	2.00	4.04	2.40	3.03	3.29	3.51
FE2O3	12.40	13.83	14.82	18.13	19.30	15.70	15.79	23.80	15.20	13.81	14.32	15.57
MGO	3.58	6.82	6.45	5.94	10.69	2.96	3.61	3.02	7.66	7.66	1.66	5.98
CAO	2.65	4.44	3.65	3.77	3.43	3.00	3.17	3.83	4.05	4.34	3.73	4.80
NA2O	0.57	0.67	0.62	0.56	0.18	0.66	0.69	0.71	0.44	0.68	1.11	0.93
K2O	1.47	1.14	0.89	0.88	0.71	1.16	1.28	0.32	0.75	1.09	1.08	0.84
MNO	0.09	0.22	0.15	0.11	0.27	0.09	0.10	0.16	0.11	0.24	0.09	0.18
P2O5	0.07	0.23	0.18	0.17	0.17	0.16	0.17	0.33	0.17	0.25	0.23	0.25
BA	339	183	206	158	279	184	223	106	149	168	168	127
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	52	134	71	71	127	49	71	90	55	97	37	83
CR	1321	2086	2300	2560	3784	1256	1348	713	1273	1605	1365	1427
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	16	26	25	29	21	27	25	45	13	31	15	35
GA	11	14	12	13	11	15	15	16	13	15	13	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	659	803	728	999	826	643	541	974	1158	895	483	779
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	18	17	24	18	27	18	13	16	18	25	21	21
RB	52	31	24	32	26	40	47	21	31	34	36	27
SC	26	41	22	44	20	37	34	66	34	47	29	51
SR	76	93	110	82	58	105	87	96	75	133	135	152
S	n.a	n.a	1018	306	768	252	259	340	289	213	380	225
SN	n.a	n.a	8	4	7	4	5	0	6	5	3	1
V	121	234	180	200	208	202	189	425	209	281	248	330
W	n.a	n.a	4	2	11	4	1	0	0	0	4	0
Y	27	22	16	16	12	17	22	19	21	22	19	23
ZN	51	68	119	75	114	90	79	99	79	120	76	96
ZR	244	175	173	164	150	166	237	151	185	166	236	152

Var.\ID:	S-929	S-928	S-927	BXS3099	BXS3098	BXS3097	BXS3096	BXS3095	BXS3094	BXS3093	BXS3092	BXS3091
SIO2	50.10	46.09	55.24	50.69	53.99	50.72	50.95	48.65	44.21	38.79	50.32	39.41
AL2O3	16.69	8.34	13.01	7.72	9.39	6.75	13.95	10.80	13.69	13.53	10.42	12.26
TIO2	2.74	2.55	2.76	1.25	2.00	1.65	3.18	2.31	4.61	4.98	2.66	4.92
FE2O3	18.04	25.37	13.39	17.00	14.16	17.53	16.99	21.36	22.14	22.44	19.80	19.37
MGO	1.45	12.80	3.60	17.65	12.28	16.61	5.10	8.01	2.17	2.14	8.19	3.65
CAO	3.95	3.62	4.27	3.56	5.39	3.83	4.85	3.82	4.66	5.37	4.35	7.36
NA2O	1.25	0.34	0.92	0.26	0.53	0.36	1.15	0.79	1.32	1.45	0.68	1.73
K2O	0.76	0.51	0.85	0.54	0.60	0.26	0.90	0.40	0.39	0.37	0.44	0.45
MNO	0.08	0.37	0.14	0.34	0.30	0.20	0.23	0.19	0.16	0.19	0.23	0.19
P2O5	0.24	0.23	0.22	0.18	0.19	0.09	0.28	0.21	0.32	0.42	0.19	0.35
BA	125	137	151	176	133	42	152	110	77	76	108	33
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	26	175	57	145	97	99	95	86	86	65	127	63
CR	521	2094	1224	2845	1473	1731	1637	2679	864	231	1783	91
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	19	54	29	41	32	44	44	55	74	109	71	90
GA	17	16	14	9	14	10	18	14	18	23	16	21
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	227	1978	473	2392	887	1446	883	1457	464	186	1054	75
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	17	10	12	10	9	5	14	15	7	9	9	3
RB	27	21	24	15	15	7	26	15	12	13	13	16
SC	41	40	40	43	44	35	57	53	92	119	65	104
SR	166	51	128	73	115	77	184	133	195	192	121	191
S	456	342	376	323	358	253	322	365	200	201	191	27
SN	3	5	5	3	2	1	0	0	4	0	1	1
V	356	289	245	213	319	250	438	334	629	983	441	909
W	3	8	3	3	1	1	4	0	5	2	5	8
Y	17	16	18	23	23	16	25	23	31	42	25	39
ZN	65	117	60	73	88	97	87	91	82	94	104	97
ZR	150	100	187	83	122	75	131	100	110	125	101	87

NAS145/cont.

Var.\ID:	BXS3079	BXS3078	BXS3077	BXS3076	BXS3075	BXS3074	BXS3073	BXS3072	BXS3041	BXS3040	BXS3039	BXS3038
SIO2	43.36	51.91	48.01	47.88	51.26	51.71	48.49	52.59	51.78	55.45	63.71	64.41
AL2O3	17.48	17.57	20.56	18.43	15.87	14.97	10.67	16.39	13.33	13.41	16.19	16.02
TIO2	4.80	2.77	2.61	3.35	2.29	3.17	1.42	1.99	2.60	3.25	2.33	1.55
FE2O3	21.28	15.80	20.45	19.86	18.80	16.44	19.08	13.85	14.61	13.58	9.19	8.86
MGO	0.00	2.46	0.10	0.76	3.98	3.68	12.73	4.11	5.02	1.55	0.00	0.81
CAO	5.92	5.20	4.89	5.24	4.58	5.32	5.19	6.58	5.86	5.89	4.38	4.41
NA2O	1.43	1.07	1.64	1.13	0.76	1.21	0.43	1.40	1.16	1.26	1.12	0.99
K2O	0.46	0.77	0.34	0.59	0.59	0.73	0.24	0.52	0.64	0.53	1.14	1.23
MNO	0.13	0.19	0.08	0.11	0.09	0.17	0.16	0.13	0.13	0.11	0.06	0.05
P2O5	0.45	0.30	0.28	0.34	0.21	0.30	0.13	0.20	0.19	0.20	0.14	0.10
BA	76	61	57	113	131	126	151	96	66	107	196	172
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	64	76	41	64	42	98	94	46	46	38	21	23
CR	184	281	203	283	1339	861	1754	275	118	186	204	276
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	82	51	51	42	28	63	67	46	32	29	17	12
GA	27	19	23	21	16	17	10	16	19	18	18	15
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	140	145	132	196	574	548	1087	219	84	83	69	87
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	5	9	5	12	13	13	36	9	7	10	13	13
RB	18	23	18	26	26	23	14	20	25	17	36	44
SC	116	71	83	73	40	55	50	51	75	73	48	40
SR	194	211	173	181	128	198	127	219	286	207	185	179
S	416	329	310	451	560	389	405	374	229	641	339	523
SN	7	0	2	1	5	0	6	4	0	12	0	2
V	807	329	387	580	271	371	243	315	339	387	213	170
W	8	3	0	0	3	4	2	3	4	0	2	3
Y	44	24	20	23	21	21	20	19	20	22	24	27
ZN	113	75	86	105	85	88	106	61	80	50	41	47
ZR	122	147	107	129	162	138	82	110	113	152	221	216

Var.\ID:	BXS3037	BXS3036	BXS3035	BXS3034	BXS3033	BXS3032	BXS3031	BXS3030	BXS3029	BXS3080	BXS3081	BXS3082
SIO2	65.55	73.46	69.63	69.29	64.06	61.53	57.81	56.64	53.72	54.64	54.07	58.12
AL2O3	15.44	14.15	14.77	14.23	16.19	16.82	17.03	18.12	19.74	19.77	19.70	17.89
TIO2	1.60	1.62	1.48	1.69	2.13	2.78	3.04	2.85	2.91	3.72	3.48	2.63
FE2O3	10.19	6.28	6.20	5.82	8.36	9.23	9.86	11.19	12.30	13.28	13.02	9.72
MGO	0.39	0.00	0.00	0.28	0.00	0.00	0.66	0.00	1.45	0.00	0.00	1.54
CAO	3.85	3.71	3.55	3.73	4.42	5.07	5.86	5.90	6.40	6.07	5.98	5.44
NA2O	0.90	0.56	0.81	0.74	0.82	0.99	0.96	0.94	0.75	0.80	0.60	0.53
K2O	1.46	1.26	1.67	1.65	1.45	1.01	0.88	0.65	0.58	0.76	0.71	1.11
MNO	0.06	0.05	0.05	0.12	0.09	0.13	0.15	0.10	0.17	0.11	0.13	0.19
P2O5	0.08	0.02	0.08	0.12	0.17	0.21	0.26	0.24	0.31	0.32	0.38	0.34
BA	226	228	285	282	247	186	167	147	116	154	149	186
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	21	11	14	18	26	28	39	43	65	34	35	39
CR	184	154	143	148	180	198	237	234	287	291	304	208
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	16	11	13	13	19	18	29	36	44	38	37	30
GA	14	12	13	14	13	16	17	16	18	19	16	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	64	47	43	46	67	86	98	100	131	116	118	86
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	18	15	14	15	14	8	12	11	7	12	13
RB	50	43	55	54	49	33	30	25	26	31	32	42
SC	34	19	19	16	28	36	46	49	51	53	47	39
SR	158	129	136	124	141	145	158	155	132	115	99	98
S	171	310	166	231	160	233	326	449	258	352	463	272
SN	2	0	3	4	2	3	2	2	2	4	10	10
V	155	139	114	106	142	160	201	197	216	261	245	187
W	1	4	6	4	0	5	4	5	4	3	4	6
Y	26	28	30	32	33	22	25	24	29	37	31	32
ZN	36	30	30	33	43	32	39	41	57	55	67	60
ZR	237	302	366	376	318	272	238	212	172	243	253	303

	NAS145/cont.											
Var.\ID:	BXS3083	BXS3084	BXS3085	BXS3086	BXS3087	BXS3088	BXS3089	BXS3090	BXS3100	BXS3101	BXS3102	BXS3103
SIO2	54.03	56.62	60.21	53.12	56.58	56.73	54.22	49.46	56.38	56.44	55.36	56.51
AL2O3	20.26	15.67	17.27	19.43	21.55	16.98	24.59	21.90	21.14	21.70	20.64	19.90
TIO2	3.58	2.93	2.63	1.73	2.25	2.82	2.00	2.33	2.06	1.81	2.13	2.63
FE2O3	13.46	10.19	9.62	13.16	11.15	10.44	12.53	14.23	11.15	11.05	11.54	11.86
MGO	0.37	2.49	1.25	5.43	1.65	2.42	0.60	2.28	1.75	1.64	2.26	0.57
CAO	6.55	6.14	5.62	6.52	6.82	6.24	6.93	7.28	6.41	6.11	6.41	5.76
NA2O	0.56	0.45	0.46	0.20	0.22	0.47	0.28	0.81	0.41	0.46	0.42	0.54
K2O	0.88	0.94	1.18	0.40	0.67	0.87	0.44	0.18	0.66	0.67	0.59	0.90
MNO	0.16	0.22	0.17	0.17	0.17	0.21	0.15	0.17	0.18	0.16	0.20	0.17
P2O5	0.35	0.50	0.36	0.32	0.36	0.43	0.34	0.35	0.38	0.35	0.41	0.45
BA	146	157	208	116	167	170	140	84	177	179	165	197
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	51	42	42	61	56	43	61	49	50	58	53	58
CR	288	236	222	307	299	221	174	251	186	165	245	148
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	35	28	24	51	30	35	39	72	50	44	49	46
GA	18	16	15	16	18	16	21	22	19	18	19	20
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	133	112	102	266	150	126	144	131	142	134	140	97
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	16	16	11	9	13	12	7	14	17	17	17
RB	35	37	45	24	36	36	25	17	32	33	30	39
SC	53	42	35	46	46	45	74	83	54	52	60	51
SR	91	101	99	77	94	102	92	114	104	107	99	96
S	165	773	448	353	363	541	229	140	454	406	487	491
SN	5	11	3	3	3	9	0	0	3	1	3	5
V	264	217	195	167	212	235	220	334	222	198	230	256
W	5	5	3	1	6	4	0	6	4	3	5	2
Y	35	34	32	35	31	33	32	65	30	36	39	33
ZN	67	88	75	66	69	86	72	88	89	80	88	108
ZR	239	271	317	175	217	250	169	106	210	204	201	257

											NAS145	NAS146
Var.\ID:	BXS3104	BXS3105	BXS3106	BXS3107	BXS3108	BXS3109	BXS3110	BXS3111	BXS3112	BXS3113	BXS3114	BXB3099
SIO2	55.12	55.95	56.82	55.40	53.63	55.20	57.50	58.45	56.31	55.00	60.03	44.02
AL2O3	19.68	19.58	17.96	20.17	19.91	25.78	22.36	16.94	20.14	20.81	16.98	5.62
TIO2	2.09	2.29	1.89	1.84	1.66	1.07	1.41	1.79	1.39	1.78	1.57	1.77
FE2O3	12.30	11.81	9.95	11.16	11.28	11.75	9.67	8.15	8.85	9.81	7.47	12.23
MGO	2.55	2.21	3.62	2.94	3.29	1.93	2.35	4.42	3.34	2.68	4.23	24.25
CAO	6.03	6.43	6.48	6.87	6.43	7.09	6.72	6.63	6.93	7.13	6.55	5.30
NA2O	0.39	0.32	0.45	0.51	0.37	0.01	0.22	0.35	0.38	1.28	0.34	0.28
K2O	0.57	0.64	0.64	0.41	0.37	0.09	0.41	0.73	0.47	0.42	0.74	0.10
MNO	0.20	0.20	0.22	0.20	0.20	0.15	0.18	0.26	0.19	0.15	0.24	0.19
P2O5	0.45	0.46	0.45	0.42	0.46	0.30	0.36	0.46	0.40	0.29	0.42	0.14
BA	148	159	145	142	130	156	208	162	206	115	155	23
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	59	59	56	55	96	51	41	62	41	41	35	87
CR	204	231	267	248	242	314	282	248	367	262	267	1513
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	36	39	34	32	36	31	28	31	30	19	29	41
GA	21	19	16	18	19	21	19	16	17	17	15	7
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	116	118	128	135	136	182	148	122	194	126	130	1488
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	14	15	18	14	13	5	12	15	17	12	13	6
RB	30	32	30	25	24	19	27	32	24	21	34	4
SC	53	47	44	52	53	65	45	35	36	47	35	32
SR	106	107	120	110	106	92	115	109	129	225	118	43
S	541	522	720	548	560	251	351	616	645	317	690	40
SN	10	7	11	15	6	16	4	2	3	2	4	0
V	255	243	183	175	162	150	138	160	130	135	128	223
W	5	4	6	3	8	2	3	3	4	4	3	2
Y	41	39	33	35	44	29	32	30	25	29	25	15
ZN	102	102	93	88	93	61	83	105	91	70	96	69
ZR	210	257	216	180	154	108	205	243	181	200	240	59

NAS146/cont.

Var.\ID:	BXB3098	BXB3097	BXB3096	BXB3095	BXB3094	BXB3093	BXB3092	BXB3091	BXB3079	BXB3078	BXB3077	BXB3076
SI02	45.56	45.66	46.64	46.66	45.20	48.28	47.30	43.08	40.42	48.67	44.45	50.07
AL203	4.55	1.53	6.12	6.03	8.15	14.46	7.24	11.98	15.39	14.83	12.98	12.98
TI02	1.23	0.38	1.28	3.40	3.49	2.60	3.45	6.63	7.46	2.12	4.52	1.68
FE203	12.16	9.16	11.46	14.02	17.79	13.83	18.11	17.71	21.76	11.40	19.05	11.88
MGO	29.34	38.72	24.40	16.37	12.96	4.92	13.15	3.11	0.00	7.46	4.03	9.68
CAO	3.67	1.35	5.33	6.65	5.58	7.08	6.17	7.55	7.45	8.13	6.02	7.35
NA20	0.08	0.00	0.27	0.79	0.90	2.27	0.52	2.07	2.23	1.71	1.51	1.98
K20	0.05	0.06	0.11	0.33	0.24	0.36	0.25	0.80	0.44	0.54	0.76	0.55
MNO	0.18	0.17	0.18	0.37	0.23	0.16	0.32	0.21	0.18	0.18	0.18	0.18
P205	0.09	0.03	0.07	0.28	0.22	0.23	0.23	0.41	0.54	0.36	0.48	0.17
BA	72	27	81	47	22	71	25	40	70	44	59	19
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	82	107	81	149	117	47	143	66	65	50	62	53
CR	1421	2138	1438	2585	2075	194	2519	65	118	293	93	220
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	46	24	29	64	70	67	86	58	83	40	73	29
GA	6	2	9	13	12	20	13	16	25	17	20	15
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1486	2244	1352	1873	1599	139	1412	61	104	170	122	131
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	5	8	4	8	8	7	5	14	9	6	7	11
RB	2	2	3	6	7	7	6	15	13	11	18	12
SC	24	18	20	42	60	63	55	75	98	36	81	47
SR	36	11	69	150	139	234	85	241	181	332	267	284
S	43	195	40	31	59	131	33	25	233	81	56	9
SN	0	0	0	0	0	0	2	2	4	4	0	0
V	158	80	145	347	415	344	425	707	880	156	468	180
W	2	8	6	0	2	5	5	7	11	2	5	7
Y	9	3	10	19	23	33	23	23	40	27	41	18
ZN	69	45	67	87	98	65	114	158	116	66	110	73
ZR	45	25	45	66	72	84	76	95	110	153	114	57

Var.\ID:	NULL	BXB3074	BXB3073	BXB3072	BXB3041	BXB3040	BXB3039	BXB3038	BXB3037	BXB3036	BXB3035	BXB3034
SI02	n.a	42.43	48.04	48.19	45.05	43.85	42.28	53.51	50.44	54.24	51.33	52.19
AL203	n.a	12.59	13.64	13.42	11.50	10.82	11.25	16.19	15.08	16.38	14.04	15.98
TI02	n.a	6.29	2.23	4.16	5.31	6.30	6.74	0.72	2.01	1.17	1.26	2.42
FE203	n.a	17.11	11.99	13.49	15.57	17.73	14.77	7.41	12.23	7.48	9.30	11.08
MGO	n.a	2.08	9.04	3.65	5.07	5.35	3.14	7.67	7.29	8.42	9.25	4.51
CAO	n.a	7.73	8.35	5.93	8.64	7.70	9.92	8.32	7.84	8.35	10.40	3.61
NA20	n.a	2.26	2.33	2.72	1.78	1.64	2.31	1.69	1.07	1.23	1.10	2.39
K20	n.a	0.38	0.29	1.10	0.41	0.58	0.42	0.81	0.62	1.10	0.73	1.87
MNO	n.a	0.18	0.18	0.16	0.17	0.14	0.19	0.09	0.14	0.16	0.12	0.10
P205	n.a	0.45	0.36	0.36	0.32	0.36	0.41	0.10	0.37	0.21	0.13	0.48
BA	n.a	30	31	28	28	26	18	51	27	101	104	16
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	n.a	52	50	55	56	57	60	33	34	37	38	46
CR	n.a	73	401	53	53	70	88	275	334	223	352	274
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	n.a	39	54	113	27	62	76	10	17	23	5	65
GA	n.a	18	17	17	20	18	18	13	18	14	15	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	n.a	121	224	91	69	94	117	128	158	159	114	113
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	n.a	6	10	7	9	10	9	8	7	10	10	18
RB	n.a	9	8	24	13	18	11	39	34	37	26	25
SC	n.a	82	33	82	86	86	83	45	39	49	55	32
SR	n.a	198	346	211	281	155	213	283	327	348	644	157
S	n.a	0	7	3	46	1	37	74	1	13	62	0
SN	n.a	0	1	4	2	0	0	2	0	0	0	1
V	n.a	538	157	346	548	606	440	119	131	124	182	160
W	n.a	3	2	0	0	0	2	3	9	6	0	5
Y	n.a	24	22	20	26	25	26	15	21	21	25	21
ZN	n.a	68	90	68	96	139	75	37	82	80	29	110
ZR	n.a	100	134	93	110	105	116	61	138	99	88	165

NAS146/cont.

Var.\ID:	BXB3033	BXB3032	BXB3031	BXB3030	BXB3029	BXB3080	BXB3081	BXB3082	BXB3083	BXB3084	BXB3085	BXB3086
SIO2	55.73	53.51	52.80	53.82	52.12	52.83	52.56	52.28	51.12	47.35	54.42	54.03
AL2O3	16.44	16.74	16.96	17.88	19.84	19.87	22.40	17.14	22.14	18.67	17.12	20.87
TIO2	1.11	1.24	0.79	0.78	1.76	1.38	2.20	1.35	3.51	4.90	1.39	1.15
FE2O3	4.75	7.50	9.55	7.83	10.74	8.95	12.57	9.92	13.24	14.56	10.11	9.34
MGO	10.52	6.93	5.53	6.05	3.47	4.92	1.38	7.26	1.38	0.98	7.07	4.48
CAO	7.02	7.47	6.76	7.91	7.17	8.78	7.08	9.57	7.13	8.46	6.99	6.93
NA2O	1.79	1.95	2.26	2.24	0.98	1.29	0.58	1.64	0.75	1.11	1.53	1.38
K2O	0.99	0.86	0.44	0.38	0.16	0.12	0.18	0.19	0.26	0.22	0.83	0.56
MNO	0.32	0.19	0.08	0.13	0.16	0.17	0.13	0.16	0.20	0.19	0.15	0.14
P2O5	0.26	0.23	0.11	0.14	0.24	0.20	0.28	0.14	0.40	0.51	0.19	0.29
BA	96	105	44	55	67	107	101	81	72	57	113	125
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	42	38	29	34	50	43	59	42	59	51	45	33
CR	341	113	79	92	238	241	376	144	187	109	119	214
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	117	16	26	30	57	45	60	22	36	23	16	34
GA	17	15	17	15	16	16	18	15	19	19	15	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	183	120	81	92	142	136	138	108	125	102	109	121
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	13	12	9	4	8	8	14	8	8	10	9	7
RB	24	27	17	16	11	9	16	11	15	16	33	23
SC	56	53	64	59	62	50	61	60	73	61	62	48
SR	339	330	241	247	156	186	128	164	96	124	160	238
S	14	20	41	26	128	34	315	64	99	66	37	69
SN	0	0	0	0	0	0	9	0	0	2	2	5
V	141	131	110	111	147	156	191	166	224	274	134	121
W	4	0	4	4	0	5	3	12	4	4	3	4
Y	19	18	13	15	24	24	32	20	32	37	26	29
ZN	71	36	50	32	44	40	52	49	72	57	57	48
ZR	57	62	35	45	83	64	121	60	141	169	94	121

Var.\ID:	BXB3087	BXB3088	BXB3089	BXB3090	BXB3100	BXB3101	BXB3102	BXB3103	BXB3104	BXB3105	BXB3106	BXB3107
SIO2	53.07	52.69	53.06	48.76	50.54	53.12	51.89	50.31	52.06	52.43	52.12	53.04
AL2O3	23.39	21.31	24.15	17.00	21.40	21.77	24.45	20.20	22.43	22.17	21.50	22.39
TIO2	2.51	1.25	1.47	3.67	3.86	1.84	2.44	3.48	2.63	1.98	2.07	1.70
FE2O3	11.34	9.91	10.87	18.01	14.21	11.97	14.08	14.23	13.69	14.55	12.95	11.70
MGO	1.16	5.35	2.56	2.08	0.70	3.67	0.96	1.77	1.37	3.35	2.65	3.26
CAO	7.29	7.83	8.65	5.94	7.46	7.78	6.91	7.68	7.99	6.80	7.89	7.89
NA2O	0.14	0.75	0.55	1.37	1.00	0.73	0.23	1.66	0.96	0.51	1.05	1.02
K2O	0.40	0.34	0.23	0.55	0.26	0.16	0.17	0.24	0.22	0.00	0.17	0.05
MNO	0.17	0.14	0.14	0.14	0.20	0.19	0.18	0.21	0.18	0.20	0.18	0.18
P2O5	0.37	0.24	0.25	0.29	0.44	0.34	0.37	0.51	0.38	0.40	0.55	0.35
BA	136	119	141	46	127	92	139	94	105	121	124	64
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	55	43	52	53	56	48	63	49	52	42	47	42
CR	376	454	173	129	124	187	209	65	117	206	142	289
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	20	41	25	40	58	69	50	43	16	37	19	41
GA	17	16	18	19	22	18	21	22	21	19	18	20
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	167	233	157	78	104	128	150	68	80	121	109	127
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	11	11	8	13	11	6	10	5	11	8	8	8
RB	25	16	19	22	17	13	18	13	14	10	18	12
SC	61	46	70	74	87	71	85	80	73	62	57	65
SR	84	142	113	139	115	130	89	127	191	114	135	154
S	248	141	132	43	175	150	222	57	105	93	72	111
SN	1	0	1	3	0	1	6	1	1	2	0	1
V	195	119	162	457	312	186	212	292	259	216	184	173
W	4	3	6	1	10	2	3	2	3	4	8	3
Y	28	34	42	43	52	57	61	101	66	56	61	43
ZN	47	54	53	66	73	67	71	90	46	80	59	62
ZR	169	105	117	87	143	122	147	207	227	111	142	97

	NAS146/cont.						NAS146	NAS147				
Var.\ID:	BXB3108	BXB3109	BXB3110	BXB3111	BXB3112	BXB3113	BXB3114	BXS3127	BXS3126	BXS3125	BXS3124	NULL
SIO2	51.18	54.05	53.93	55.34	53.88	53.90	55.17	51.61	55.90	49.89	50.92	n.a
AL2O3	23.13	22.69	19.61	23.01	21.03	19.46	17.16	14.24	15.98	16.67	11.80	n.a
TIO2	2.28	1.17	1.66	1.61	1.18	1.27	0.97	4.86	1.90	1.85	2.38	n.a
FE2O3	14.63	10.60	9.60	8.97	10.30	9.67	8.20	12.78	9.19	13.64	13.49	n.a
MGO	2.10	3.52	4.51	2.72	5.41	5.68	7.27	0.00	2.58	4.13	9.05	n.a
CAO	7.66	8.62	8.57	7.76	7.26	8.73	8.18	6.46	5.69	6.36	5.51	n.a
NA2O	0.45	0.66	2.09	0.65	0.48	1.44	1.74	1.38	1.57	1.22	0.70	n.a
K2O	0.00	0.00	0.08	0.22	0.26	0.20	0.45	0.59	0.84	0.35	0.46	n.a
MNO	0.20	0.14	0.15	0.18	0.18	0.15	0.21	0.12	0.10	0.12	0.18	n.a
P2O5	0.47	0.23	0.17	0.28	0.28	0.15	0.18	0.30	0.18	0.19	0.20	n.a
BA	89	97	59	102	177	97	97	80	103	63	90	n.a
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	51	44	35	43	48	34	48	33	29	39	70	n.a
CR	205	278	145	331	513	97	138	245	341	344	1312	n.a
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	41	15	13	15	31	9	33	43	20	36	33	n.a
GA	21	17	18	17	14	15	14	17	14	17	13	n.a
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	126	148	104	173	230	79	100	153	106	247	1009	n.a
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	7	10	8	6	16	10	8	11	10	12	10	n.a
RB	11	13	7	16	16	10	14	18	22	13	15	n.a
SC	67	52	48	48	43	55	57	77	40	58	39	n.a
SR	115	149	184	125	121	178	214	246	282	260	170	n.a
S	136	99	35	106	260	37	103	663	437	546	516	n.a
SN	6	0	0	2	0	1	0	6	5	2	4	n.a
V	230	124	157	128	121	174	139	486	209	292	235	n.a
W	4	6	5	2	4	2	2	13	5	10	12	n.a
Y	81	41	38	35	25	25	20	17	14	13	14	n.a
ZN	85	31	41	41	58	37	41	46	37	40	60	n.a
ZR	113	114	183	202	141	81	87	158	143	89	150	n.a

Var.\ID:	BXS3071	BXS3070	BXS3069	BXS3068	BXS3067	BXS3066	BXS3065	BXS3064	BXS3063	BXS3062	BXS3061	BXS3060
SIO2	51.88	56.01	50.84	55.89	53.49	49.02	50.30	53.80	53.50	55.57	55.07	53.20
AL2O3	14.07	11.10	11.60	19.33	20.58	19.22	13.97	13.78	21.41	20.78	20.73	14.61
TIO2	2.87	2.17	1.62	1.71	1.29	2.31	0.85	1.00	1.47	0.99	1.01	1.45
FE2O3	14.94	9.76	16.22	12.08	11.22	16.74	13.15	10.43	10.88	11.50	11.56	14.47
MGO	5.45	9.16	12.14	3.09	2.99	4.48	12.63	11.52	2.25	2.21	2.74	7.08
CAO	5.09	4.98	4.82	5.36	5.85	5.43	5.55	5.41	7.35	5.24	5.45	5.26
NA2O	0.99	0.82	0.70	1.14	1.22	0.93	0.69	0.61	1.20	1.31	1.22	0.93
K2O	0.68	0.84	0.46	0.82	0.35	0.14	0.23	0.44	0.21	0.34	0.59	0.40
MNO	0.15	0.21	0.18	0.08	0.08	0.10	0.13	0.15	0.09	0.09	0.07	0.15
P2O5	0.25	0.22	0.13	0.17	0.21	0.24	0.13	0.13	0.21	0.18	0.19	0.14
BA	116	162	99	158	150	74	118	136	95	140	161	91
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	87	62	116	40	47	60	72	69	44	45	43	64
CR	1988	1744	2812	795	419	712	1433	764	462	265	298	514
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	42	15	32	29	35	47	19	25	15	44	32	101
GA	14	12	14	15	15	19	13	11	15	15	16	13
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1122	781	2040	560	415	677	1226	965	425	299	425	338
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	14	11	10	16	7	14	11	13	11	10	9	14
RB	22	25	19	35	19	13	14	16	16	18	23	17
SC	42	29	38	46	56	72	42	32	63	58	61	48
SR	166	128	112	143	128	100	99	96	336	166	165	148
S	345	397	158	333	434	363	477	371	390	407	511	297
SN	53	3	3	2	0	6	5	0	3	2	0	0
V	215	153	164	170	149	236	146	113	178	109	136	153
W	7	1	5	5	7	4	2	6	4	1	1	0
Y	21	22	28	21	15	16	20	15	23	16	17	20
ZN	66	54	73	51	47	71	55	49	35	32	49	71
ZR	138	195	108	139	102	111	70	109	94	91	90	102

NAS147/cont.

Var.\ID:	BXS3059	BXS3058	BXS3057	BXS3056	BXS3055	BXS3054	BXS3053	BXS3052	BXS3051	BXS3050	BXS3049	BXS3048
SIO2	54.42	53.10	52.15	57.63	53.47	55.11	52.78	59.09	52.91	50.99	52.72	50.92
AL2O3	12.17	9.74	11.15	14.18	9.76	13.38	7.60	11.83	8.29	13.16	12.39	15.78
TIO2	1.22	1.31	0.75	1.59	1.09	2.17	0.35	1.32	0.62	0.89	0.67	0.63
FE2O3	12.60	15.11	14.18	13.41	12.39	11.39	15.67	9.55	15.12	10.71	6.71	9.29
MGO	11.82	11.80	15.72	5.39	14.20	7.19	15.47	8.61	14.64	10.18	17.58	15.05
CAO	5.09	4.12	4.83	4.11	4.03	5.24	3.30	5.27	4.14	8.13	6.30	6.93
NA2O	0.52	0.37	0.23	0.61	0.39	0.84	0.17	0.86	0.23	1.22	0.24	0.09
K2O	0.46	0.65	0.44	0.95	0.41	0.90	0.10	0.83	0.30	0.14	0.16	0.00
MNO	0.21	0.29	0.19	0.12	0.15	0.20	0.06	0.17	0.20	0.13	0.18	0.12
P2O5	0.14	0.25	0.07	0.12	0.12	0.19	0.00	0.10	0.06	0.06	0.11	0.09
BA	155	182	140	173	143	157	74	179	119	79	94	69
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	106	132	106	71	78	100	108	66	87	33	50	46
CR	1247	2570	1554	1732	1657	2104	2390	1394	2038	351	633	409
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	38	37	35	31	26	35	47	22	46	22	40	23
GA	13	9	10	12	9	13	6	9	7	11	9	9
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1095	1861	1735	1164	1252	1028	2137	547	1856	366	936	1201
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	11	10	12	9	6	8	6	10	9	5	7	4
RB	16	19	14	33	15	7	23	7	15	6	6	5
SC	39	32	33	37	26	40	26	30	33	63	28	29
SR	98	91	61	107	91	211	149	35	53	167	99	58
S	333	527	166	228	261	167	215	205	211	164	221	370
SN	0	0	2	2	2	4	0	3	0	0	0	0
V	156	150	109	141	108	181	79	140	107	174	93	100
W	0	1	6	4	3	13	5	0	1	1	3	1
Y	18	20	15	21	15	21	9	13	11	14	14	12
ZN	54	82	61	61	52	56	48	48	59	27	35	31
ZR	111	123	70	180	109	139	44	127	61	40	52	32

Var.\ID:	BXS3047	BXS3046	BXS3045	BXS3044	BXS3043	BXS3042	S-1184	S-1185	S-1186	S-1187	S-1188	S-1189
SIO2	50.40	51.42	49.83	49.94	54.46	54.10	59.32	67.66	67.75	65.75	68.07	68.73
AL2O3	13.74	11.75	1.21	11.93	11.31	14.58	13.74	12.01	13.37	13.88	12.41	11.03
TIO2	0.60	0.87	0.77	1.23	1.17	1.44	2.09	1.57	1.15	1.09	1.08	1.02
FE2O3	6.93	14.43	9.25	11.15	9.48	10.54	7.55	6.18	6.17	8.01	6.25	8.25
MGO	13.66	13.78	30.30	10.00	10.79	6.79	2.51	0.74	0.16	0.65	0.79	1.82
CAO	7.34	4.77	4.23	5.89	6.86	6.43	4.72	3.03	2.65	2.57	2.54	2.43
NA2O	2.36	0.24	0.00	0.86	0.99	0.92	0.63	0.58	0.47	0.52	0.42	0.36
K2O	0.56	0.08	0.66	0.45	0.70	0.53	0.48	1.60	1.79	1.83	1.78	1.60
MNO	0.14	0.14	0.67	0.14	0.17	0.16	0.10	0.08	0.06	0.05	0.07	0.08
P2O5	0.09	0.07	0.27	0.16	0.09	0.20	0.17	0.22	0.21	0.17	0.19	0.16
BA	85	105	172	139	126	156	167	250	339	362	352	310
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	38	70	208	47	37	49	57	23	15	19	20	32
CR	356	849	2925	649	516	612	830	511	254	325	326	628
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	14	40	19	29	53	49	12	9	6	8	7	7
GA	10	8	5	12	10	11	12	10	12	11	12	10
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	301	747	2936	583	271	507	373	169	92	126	113	159
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	11	19	23	25	13	12	13	20	22	21	22	23
RB	11	7	7	13	15	17	18	59	71	70	67	60
SC	38	49	30	51	45	52	30	13	13	10	12	12
SR	149	98	43	153	172	172	117	90	83	88	81	77
S	261	221	257	332	410	710	n.a	n.a	n.a	n.a	n.a	n.a
SN	0	0	0	1	0	0	n.a	n.a	n.a	n.a	n.a	n.a
V	118	150	120	142	140	156	111	65	57	66	58	64
W	0	2	6	7	3	2	n.a	n.a	n.a	n.a	n.a	n.a
Y	11	12	9	10	13	15	19	24	23	22	24	24
ZN	92	91	150	81	77	64	71	47	43	38	39	39
ZR	33	49	44	65	71	89	120	354	393	390	381	374

	NAS147/cont.											
Var.\ID:	S-1190	S-1191	S-1192	S-1193	S-1194	S-1195	S-1196	S-1197	S-1198	S-1199	S-1200	S-1201
SIO2	70.61	70.01	70.48	69.45	69.63	71.99	69.57	67.64	66.12	63.59	68.59	71.40
AL2O3	13.34	11.43	11.16	12.58	14.74	12.59	14.02	11.21	14.45	12.88	12.72	13.84
TIO2	0.99	1.03	0.97	0.99	0.82	0.99	0.88	0.96	1.00	1.02	0.86	0.94
FE2O3	5.80	5.09	4.57	5.74	5.99	6.05	5.45	7.17	7.06	9.55	6.71	5.03
MGO	0.37	0.88	1.10	0.43	0.00	0.00	0.00	3.01	2.14	5.47	1.31	0.00
CAO	2.83	2.61	2.66	2.52	2.29	2.36	2.30	2.35	3.45	3.63	2.72	2.73
NA2O	0.30	0.41	0.41	0.53	0.68	0.59	0.59	0.56	0.97	0.50	0.32	0.48
K2O	1.84	1.74	1.73	1.84	2.05	1.99	2.01	1.80	1.63	1.02	1.76	1.91
MNO	0.06	0.07	0.07	0.05	0.03	0.04	0.04	0.13	0.05	0.08	0.07	0.04
P2O5	0.21	0.18	0.16	0.13	0.08	0.06	0.10	0.10	0.06	0.05	0.19	0.13
BA	357	338	321	349	366	369	365	352	327	253	335	344
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	29	26	30	20	15	18	20	79	26	51	24	13
CR	263	279	364	358	196	338	204	692	619	1295	437	300
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	9	8	9	6	10	5	6	8	10	14	8	7
GA	11	10	10	11	9	11	11	9	13	12	11	12
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	107	107	127	105	91	127	98	203	260	552	167	96
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	27	20	19	30	19	17	21	24	15	15	26	22
RB	72	66	64	72	75	72	76	59	48	36	65	70
SC	7	10	10	10	14	6	9	9	20	28	11	10
SR	82	90	89	88	82	88	78	71	128	96	75	85
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	53	50	50	58	53	47	51	57	79	86	56	50
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	24	25	24	24	25	26	23	22	21	19	25	23
ZN	54	41	41	42	38	38	39	42	39	69	43	32
ZR	390	396	408	412	402	408	406	342	298	208	365	400

					NAS147	NAS148						
Var.\ID:	S-1202	S-1203	S-1204	S-1205	S-1206	BXB3127	BXB3126	BXB3125	BXB3124	BXB3123	BXB3071	BXB3070
SIO2	76.59	70.50	70.06	69.43	71.75	47.66	53.32	51.64	47.58	45.40	47.21	48.27
AL2O3	12.32	15.57	14.80	13.81	13.33	12.26	13.59	12.71	7.03	7.68	7.46	3.17
TIO2	1.05	0.95	0.90	0.93	0.91	4.52	1.19	1.58	1.44	3.40	1.09	0.76
FE2O3	4.27	7.12	7.31	6.93	7.33	12.72	9.64	9.81	9.90	11.57	10.24	7.17
MGO	0.00	0.00	0.00	0.91	0.00	5.69	9.29	10.78	27.32	21.57	26.11	30.93
CAO	2.73	2.65	2.29	2.65	2.39	9.39	8.75	8.86	6.21	7.74	5.70	5.06
NA2O	0.51	0.51	0.54	0.58	0.56	2.23	2.00	2.21	0.20	0.56	0.09	0.00
K2O	1.69	2.01	2.08	1.96	1.82	0.41	0.39	0.66	0.06	0.05	0.02	0.24
MNO	0.04	0.03	0.03	0.09	0.06	0.16	0.14	0.14	0.19	0.15	0.18	0.34
P2O5	0.03	0.08	0.07	0.08	0.07	0.28	0.10	0.06	0.11	0.16	0.13	0.14
BA	349	404	407	390	382	43	78	21	98	26	75	59
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	21	25	30	38	25	47	38	46	78	61	67	89
CR	381	340	165	281	221	154	201	146	809	687	975	2880
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	4	8	7	6	6	41	38	22	28	53	18	13
GA	11	13	12	12	10	15	14	14	8	10	10	6
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	93	122	69	98	59	147	131	243	1002	686	1182	2087
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	20	22	20	18	17	6	8	11	9	9	6	5
RB	65	77	85	74	70	12	10	16	3	3	4	4
SC	6	12	7	11	6	68	51	61	30	40	26	26
SR	91	78	80	89	80	236	284	239	63	69	42	21
S	n.a	n.a	n.a	n.a	n.a	305	30	320	87	34	92	121
SN	n.a	n.a	n.a	n.a	n.a	2	3	0	2	2	4	0
V	48	60	53	55	46	371	160	174	138	240	101	106
W	n.a	n.a	n.a	n.a	n.a	3	0	1	4	3	3	5
Y	26	25	28	25	23	22	18	18	16	19	17	15
ZN	24	38	30	34	30	50	44	46	54	56	52	54
ZR	401	343	403	374	414	102	49	50	73	87	106	43

NAS148/cont.

Var.\ID:	BXB3069	BXB3068	BXB3067	BXB3066	BXB3065	BXB3064	BXB3063	BXB3062	BXB3061	BXB3060	BXB3059	BXB3058
SI02	50.82	51.23	51.23	52.78	48.71	51.94	52.26	51.70	53.05	47.53	48.80	49.22
AL203	0.00	5.84	18.49	17.07	10.22	13.32	16.61	8.27	15.18	7.31	6.93	0.55
TI02	0.66	0.42	0.67	0.56	1.79	0.41	0.99	0.63	0.46	1.84	0.35	0.35
FE203	5.33	12.87	8.63	8.06	10.90	5.85	9.79	13.85	9.19	10.65	10.42	9.75
MGO	37.12	24.08	7.46	10.33	18.77	14.24	8.60	17.64	10.36	21.68	26.65	34.89
CAO	5.84	4.74	8.05	8.18	6.40	8.01	8.72	6.24	8.62	7.78	6.89	3.76
NA20	0.00	0.12	1.24	1.93	0.93	2.30	1.68	0.55	1.08	0.29	0.39	0.00
K20	0.55	0.23	0.40	0.28	0.31	0.98	0.15	0.03	0.26	0.03	0.02	0.25
MNO	0.74	0.34	0.10	0.12	0.18	0.13	0.11	0.19	0.09	0.18	0.17	0.42
P205	0.28	0.07	0.16	0.08	0.12	0.05	0.11	0.03	0.02	0.08	0.00	0.09
BA	155	59	113	57	38	62	90	49	38	16	36	43
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	133	166	30	53	50	36	40	106	41	67	87	120
CR	3145	2973	98	98	408	100	282	1727	79	639	967	2327
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	44	111	54	24	28	25	15	68	51	30	31	90
GA	6	8	13	10	11	11	13	10	12	11	6	4
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	4468	2650	315	382	783	243	325	1294	251	715	1136	2477
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	6	9	9	6	10	8	10	15	9	9	7	4
RB	5	7	16	11	11	21	9	2	16	4	4	2
SC	22	37	47	34	51	38	44	38	53	41	36	21
SR	25	43	196	150	114	148	328	128	170	68	76	33
S	68	54	59	120	72	27	56	8	11	0	43	100
SN	0	3	3	0	0	0	2	0	0	0	0	0
V	109	81	109	90	167	105	150	101	105	177	99	78
W	2	5	2	3	3	1	7	4	5	8	2	7
Y	26	18	25	17	19	10	24	18	11	23	8	7
ZN	62	85	52	58	107	110	28	95	38	72	49	78
ZR	39	29	41	34	56	26	48	53	30	68	25	31

Var.\ID:	BXB3057	BXB3056	BXB3055	BXB3054	BXB3053	BXB3052	BXB3051	BXB3050	BXB3049	BXB3048	BXB3047	BXB3046
SI02	47.78	50.13	49.04	45.85	50.05	50.76	47.73	45.96	47.95	44.38	46.67	46.05
AL203	9.19	4.65	6.72	1.80	4.63	12.44	4.99	7.12	8.81	3.99	5.02	4.73
TI02	0.39	0.62	0.74	0.30	0.34	0.77	0.26	0.66	1.97	0.22	0.25	0.32
FE203	7.69	11.93	11.13	7.70	11.22	6.74	10.12	8.20	11.75	9.61	11.07	12.27
MGO	21.40	26.44	24.28	34.15	25.10	12.97	28.93	22.78	18.86	31.05	32.65	30.92
CAO	7.64	3.15	4.20	1.58	4.63	8.08	3.97	5.71	5.68	3.75	3.07	4.15
NA20	0.84	0.11	0.15	0.12	0.01	2.37	0.11	1.16	0.66	0.27	0.03	0.05
K20	0.10	0.22	0.12	0.24	0.08	0.76	0.05	0.21	0.28	0.07	0.00	0.00
MNO	0.16	0.21	0.16	0.23	0.18	0.16	0.18	0.15	0.16	0.15	0.15	0.14
P205	0.07	0.07	0.08	0.10	0.03	0.09	0.03	0.07	0.12	0.03	0.01	0.00
BA	51	71	72	63	28	102	34	38	28	36	12	28
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	69	116	83	122	97	43	97	69	78	97	91	91
CR	812	2369	1246	2240	2068	442	1752	1004	1052	1764	1166	1265
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	26	40	34	30	42	17	41	31	41	27	63	57
GA	7	4	8	2	5	12	4	8	9	4	5	5
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	945	2424	1258	2400	1844	272	1916	1009	1036	1874	1276	1118
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	8	11	6	7	11	9	7	7	7	3	26	20
RB	5	8	7	2	4	12	3	4	9	1	2	2
SC	27	21	20	17	21	30	23	26	35	25	18	27
SR	85	41	50	14	29	159	29	134	91	25	33	30
S	79	145	74	77	187	105	125	45	216	99	78	56
SN	2	0	0	0	1	0	0	0	2	0	2	0
V	84	80	87	61	67	115	61	93	184	66	51	66
W	5	7	7	9	7	4	4	8	5	5	7	8
Y	11	12	14	9	10	12	7	9	11	5	6	9
ZN	53	63	59	48	53	37	54	46	54	45	180	75
ZR	23	50	69	22	30	53	25	35	68	23	21	24

	NAS148/cont.			NAS148	NAS149							
Var.\ID:	BXB3045	BXB3044	BXB3043	BXB3042	BXS3128	BXS3129	BXS3130	BXS3131	BXS3132	BXS3133	BXS3134	BXS3135
SIO2	48.20	49.50	51.90	49.72	53.71	55.70	52.97	56.90	54.21	56.28	52.76	54.49
AL2O3	1.45	12.84	11.21	12.89	11.39	17.05	16.19	18.18	18.95	17.66	16.16	14.56
TIO2	0.33	0.65	0.66	0.56	2.28	0.89	0.74	0.93	0.86	0.93	0.79	0.76
FE2O3	9.65	7.29	7.55	7.93	11.03	7.98	10.37	9.13	10.85	7.79	8.03	12.16
MGO	31.77	11.77	14.54	12.93	7.68	5.64	7.70	3.27	4.81	5.07	7.88	10.09
CAO	2.07	8.90	7.41	9.50	5.34	5.66	5.77	5.04	5.48	5.42	6.32	5.37
NA2O	0.00	2.30	1.60	2.28	1.07	1.42	1.23	1.09	1.14	1.16	1.35	0.57
K2O	0.29	0.60	1.09	0.41	0.95	0.79	0.61	0.67	0.49	0.87	0.71	0.58
MNO	0.33	0.12	0.14	0.14	0.26	0.16	0.17	0.10	0.10	0.16	0.18	0.25
P2O5	0.12	0.05	0.05	0.02	0.22	0.17	0.16	0.16	0.15	0.19	0.18	0.15
BA	78	59	76	47	106	157	123	148	117	173	113	144
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	133	34	46	47	51	53	62	32	38	54	61	65
CR	2653	164	196	252	392	698	1058	402	570	470	586	1170
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	17	32	70	66	38	32	28	36	40	35	35	47
GA	3	12	10	11	15	14	12	12	15	12	12	12
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	3164	291	221	322	243	443	535	237	350	275	446	735
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	19	11	13	16	10	13	9	14	11	12	8	10
RB	4	10	18	8	28	24	18	23	19	26	20	18
SC	20	46	46	42	53	34	37	44	46	36	38	45
SR	18	207	178	163	234	210	199	171	166	186	202	109
S	217	61	111	89	0	369	304	502	500	411	173	268
SN	0	0	0	0	5	3	0	3	4	1	0	2
V	61	124	119	129	276	119	144	107	130	131	137	158
W	2	1	6	3	4	9	7	3	0	5	1	0
Y	6	11	13	12	17	12	8	11	10	12	8	10
ZN	91	46	116	87	46	36	45	38	42	34	40	56
ZR	27	32	37	33	99	126	89	139	99	136	76	100

	NAS149	NAS150								NAS150	NAS151	
Var.\ID:	BXS3136	NULL	BXB3129	BXB3130	BXB3131	BXB3132	BXB3133	BXB3134	BXB3135	BXB3136	BXS4000	BXS4001
SIO2	60.44	n.a	52.57	51.60	53.52	54.09	53.55	51.28	51.14	54.11	51.48	46.19
AL2O3	17.07	n.a	9.98	8.43	14.70	23.03	18.25	16.41	9.69	14.87	15.20	16.49
TIO2	1.07	n.a	0.43	0.47	0.44	0.56	1.16	1.42	0.50	0.45	3.91	4.01
FE2O3	6.64	n.a	9.03	13.33	9.08	9.95	8.94	9.80	11.16	7.19	12.11	17.18
MGO	3.49	n.a	19.94	19.24	12.12	2.79	7.16	9.74	19.27	11.76	3.01	3.07
CAO	5.27	n.a	7.64	6.83	7.59	9.10	7.48	6.40	8.05	9.66	6.31	8.01
NA2O	1.29	n.a	0.17	0.21	1.46	1.04	1.97	1.56	0.29	1.88	0.74	0.94
K2O	1.23	n.a	0.12	0.10	0.11	0.00	0.25	0.28	0.13	0.50	1.10	0.42
MNO	0.12	n.a	0.32	0.36	0.19	0.08	0.14	0.16	0.32	0.16	0.26	0.19
P2O5	0.14	n.a	0.08	0.06	0.06	0.10	0.19	0.21	0.06	0.02	0.46	0.51
BA	203	n.a	54	47	46	64	79	85	49	31	152	83
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	31	n.a	106	157	57	28	46	52	110	40	62	63
CR	335	n.a	2084	3580	809	324	374	363	1336	347	267	111
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	12	n.a	23	71	76	49	57	67	64	57	26	44
GA	13	n.a	9	7	11	15	14	12	8	12	18	25
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	110	n.a	2036	2487	604	377	339	632	1298	195	128	137
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	12	n.a	8	8	13	7	7	9	7	9	14	8
RB	31	n.a	4	3	6	5	11	8	4	14	32	14
SC	34	n.a	38	47	45	56	39	39	41	46	52	83
SR	212	n.a	139	87	222	177	264	214	104	254	134	205
S	245	n.a	12	5	32	95	55	24	14	4	392	95
SN	8	n.a	0	0	0	2	0	0	0	0	1	0
V	125	n.a	96	110	97	116	91	90	115	101	343	457
W	6	n.a	7	6	0	5	8	0	7	0	4	15
Y	17	n.a	13	13	10	15	21	23	12	11	27	79
ZN	52	n.a	50	87	53	28	45	52	65	39	97	84
ZR	170	n.a	29	30	28	32	92	104	30	24	200	153

NAS151/cont.

Var.\ID:	BXS4002	BXS4003	BXS4004	BXS4005	BXS4006	BXS4007	BXS4008	BXS4009	BXS4010	BXS4011	BXS4012	BXS4013
SIO2	56.11	58.69	53.66	50.43	55.69	64.26	49.21	53.12	63.12	58.78	54.64	47.39
AL203	14.98	14.46	18.71	13.08	15.52	14.57	14.45	14.55	15.59	14.44	14.05	14.71
TIO2	3.73	3.27	3.67	4.68	2.95	3.72	4.54	4.51	3.04	3.18	4.12	7.26
FE203	11.43	11.07	13.49	14.02	11.44	8.76	19.72	14.89	10.72	10.69	10.82	12.14
MGO	1.84	1.40	0.00	2.85	2.33	0.00	0.62	0.00	0.00	0.36	0.09	0.00
CAO	6.26	5.63	5.95	5.78	4.96	4.78	5.09	4.68	4.43	4.79	5.37	7.41
NA20	0.66	0.57	1.18	1.04	0.92	1.13	1.31	1.22	0.99	1.24	1.54	1.83
K20	1.02	1.04	0.83	1.15	1.46	1.33	0.89	1.11	1.50	1.46	1.28	0.99
MNO	0.22	0.19	0.11	0.25	0.20	0.11	0.14	0.11	0.07	0.10	0.11	0.14
P205	0.47	0.44	0.33	0.39	0.31	0.26	0.31	0.30	0.17	0.22	0.30	0.46
BA	166	183	149	164	193	218	129	185	256	206	186	130
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	56	41	35	72	53	29	58	36	31	33	43	59
CR	236	270	246	212	248	248	211	282	240	340	382	549
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	31	36	25	23	25	19	25	17	21	25	28	25
GA	17	19	20	17	16	15	22	18	16	16	17	20
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	120	114	124	93	97	75	83	81	82	113	136	141
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	15	16	12	9	15	18	8	19	16	14	14	15
RB	38	40	27	32	43	43	24	34	48	42	36	24
SC	41	38	56	58	42	28	65	45	37	38	40	46
SR	133	127	183	172	153	142	168	159	160	219	242	309
S	513	482	363	200	338	390	265	290	223	117	300	607
SN	8	4	2	1	3	4	3	2	2	7	2	11
V	294	293	348	469	336	197	560	429	307	286	352	526
W	20	16	11	14	18	29	2	7	6	6	6	10
Y	34	28	29	34	27	26	19	23	28	28	28	21
ZN	107	107	63	63	62	60	67	50	49	53	57	68
ZR	237	256	208	238	264	333	174	274	310	238	225	161

Var.\ID:	BXS4014	BXS4015	BXS4016	BXS4017	BXS4018	BXS4019	BXS4020	BXS4021	BXS4022	BXS4023	BXS4024	BXS4025
SIO2	50.34	60.56	43.74	45.90	41.08	41.31	42.35	45.73	39.85	45.19	52.67	42.23
AL203	12.99	14.49	12.55	15.56	13.96	12.77	12.75	11.69	12.87	13.12	6.11	11.92
TIO2	3.95	1.99	2.79	5.62	6.29	5.63	5.22	5.87	5.71	4.49	1.13	4.63
FE203	9.33	8.69	19.47	18.56	19.06	21.51	19.83	15.68	21.55	18.84	11.37	14.78
MGO	1.38	2.35	5.50	0.00	0.00	2.52	3.71	3.63	2.01	4.07	22.34	4.51
CAO	5.92	4.70	5.83	6.00	5.52	5.68	5.78	5.26	5.62	5.00	3.43	7.49
NA20	1.67	1.04	1.17	1.43	1.75	1.50	1.46	1.52	1.63	1.45	0.12	2.42
K20	1.03	1.50	0.57	0.75	0.75	0.65	0.86	1.30	0.83	0.85	0.31	0.69
MNO	0.12	0.08	0.16	0.11	0.14	0.18	0.24	0.27	0.17	0.15	0.12	0.19
P205	0.34	0.15	0.26	0.38	0.46	0.38	0.41	0.48	0.42	0.31	0.05	0.41
BA	103	201	58	100	109	83	106	135	80	56	117	55
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	44	31	52	44	50	54	80	82	66	55	94	61
CR	264	305	93	157	164	133	219	440	259	187	3211	240
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	20	24	17	18	22	25	38	43	39	32	12	33
GA	17	15	20	21	22	20	20	19	21	19	6	21
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	108	137	89	116	107	149	224	392	261	268	1688	170
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	10	17	10	16	7	17	5	9	9	4	11	7
RB	26	48	21	22	21	23	22	26	34	28	11	17
SC	47	48	109	89	81	108	84	69	87	89	29	56
SR	225	181	286	185	219	211	237	178	243	185	40	211
S	12559	2318	156	333	335	248	371	471	331	161	294	209
SN	141	2	0	2	0	3	1	4	2	1	1	3
V	487	315	692	608	690	849	829	516	820	592	168	540
W	5	4	0	0	7	3	6	9	4	7	3	14
Y	24	33	35	26	23	24	21	15	25	33	12	27
ZN	69	66	42	71	71	94	70	78	87	87	109	81
ZR	155	258	94	145	146	118	117	116	114	174	91	122

	NAS151/cont.		NAS151	NAS152								
Var.\ID:	BXS4026	BXS4027	BXS4028	BXB4000	BXB4001	BXB4002	BXB4003	BXB4004	BXB4005	BXB4006	BXB4007	BXB4008
SIO2	50.63	47.23	41.32	54.91	54.67	45.02	45.19	44.69	46.09	46.77	42.90	45.20
AL2O3	12.08	12.82	16.01	20.55	15.40	14.42	14.74	15.27	12.49	11.43	11.10	12.47
TIO2	3.53	4.23	4.67	1.05	5.12	5.52	6.59	6.64	5.98	5.09	6.27	6.39
FE2O3	12.94	15.06	19.57	9.36	12.55	17.22	19.04	18.93	16.33	15.02	20.98	16.63
MGO	4.53	2.98	1.30	5.04	0.50	2.87	1.43	0.00	4.69	6.75	3.57	2.20
CAO	5.64	5.74	5.33	8.82	6.51	8.27	8.54	7.78	6.47	8.92	7.12	7.41
NA2O	1.00	1.36	1.49	1.35	0.94	2.27	0.98	2.48	1.60	1.55	1.68	2.06
K2O	0.89	0.95	0.60	0.72	1.29	0.71	0.98	0.56	1.15	0.75	1.02	1.05
MNO	0.18	0.18	0.17	0.13	0.23	0.19	0.19	0.19	0.19	0.37	0.23	0.23
P2O5	0.44	0.48	0.43	0.17	0.49	0.44	0.43	0.49	0.47	0.46	0.49	0.46
BA	123	121	92	87	161	61	59	43	72	54	53	49
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	70	58	55	36	10	55	66	75	73	69	77	74
CR	820	566	333	323	256	70	69	84	247	68	66	120
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	32	43	32	11	30	55	31	69	82	28	46	69
GA	16	18	22	16	17	22	22	22	20	23	22	22
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	337	294	319	157	116	82	104	119	75	100	96	90
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	13	15	9	3	17	11	5	2	15	9	11	5
RB	25	31	19	21	40	19	19	16	24	14	20	23
SC	49	62	91	43	40	72	81	73	80	73	88	71
SR	157	191	208	271	116	190	185	214	150	231	215	212
S	742	719	487	63	396	26	2	32	30	40	0	462
SN	6	4	0	0	12	1	1	1	0	0	2	2
V	344	499	649	137	324	631	554	684	636	664	783	694
W	2	3	6	2	7	0	0	1	0	19	4	1
Y	28	26	22	21	28	29	39	35	43	38	38	30
ZN	96	87	61	34	98	100	63	104	227	63	135	100
ZR	174	150	116	67	252	118	131	132	128	134	146	138

Var.\ID:	BXB4009	BXB4010	BXB4011	BXB4012	BXB4013	BXB4014	BXB4015	BXB4016	BXB4017	BXB4018	BXB4019	BXB4020
SIO2	45.87	52.74	43.37	43.86	44.73	51.93	53.07	45.60	43.42	45.96	44.89	44.42
AL2O3	12.80	15.12	10.91	11.44	10.70	13.44	13.78	11.38	11.14	12.24	13.91	12.53
TIO2	7.32	5.96	5.94	5.61	5.82	1.91	1.08	4.24	5.59	5.32	5.58	5.19
FE2O3	14.81	13.81	19.58	18.56	18.39	10.14	10.01	17.42	17.33	16.90	19.14	18.63
MGO	1.16	0.00	5.29	4.49	6.78	9.31	12.97	6.45	4.98	4.80	2.68	3.64
CAO	8.09	6.65	8.44	8.36	6.78	7.05	6.97	8.21	8.47	6.54	6.11	7.36
NA2O	2.39	2.01	1.57	2.20	1.79	2.15	1.65	2.05	1.79	2.02	1.83	2.56
K2O	0.94	1.21	0.81	0.76	0.79	1.09	0.88	0.80	0.80	1.25	0.73	1.28
MNO	0.26	0.13	0.27	0.19	0.20	0.15	0.13	0.17	0.14	0.12	0.14	0.16
P2O5	0.50	0.37	0.44	0.39	0.37	0.17	0.09	0.33	0.36	0.35	0.37	0.36
BA	77	132	49	27	76	60	122	37	33	40	47	40
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	29	45	79	81	75	34	32	56	67	49	59	65
CR	140	207	82	69	84	157	175	75	60	90	109	83
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	24	25	34	18	42	16	12	20	8	16	35	38
GA	18	17	22	17	18	14	15	18	16	17	19	22
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	101	85	115	110	92	106	144	75	70	93	129	103
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	6	13	7	4	11	3	10	4	11	10	9	6
RB	20	32	16	16	20	34	19	16	19	22	20	52
SC	62	48	77	82	90	59	44	82	91	92	82	81
SR	241	208	148	193	202	282	227	253	207	204	167	223
S	310	451	54	12	0	80	77	34	36	47	130	72
SN	0	4	4	1	0	2	0	2	1	2	2	1
V	520	408	884	719	698	189	155	640	707	573	640	744
W	0	10	8	0	0	2	4	1	8	2	2	3
Y	27	30	34	27	27	18	17	34	33	26	30	30
ZN	63	61	79	55	153	52	114	53	39	70	95	89
ZR	144	202	117	124	108	59	49	120	125	98	99	100

	NAS152/cont.							NAS152	NAS153			
Var.\ID:	BXB4021	BXB4022	BXB4023	BXB4024	BXB4025	BXB4026	BXB4027	NULL	BXS4029	BXS4030	BXS4031	BXS4032
SIO2	45.26	45.19	44.07	47.51	43.51	46.53	48.29	n.a	49.32	46.16	51.24	51.19
AL2O3	11.89	12.31	12.64	5.92	12.43	12.94	14.15	n.a	8.56	9.76	6.26	8.14
TIO2	4.58	5.31	5.71	1.64	5.59	4.99	3.76	n.a	1.35	2.58	2.11	1.32
FE2O3	18.52	18.14	19.24	11.55	17.00	16.27	16.05	n.a	12.98	10.38	15.05	13.30
MGO	7.70	5.16	3.91	27.94	3.56	4.70	5.60	n.a	13.40	19.31	16.41	19.31
CAO	6.76	7.26	5.92	4.19	8.38	7.90	7.02	n.a	5.55	7.91	3.73	4.03
NA2O	1.43	1.97	2.13	0.17	2.97	2.20	2.10	n.a	0.83	0.10	0.23	0.23
K2O	0.67	0.69	0.86	0.08	0.70	0.86	1.08	n.a	0.21	0.27	0.59	0.16
MNO	0.16	0.19	0.15	0.09	0.19	0.18	0.16	n.a	0.19	0.28	0.26	0.13
P2O5	0.30	0.35	0.37	0.05	0.36	0.32	0.29	n.a	0.10	0.28	0.14	0.10
BA	34	50	53	27	39	50	32	n.a	84	36	122	101
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	64	62	60	77	56	60	55	n.a	76	63	124	66
CR	95	86	125	1459	158	334	186	n.a	886	319	2606	1362
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	60	68	38	10	44	40	83	n.a	27	10	23	17
GA	19	21	20	7	18	18	18	n.a	12	12	9	9
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	118	164	158	1227	122	306	192	n.a	729	609	1687	1228
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	3	4	4	8	9	4	7	n.a	4	8	8	7
RB	23	19	21	5	17	23	27	n.a	3	5	16	8
SC	68	77	74	27	63	62	65	n.a	36	45	33	28
SR	111	204	235	39	202	211	201	n.a	171	48	44	78
S	7	29	36	120	99	212	35	n.a	244	497	401	293
SN	0	0	5	1	1	1	0	n.a	0	0	2	1
V	612	668	623	206	608	541	469	n.a	144	209	184	154
W	0	12	3	0	19	11	3	n.a	3	3	2	0
Y	26	30	29	16	29	23	32	n.a	14	39	16	34
ZN	110	106	107	89	85	83	88	n.a	51	104	101	64
ZR	94	94	102	75	106	90	100	n.a	46	211	112	145

Var.\ID:	BXS4033	BXS4034	BXS4035	BXS4036	BXS4037	BXS4038	BXS4039	BXS4040	BXS4041	BXS4042	BXS4043	BXS4044
SIO2	47.08	48.96	45.31	51.60	47.49	46.78	48.64	49.70	50.24	50.67	42.33	45.97
AL2O3	6.66	9.72	7.18	5.98	3.76	11.42	12.43	13.45	13.46	13.44	13.00	16.22
TIO2	2.31	1.43	1.14	0.89	0.28	2.72	3.54	3.11	3.67	4.44	5.17	4.12
FE2O3	17.51	11.82	21.13	13.96	12.65	14.70	16.36	12.77	12.79	13.53	17.24	15.23
MGO	15.42	19.75	18.22	19.82	30.47	8.63	6.28	5.76	4.12	3.26	3.37	1.94
CAO	4.94	4.60	4.38	2.99	1.87	5.56	5.00	5.60	5.55	5.39	7.63	6.95
NA2O	0.56	0.28	0.19	0.12	0.04	1.40	1.06	1.35	1.28	1.32	1.87	1.83
K2O	0.36	0.28	0.32	0.47	0.10	1.22	1.26	0.92	1.18	1.55	0.58	0.87
MNO	0.26	0.15	0.33	0.23	0.18	0.19	0.15	0.19	0.19	0.20	0.22	0.14
P2O5	0.15	0.12	0.14	0.08	0.03	0.25	0.31	0.38	0.47	0.43	0.44	0.35
BA	62	119	161	112	30	61	95	97	112	128	77	72
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	118	66	162	118	123	53	57	56	59	60	65	54
CR	2445	1424	4866	2827	3294	289	429	537	450	507	186	114
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	38	24	19	14	8	20	30	33	32	30	81	70
GA	14	11	9	8	3	16	18	16	15	14	23	21
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1530	1027	1465	1868	2969	236	322	326	236	262	163	192
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	10	8	10	11	6	11	17	13	15	17	7	9
RB	10	11	12	12	4	24	44	25	32	37	17	23
SC	46	27	44	34	22	76	70	53	56	49	81	74
SR	112	47	37	29	18	299	152	190	178	179	197	240
S	333	435	607	468	300	160	382	567	710	491	235	138
SN	1	0	0	0	2	6	5	0	3	10	5	0
V	270	129	253	134	77	332	412	306	329	412	730	511
W	1	3	0	1	0	0	0	10	12	10	4	11
Y	18	18	15	15	8	13	20	22	25	21	24	19
ZN	68	60	112	59	55	104	125	117	107	104	103	78
ZR	71	120	71	94	36	57	92	145	156	178	107	113

	NAS153/cont.										NAS153	NAS154
Var.\ID:	BXS4045	BXS4046	BXS4047	BXS4048	BXS4049	BXS4050	BXS4051	BXS4052	BXS4053	BXS4054	BXS4055	BXB4029
SIO2	50.74	46.67	50.08	48.42	52.03	53.88	48.58	49.07	61.68	58.52	58.31	49.50
AL203	16.56	14.08	12.69	17.18	13.86	15.75	15.52	14.22	15.34	15.03	12.98	10.91
TIO2	2.74	3.21	4.67	4.31	5.67	4.50	4.20	5.28	3.89	3.28	3.92	2.02
FE203	13.96	14.94	11.87	15.38	12.89	11.92	17.26	15.48	9.30	10.70	9.46	12.02
MGO	5.42	5.14	3.15	1.92	0.00	0.00	1.56	0.48	0.00	0.00	1.77	14.00
CAO	5.25	7.19	6.16	6.02	4.79	5.01	4.81	5.12	4.83	4.64	5.17	7.63
NA2O	0.98	1.54	1.31	1.21	1.45	1.35	1.22	1.14	1.24	1.13	1.16	1.61
K2O	1.25	0.56	1.35	0.99	1.96	1.41	1.49	1.54	1.44	1.41	1.55	0.20
MNO	0.18	0.18	0.24	0.19	0.14	0.14	0.17	0.18	0.11	0.11	0.23	0.14
P205	0.31	0.38	0.51	0.39	0.40	0.37	0.37	0.42	0.25	0.27	0.35	0.07
BA	100	70	144	132	123	204	182	184	216	205	217	8
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	68	55	62	62	52	59	52	66	28	28	43	48
CR	284	169	366	331	290	393	227	285	272	214	274	347
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	38	33	29	28	28	19	29	33	15	21	26	33
GA	20	21	15	19	16	15	19	18	16	16	14	13
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	232	153	201	286	131	105	113	116	83	96	116	291
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	6	4	16	10	14	17	14	16	13	13	11	6
RB	30	18	30	30	38	42	48	44	42	44	48	5
SC	49	68	55	81	62	39	66	54	33	40	36	38
SR	163	232	192	196	130	190	164	172	171	158	156	193
S	253	242	714	415	312	483	475	376	290	329	378	296
SN	1	2	11	8	27	6	0	0	4	3	5	0
V	324	458	394	466	404	325	515	469	258	285	342	219
W	0	7	14	6	15	10	0	12	18	10	10	0
Y	17	28	21	21	25	20	20	24	24	26	24	15
ZN	74	77	92	83	96	52	63	71	45	60	76	50
ZR	128	114	175	130	201	281	206	231	303	263	285	42

Var.\ID:	BXB4030	BXB4031	BXB4032	BXB4033	BXB4034	BXB4035	BXB4036	BXB4037	BXB4038	BXB4039	BXB4040	BXB4041
SIO2	45.88	49.09	50.22	47.77	46.71	47.17	46.51	47.13	51.37	49.97	48.33	49.49
AL203	11.64	7.75	7.44	8.24	6.06	7.89	5.95	2.94	13.13	13.48	11.69	15.21
TIO2	2.33	2.00	1.28	2.60	1.33	2.61	2.30	0.65	2.17	3.47	2.83	3.00
FE203	10.59	12.11	14.23	16.20	12.35	19.37	11.37	11.99	12.13	15.96	17.50	17.34
MGO	17.97	17.35	20.93	14.91	27.88	13.66	28.83	33.91	9.50	7.46	9.78	6.58
CAO	9.34	10.54	5.07	6.33	4.04	4.65	4.91	2.21	6.31	4.88	5.90	4.83
NA2O	0.30	0.19	0.24	0.89	0.17	0.41	0.07	0.05	1.99	1.63	0.95	1.86
K2O	0.34	0.08	0.03	0.44	0.11	0.49	0.03	0.09	1.32	1.74	0.31	0.72
MNO	0.20	0.12	0.13	0.22	0.16	0.26	0.13	0.16	0.16	0.13	0.14	0.13
P205	0.33	0.00	0.03	0.12	0.08	0.18	0.09	0.02	0.27	0.24	0.16	0.21
BA	18	14	69	57	87	122	18	58	26	34	39	64
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	47	62	68	88	86	121	84	110	47	54	68	62
CR	219	995	1343	1714	1418	3423	1374	2305	235	268	1168	198
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	8	16	19	32	29	21	26	9	27	30	33	29
GA	13	9	10	11	8	9	6	3	16	16	15	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	384	988	1234	1159	1435	1080	1329	2375	242	224	669	218
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	3	5	5	6	12	8	6	7	8	11	14	14
RB	6	4	4	9	6	17	4	3	30	42	12	17
SC	39	31	28	46	25	37	32	20	53	62	60	81
SR	139	69	67	154	32	48	26	31	223	162	146	210
S	165	107	62	165	227	687	59	191	26	52	122	12
SN	0	1	1	0	0	3	0	0	2	0	0	0
V	198	308	158	263	144	245	202	85	214	333	349	329
W	4	2	1	2	0	6	1	0	5	0	3	6
Y	40	16	21	19	13	17	14	9	30	19	32	23
ZN	81	43	80	60	60	112	53	49	100	119	167	146
ZR	196	79	74	71	63	116	54	41	120	75	93	62

NAS154/cont.

Var.\ID:	BXB4042	BXB4043	BXB4044	BXB4045	BXB4046	BXB4047	BXB4048	BXB4049	BXB4050	BXB4051	BXB4052	BXB4053
SI02	53.60	42.97	43.74	52.35	44.38	50.82	48.27	46.49	45.80	50.12	55.59	52.15
AL203	19.74	14.37	14.50	12.87	14.15	15.16	16.12	13.14	12.07	11.86	13.58	15.88
TI02	1.95	6.41	6.93	1.46	6.23	6.24	6.00	6.06	5.62	3.39	1.25	2.69
FE203	14.59	20.41	18.92	10.49	17.04	13.37	14.91	15.60	14.59	11.52	3.36	11.00
MGO	4.04	1.36	0.30	10.38	1.28	1.88	1.16	3.72	5.30	9.41	13.82	4.53
CAO	5.49	8.03	8.20	8.34	8.28	3.47	6.32	7.80	8.12	7.10	8.83	8.41
NA20	1.41	2.85	2.36	2.23	2.52	2.18	2.19	2.06	2.64	2.28	2.25	2.18
K20	1.76	0.70	0.63	0.73	0.62	3.99	1.99	0.94	0.76	1.17	0.93	0.58
MNO	0.09	0.20	0.18	0.20	0.18	0.13	0.17	0.16	0.22	0.28	0.47	0.15
P205	0.20	0.40	0.44	0.20	0.45	0.46	0.47	0.40	0.51	0.36	0.29	0.22
BA	70	46	51	101	49	80	102	42	61	68	93	60
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	45	72	65	46	62	52	67	64	50	47	46	60
CR	213	121	122	130	131	97	122	130	73	57	85	130
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	22	92	85	26	78	37	26	39	30	25	14	15
GA	19	22	20	13	19	17	18	17	18	16	16	15
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	290	143	185	128	161	122	192	127	119	90	187	124
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	7	9	2	4	9	16	14	3	12	5	9	9
RB	44	15	17	12	15	55	39	23	19	29	17	16
SC	83	71	86	56	89	82	81	73	72	64	42	56
SR	176	185	186	270	221	91	176	151	187	276	305	238
S	25	64	78	0	126	30	95	77	0	14	0	65
SN	0	6	1	2	3	0	2	4	1	0	4	0
V	271	858	733	201	544	351	469	457	493	362	182	261
W	5	7	0	1	3	3	6	17	2	6	8	7
Y	27	24	30	27	32	25	32	26	35	28	21	31
ZN	106	116	98	55	81	122	84	75	88	62	40	43
ZR	69	107	119	74	126	108	119	114	159	102	62	92

		NAS154	NAS155									
Var.\ID:	BXB4054	BXB4055	BXS4056	BXS4057	BXS4058	RXS4059	BXS4060	BXS4061	BXS4062	BXS4063	BXS4064	RXS4065
SI02	47.57	52.55	48.78	52.81	52.42	52.92	52.39	49.65	47.17	48.78	51.48	54.64
AL203	15.86	18.25	19.63	16.29	19.80	16.32	15.83	19.08	20.61	21.73	22.22	25.83
TI02	5.86	2.97	3.20	3.24	2.67	3.44	3.20	3.53	3.16	4.25	2.13	1.13
FE203	13.38	11.22	14.30	12.03	13.70	12.06	12.07	13.50	15.57	13.55	13.77	12.41
MGO	0.69	3.62	2.04	3.01	2.13	2.64	3.11	1.55	0.84	0.00	1.74	2.38
CAO	9.18	7.81	7.76	6.60	6.27	6.59	6.77	7.21	10.50	8.90	7.08	7.10
NA20	2.72	2.19	1.13	0.34	0.81	0.44	0.43	0.35	0.00	0.01	0.23	0.08
K20	0.71	0.67	0.82	0.93	1.16	1.03	0.95	0.79	0.00	0.74	0.66	0.47
MNO	0.14	0.15	0.21	0.24	0.16	0.23	0.22	0.19	0.14	0.13	0.17	0.18
P205	0.38	0.25	0.60	0.61	0.44	0.55	0.53	0.48	1.13	0.58	0.44	0.32
BA	8	29	106	134	137	160	150	130	111	147	168	186
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	47	46	54	50	47	58	46	64	48	80	57	57
CR	85	95	105	272	251	263	233	268	119	149	169	105
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	32	46	41	29	33	32	26	13	20	31	61
GA	17	18	24	18	22	19	18	21	22	23	20	19
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	147	205	99	148	129	138	126	143	93	151	107	102
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	7	7	10	12	12	14	20	13	6	10	8	10
RB	19	19	25	35	39	40	38	35	26	39	33	24
SC	74	73	69	47	55	49	50	54	55	64	66	89
SR	268	220	206	128	154	128	140	134	144	152	135	134
S	0	0	306	688	379	672	659	351	267	309	148	341
SN	0	0	1	7	2	6	5	0	2	0	0	0
V	448	281	358	264	242	310	322	392	314	412	268	223
W	1	2	14	7	4	16	15	5	5	8	5	3
Y	24	30	45	35	54	32	35	31	80	46	35	40
ZN	43	55	97	120	128	119	113	97	83	73	81	67
ZR	100	66	151	194	192	205	196	190	179	184	138	65

Var.\ID:	NAS155/cont. BXS4066	BXS4067	BXS4068	BXS4069	BXS4070	BXS4071	BXS4072	BXS4073	BXS4074	BXS4075	BXS4076	BXS4077
SIO2	48.92	50.72	53.44	54.74	54.77	55.46	54.78	50.62	55.58	47.19	53.06	51.59
AL2O3	17.80	18.32	18.07	16.32	17.76	19.96	16.55	20.66	23.14	19.06	23.61	18.63
TIO2	3.37	2.71	2.61	2.77	2.18	1.95	2.51	1.97	1.50	2.16	1.45	2.08
FE2O3	16.14	14.66	11.57	10.72	10.93	11.83	10.59	11.94	10.27	11.50	11.09	12.05
MGO	3.01	3.16	3.03	3.39	3.70	2.79	2.91	1.87	3.27	5.00	2.80	3.89
CAO	6.86	7.29	6.87	6.53	6.44	6.34	5.77	8.09	6.64	7.87	7.83	7.47
NA2O	0.24	0.27	0.19	0.35	0.39	0.19	0.50	0.54	0.19	1.28	0.13	0.19
K2O	0.97	0.70	0.77	0.90	0.86	0.75	1.03	0.36	1.11	0.45	0.29	0.49
MNO	0.19	0.21	0.22	0.25	0.23	0.19	0.22	0.17	0.18	0.24	0.19	0.23
P2O5	0.57	0.59	0.52	0.54	0.44	0.39	0.49	0.80	0.36	0.45	0.39	0.70
BA	122	115	151	156	156	148	176	105	112	104	157	114
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	64	68	53	47	59	62	50	48	52	55	52	50
CR	156	168	216	218	196	240	192	103	304	95	184	204
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	27	34	37	39	30	34	37	27	28	58	29	39
GA	23	23	18	20	18	21	17	22	20	20	19	21
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	115	110	130	115	119	118	111	89	166	102	144	125
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	15	11	14	11	13	15	15	10	10	5	7	14
RB	54	34	37	39	36	37	39	26	44	20	21	26
SC	78	50	47	43	47	53	48	53	58	82	62	52
SR	128	118	108	113	106	104	114	209	106	188	105	137
S	566	601	643	724	579	518	507	275	246	98	209	466
SN	2	5	4	7	2	0	8	5	0	1	0	2
V	500	412	274	271	246	230	257	250	194	334	162	229
W	7	12	15	15	6	11	3	4	4	6	3	0
Y	62	34	25	26	25	31	30	65	33	45	41	47
ZN	128	118	100	113	114	104	107	77	111	80	78	124
ZR	148	170	195	206	194	179	230	224	139	80	116	157

Var.\ID:	BXS4078	BXS4079	BXS4080	BXS4081	NAS155 BXS4082	NAS156 BXB4056	BXB4057	BXB4058	BXB4059	BXB4060	BXB4061	BXB4062
SIO2	53.37	53.01	53.66	52.29	50.59	50.07	55.28	52.71	51.35	49.83	51.57	51.59
AL2O3	19.33	16.41	16.64	19.44	21.88	16.80	20.24	17.40	16.45	17.83	18.78	18.03
TIO2	1.90	2.75	2.63	2.70	2.11	3.28	1.49	2.84	2.60	5.14	3.45	2.51
FE2O3	12.05	11.87	11.63	12.81	14.15	14.84	11.50	12.40	12.60	15.44	14.13	13.36
MGO	2.88	3.00	3.03	2.28	2.32	4.65	4.89	5.91	5.86	2.12	3.59	5.13
CAO	7.06	7.23	7.29	7.45	8.44	8.91	7.26	7.73	9.24	7.26	7.77	8.03
NA2O	0.30	0.00	0.00	0.05	0.00	1.71	1.20	1.26	1.74	1.14	0.62	1.06
K2O	0.60	0.45	0.38	0.32	0.00	0.76	1.19	1.39	0.59	1.14	1.01	1.09
MNO	0.19	0.24	0.25	0.22	0.20	0.20	0.17	0.18	0.18	0.19	0.14	0.15
P2O5	0.61	0.87	0.89	0.76	0.97	0.41	0.22	0.27	0.30	0.42	0.37	0.41
BA	134	133	152	119	98	48	70	34	45	27	45	54
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	39	43	38	48	45	49	44	61	41	69	56	46
CR	130	216	197	182	197	89	128	415	106	203	302	268
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	41	46	48	57	56	28	25	17	11	20	10	20
GA	21	19	20	22	23	20	19	16	20	19	18	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	91	109	104	113	127	91	126	179	83	97	135	103
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	8	17	15	13	10	6	8	13	6	14	12	11
RB	28	27	28	23	16	17	27	30	14	26	27	27
SC	48	53	51	70	67	62	62	44	50	62	60	56
SR	137	131	129	127	144	226	279	140	211	120	213	187
S	326	656	611	667	345	0	0	0	0	0	0	0
SN	6	8	11	12	0	0	2	0	4	2	0	0
V	208	251	238	294	227	340	194	250	293	391	294	194
W	4	5	6	2	3	3	2	7	16	10	4	8
Y	31	42	43	46	93	65	34	26	40	45	45	66
ZN	98	115	114	122	103	83	83	113	70	148	59	114
ZR	159	221	209	181	104	122	81	83	104	158	126	172

Var.\ID:	NAS156/cont. BXB4063	BXB4064	BXB4065	BXB4066	BXB4067	BXB4068	BXB4069	BXB4070	BXB4071	BXB4072	BXB4073	BXB4074
SI02	51.58	50.74	49.19	46.26	47.01	52.90	45.30	51.64	52.77	52.09	53.53	55.35
AL203	17.08	18.60	20.68	18.52	17.83	19.37	18.80	18.04	20.13	18.10	19.86	23.05
TI02	4.68	2.87	3.78	5.01	4.06	1.95	6.03	2.62	2.43	1.87	1.52	1.03
FE203	13.76	15.08	16.23	18.92	18.56	13.10	20.05	14.93	14.48	12.50	11.46	10.83
MGO	1.39	4.06	1.71	1.31	2.40	5.15	0.00	4.49	4.21	5.63	5.43	4.55
CAO	7.49	8.74	9.00	9.78	9.84	7.63	7.37	7.79	7.49	10.03	9.49	7.91
NA20	0.37	1.16	1.10	0.44	0.47	1.31	1.64	1.01	0.66	1.16	1.42	0.70
K20	1.00	0.30	0.39	0.87	0.35	0.27	0.43	0.81	0.47	0.20	0.32	0.39
MNO	0.20	0.19	0.17	0.15	0.19	0.17	0.22	0.17	0.17	0.16	0.16	0.15
P205	0.59	0.33	0.32	0.46	0.69	0.28	0.62	0.36	0.26	0.21	0.25	0.21
BA	84	36	57	60	36	49	38	70	65	34	57	142
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	52	46	62	73	52	53	70	55	65	46	46	48
CR	239	124	76	73	105	153	91	128	276	213	358	393
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	25	41	45	17	19	110	56	18	32	16	28	12
GA	19	20	20	24	24	20	25	21	18	18	17	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	156	79	82	91	59	111	113	104	148	108	149	171
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	11	8	15	10	9	3	7	12	9	6	6
RB	36	15	16	40	21	17	29	33	26	12	12	23
SC	54	56	88	85	63	66	107	66	70	50	53	51
SR	118	150	150	238	147	177	130	228	118	243	226	129
S	539	0	0	11	24	0	0	0	0	0	0	0
SN	0	1	1	0	3	2	6	1	0	6	0	0
V	336	288	517	615	371	225	546	316	255	177	162	140
W	7	12	3	3	8	6	7	7	1	12	8	3
Y	38	57	61	92	86	30	60	49	52	39	61	23
ZN	98	87	73	95	78	90	122	102	105	49	61	75
ZR	199	141	105	124	175	73	162	131	103	124	90	78

Var.\ID:	BXB4075	BXB4076	BXB4077	BXB4078	BXB4079	BXB4080	BXB4081	NAS156 BXB4082	NAS157 BXS3122	BXS3121	BXS3120	BXS3119
SI02	52.68	54.22	53.58	54.02	52.06	52.58	46.94	54.55	55.26	55.26	51.71	54.72
AL203	21.83	23.13	21.71	22.21	21.39	19.35	18.94	19.78	18.72	15.95	17.90	21.97
TI02	2.14	1.46	1.71	1.57	2.56	2.68	6.02	0.61	1.63	1.54	1.42	1.03
FE203	11.98	11.89	12.15	11.56	13.36	13.86	17.08	9.63	11.46	10.23	11.88	11.50
MGO	2.77	3.51	3.81	4.04	1.50	3.75	0.00	7.87	3.69	5.68	5.44	3.90
CAO	7.61	8.28	9.12	8.33	8.45	7.91	8.73	8.26	5.74	6.13	6.78	7.29
NA20	1.64	0.51	0.37	0.61	1.07	0.66	1.47	1.25	0.53	0.52	0.63	0.67
K20	0.59	0.18	0.22	0.34	0.10	0.55	0.25	0.38	1.22	1.25	1.18	0.83
MNO	0.17	0.17	0.19	0.20	0.17	0.21	0.22	0.13	0.20	0.23	0.21	0.16
P205	0.36	0.31	0.42	0.30	0.50	0.58	0.65	0.13	0.31	0.39	0.30	0.24
BA	84	91	103	69	85	44	57	60	175	151	214	182
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	51	54	46	50	43	42	52	46	46	37	50	53
CR	88	195	273	90	94	91	81	385	251	382	306	415
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	27	19	30	26	30	25	60	30	27	29	36	15
GA	21	19	19	19	21	23	26	15	14	15	18	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	97	142	137	90	83	71	81	237	118	161	186	348
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	5	9	9	5	4	10	6	7	15	17	13	8
RB	18	17	17	16	13	22	13	10	39	39	35	29
SC	69	66	54	76	71	66	95	39	38	41	46	36
SR	229	132	143	131	229	141	154	199	130	131	152	205
S	68	42	157	15	14	0	47	0	333	693	198	235
SN	3	2	7	0	4	1	4	0	7	3	1	9
V	259	171	168	185	251	244	447	98	169	158	213	117
W	8	6	12	12	16	10	22	1	10	50	15	1
Y	77	53	48	124	81	116	104	15	24	26	33	34
ZN	69	62	94	74	75	122	96	42	122	121	99	94
ZR	93	99	136	89	254	134	197	41	176	171	131	170

	NAS157/cont.											
Var.\ID:	BXS3118	BXS3117	BXS3116	BXS3115	S-731	S-732	S-733	S-734	S-735	S-736	S-737	S-738
SI02	52.13	51.73	54.75	54.50	57.60	55.17	68.15	69.60	67.93	68.24	65.02	60.38
AL203	22.26	13.82	18.42	16.34	4.27	3.69	10.52	12.92	15.01	12.94	11.44	3.25
TI02	1.58	0.67	0.69	0.71	0.75	0.60	0.86	0.90	0.90	0.85	0.92	0.91
FE203	14.99	13.18	11.55	11.68	17.49	12.44	6.02	6.89	8.16	6.52	8.75	9.17
MGO	2.83	15.27	6.97	10.19	19.94	22.97	6.99	2.85	0.96	0.76	4.86	18.23
CAO	6.70	4.93	6.16	5.81	3.66	3.27	3.28	2.66	2.64	2.30	3.09	3.77
NA20	0.42	0.08	0.55	0.44	0.03	0.00	0.30	0.44	0.45	0.52	0.41	0.00
K20	0.61	0.33	1.20	1.30	1.40	1.36	1.55	1.82	1.78	1.75	1.40	1.50
MNO	0.16	0.17	0.18	0.15	0.63	0.67	0.21	0.13	0.08	0.06	0.14	0.67
P205	0.23	0.13	0.19	0.12	0.19	0.28	0.08	0.07	0.09	0.14	0.15	0.28
BA	131	122	195	140	329	324	326	385	380	331	297	349
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	52	67	53	56	276	245	52	56	40	32	67	193
CR	431	1266	553	755	4439	4444	890	789	742	534	1660	3615
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	17	46	28	33	17	14	7	7	9	7	15	9
GA	19	16	13	13	6	9	9	11	12	10	10	8
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	307	923	343	574	1457	3459	401	373	247	135	768	777
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	12	13	15	13	29	23	17	20	20	26	21	49
RB	32	17	45	44	35	38	51	73	70	64	51	40
SC	56	38	50	49	16	35	15	17	14	11	19	18
SR	144	96	237	131	61	33	73	73	71	64	78	48
S	226	378	468	268	580	539	258	278	318	783	578	730
SN	0	2	0	2	1	1	0	2	3	3	4	7
V	187	118	150	136	175	108	72	72	78	59	86	133
W	0	0	4	0	7	6	7	8	10	10	15	19
Y	15	14	16	14	12	13	21	24	21	24	23	17
ZN	84	167	92	283	124	109	58	52	68	47	121	231
ZR	103	73	91	62	166	94	320	341	362	377	279	207

									NAS157	NAS158		
Var.\ID:	S-739	S-740	S-741	S-742	S-743	S-744	S-745	S-746	S-747	BXB3122	BXB3121	BXB3120
SI02	53.65	66.60	65.11	65.57	64.12	65.55	69.04	60.50	71.04	52.12	53.22	52.42
AL203	15.94	15.34	15.67	13.70	15.17	14.18	14.07	15.67	11.84	18.97	19.28	21.90
TI02	0.96	0.90	0.88	1.11	1.29	1.09	0.98	0.88	0.80	1.60	1.44	1.51
FE203	14.40	7.53	9.44	5.99	9.71	7.85	7.41	10.72	5.49	14.22	12.58	13.40
MGO	7.02	0.00	1.27	5.11	2.95	4.30	1.43	2.60	1.36	5.72	5.60	4.53
CAO	4.08	2.23	2.55	3.27	3.11	3.19	2.44	3.13	2.77	8.72	8.21	7.60
NA20	0.44	0.58	0.56	0.45	0.50	0.47	0.55	0.33	0.15	0.92	0.96	0.25
K20	1.34	1.83	1.74	2.03	1.75	1.81	1.90	1.00	0.87	0.75	0.97	1.13
MNO	0.13	0.04	0.05	0.24	0.11	0.21	0.05	0.11	0.08	0.20	0.20	0.21
P205	0.16	0.11	0.09	0.19	0.12	0.16	0.06	0.16	0.03	0.19	0.25	0.29
BA	238	353	334	393	389	363	367	300	293	96	170	177
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	80	26	33	106	52	116	32	47	35	50	50	46
CR	2004	347	840	885	1232	1010	533	771	619	236	301	319
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	35	5	15	24	25	19	6	5	3	23	37	37
GA	11	10	12	13	12	12	11	13	10	19	16	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	663	114	259	677	656	434	266	300	282	95	141	187
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	34	16	18	27	29	31	23	22	22	9	11	12
RB	48	69	66	73	69	64	71	51	38	19	24	45
SC	39	8	12	22	23	23	14	21	15	59	53	50
SR	69	59	60	73	74	68	75	61	54	222	197	134
S	515	641	281	249	244	392	170	1236	1484	118	219	161
SN	4	2	3	2	2	9	2	2	0	1	0	0
V	172	59	77	90	98	99	71	72	50	246	224	205
W	8	11	14	9	11	4	10	7	7	6	8	9
Y	11	23	21	29	30	30	27	22	23	40	36	37
ZN	133	37	64	79	83	71	63	132	73	81	89	118
ZR	156	363	331	328	362	376	372	257	236	87	95	102

	NAS158/cont.				NAS158	NAS159						
Var.\ID:	BXB3119	BXB3118	BXB3117	BXB3116	BXB3115	BXS3137	BXS3138	NULL	BXS3140	*XS3141	NULL	BXS3143
SIO2	53.32	51.73	53.15	54.08	52.17	52.26	56.92	n.a	53.44	51.37	n.a	55.31
AL2O3	18.95	18.89	14.67	17.21	14.94	15.86	8.37	n.a	23.93	10.43	n.a	9.84
TIO2	1.18	1.47	0.57	0.75	0.58	0.91	0.69	n.a	0.93	0.69	n.a	0.77
FE2O3	11.41	13.11	10.24	9.54	10.20	13.91	13.32	n.a	16.28	14.15	n.a	12.77
MGO	5.94	5.50	14.60	9.52	14.09	10.15	14.61	n.a	2.80	14.61	n.a	12.11
CAO	9.00	9.96	4.41	8.28	8.18	5.47	2.81	n.a	4.25	5.46	n.a	3.86
NA2O	1.31	1.34	0.84	1.27	0.40	0.65	0.22	n.a	0.07	0.17	n.a	0.48
K2O	0.72	0.37	1.38	1.08	0.72	0.73	1.15	n.a	0.98	0.42	n.a	1.19
MNO	0.18	0.17	0.21	0.20	0.16	0.20	0.30	n.a	0.16	0.22	n.a	0.21
P2O5	0.20	0.17	0.16	0.13	0.06	0.15	0.12	n.a	0.24	0.09	n.a	0.10
BA	167	66	113	137	100	151	222	n.a	209	125	n.a	236
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	46	40	44	43	51	57	134	n.a	80	81	n.a	88
CR	390	241	381	304	717	827	3518	n.a	791	1685	n.a	2034
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	21	15	35	31	22	61	21	n.a	49	55	n.a	48
GA	18	17	12	12	10	15	8	n.a	17	11	n.a	12
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	279	146	369	223	394	698	2766	n.a	669	1106	n.a	749
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	9	7	11	8	14	42	23	n.a	25	144	n.a	52
RB	22	16	31	30	24	24	35	n.a	42	16	n.a	30
SC	39	46	53	44	43	47	32	n.a	52	48	n.a	29
SR	246	194	100	346	160	81	51	n.a	65	60	n.a	93
S	182	34	36	176	122	211	39	n.a	330	239	n.a	119
SN	0	2	1	2	0	6	0	n.a	4	3	n.a	0
V	172	200	130	138	137	166	97	n.a	150	233	n.a	137
W	3	7	4	7	8	0	9	n.a	0	0	n.a	1
Y	39	38	9	15	9	17	15	n.a	12	20	n.a	17
ZN	87	67	138	82	115	155	217	n.a	127	541	n.a	127
ZR	132	86	30	56	43	60	176	n.a	82	82	n.a	150

								NAS159	NAS160			
Var.\ID:	NULL	BXS3145	BXS3146	NULL	BXS3148	BXS3149	BXS3150	BXS3151	BXB3137	BXB3138	BXB3139	BXB3140
SIO2	n.a	53.39	53.45	n.a	56.56	52.04	51.06	56.70	51.90	49.94	55.44	53.35
AL2O3	n.a	11.86	7.62	n.a	13.92	3.16	7.35	12.81	14.01	2.68	5.66	25.85
TIO2	n.a	0.91	0.58	n.a	0.94	0.24	0.62	1.19	0.62	0.26	0.44	0.67
FE2O3	n.a	15.29	13.27	n.a	12.66	15.47	13.84	10.94	11.19	9.06	10.89	13.27
MGO	n.a	12.26	15.90	n.a	9.61	23.46	20.29	9.07	13.43	32.82	21.70	2.81
CAO	n.a	4.41	4.04	n.a	4.17	2.59	4.05	4.47	7.52	1.74	3.37	7.87
NA2O	n.a	0.25	0.14	n.a	0.45	0.00	0.11	0.74	1.18	0.00	0.01	0.16
K2O	n.a	0.82	0.86	n.a	1.15	0.41	0.19	1.46	1.39	0.44	0.75	0.42
MNO	n.a	0.24	0.30	n.a	0.19	0.46	0.19	0.24	0.19	0.30	0.32	0.14
P2O5	n.a	0.12	0.11	n.a	0.13	0.12	0.03	0.17	0.08	0.09	0.09	0.18
BA	n.a	212	181	n.a	260	79	79	290	134	73	174	224
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	n.a	121	145	n.a	103	163	95	69	47	125	121	74
CR	n.a	2660	3072	n.a	1756	4201	2795	1360	383	2868	3053	338
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	n.a	65	72	n.a	45	26	68	29	83	15	21	78
GA	n.a	12	9	n.a	12	6	8	14	15	2	7	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	n.a	1727	1836	n.a	861	3377	2247	608	269	2667	2041	470
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	n.a	16	12	n.a	21	27	44	27	32	16	32	12
RB	n.a	28	23	n.a	37	10	9	40	34	10	26	22
SC	n.a	36	34	n.a	32	40	33	33	45	18	22	58
SR	n.a	78	57	n.a	83	14	46	129	297	17	27	132
S	n.a	73	180	n.a	205	0	80	215	33	164	304	203
SN	n.a	2	1	n.a	2	0	0	7	0	1	0	0
V	n.a	151	107	n.a	116	96	119	137	201	52	74	179
W	n.a	6	2	n.a	0	0	6	5	8	8	10	5
Y	n.a	20	12	n.a	20	7	9	23	11	6	7	13
ZN	n.a	98	85	n.a	89	308	135	123	113	204	82	97
ZR	n.a	126	97	n.a	151	19	62	206	33	60	78	30

	NAS160/cont.										NAS160
Var.\ID:	BXB3141	BXB3142	BXB3143	BXB3144	BXB3145	BXB3146	BXB3147	*XB3148	BXB3149	BXB3150	NULL
SIO2	50.71	48.04	52.01	50.32	51.10	49.72	53.56	52.65	50.87	49.55	n.a
AL2O3	11.47	5.93	11.12	0.81	6.23	2.82	1.96	5.45	0.95	3.77	n.a
TIO2	0.65	0.35	0.56	0.46	0.55	0.16	0.66	0.46	0.13	0.34	n.a
FE2O3	10.97	22.23	12.27	9.20	13.18	11.63	12.48	11.80	10.99	13.90	n.a
MGO	17.54	20.41	17.06	31.59	22.22	30.93	27.16	25.94	33.65	29.36	n.a
CAO	7.34	1.84	7.26	2.42	4.86	1.84	2.82	5.21	2.21	2.71	n.a
NA2O	1.22	0.00	0.71	0.00	0.19	0.02	0.00	0.00	0.00	0.00	n.a
K2O	0.78	0.63	1.03	0.77	0.34	0.19	1.29	0.10	0.25	0.03	n.a
MNO	0.20	0.39	0.16	0.53	0.22	0.15	0.61	0.17	0.36	0.17	n.a
P2O5	0.07	0.13	0.00	0.24	0.02	0.00	0.21	0.00	0.05	0.00	n.a
BA	115	181	189	160	102	57	267	59	51	37	n.a
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	53	222	53	196	116	107	261	107	131	126	n.a
CR	623	4797	849	3020	2215	2469	4445	3140	3158	2817	n.a
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	78	34	71	15	64	27	30	661	15	33	n.a
GA	10	4	12	3	9	2	5	6	2	5	n.a
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	490	2979	273	2013	2050	2078	1802	1889	3323	3206	n.a
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	22	16	14	21	12	10	25	13	22	12	n.a
RB	20	20	32	14	9	7	28	5	5	2	n.a
SC	47	34	46	20	33	20	23	41	21	25	n.a
SR	167	29	157	23	60	14	38	32	10	17	n.a
S	7	425	109	1346	33	138	431	0	46	46	n.a
SN	3	5	0	5	0	0	2	1	0	3	n.a
V	159	106	179	78	117	57	106	179	63	85	n.a
W	7	8	3	9	3	7	6	5	14	8	n.a
Y	11	9	10	7	12	3	9	6	4	11	n.a
ZN	121	115	124	104	79	46	77	125	260	99	n.a
ZR	32	71	25	79	52	32	132	33	17	39	n.a

	NAS143								NAS143	NAS147	
Var.\ID:	BXS3002	BXS3002b	BXS3002c	BXB3002	BXS3004	BXS3004b	BXS3004c	BXS3004d	BXB3004	BXS3047	BXS3047b
SIO2	67.61	54.97	51.76	43.88	62.89	50.26	50.25	48.07	52.51	50.40	47.47
AL2O3	14.17	5.94	5.38	12.28	13.80	13.71	11.38	12.49	13.76	13.74	9.52
TIO2	2.49	0.71	1.30	5.11	2.83	3.69	1.52	1.64	4.14	0.60	0.50
FE2O3	7.27	15.29	17.30	14.33	8.37	14.71	13.66	12.92	12.35	6.93	3.76
MGO	0.00	19.26	21.05	7.06	0.00	2.28	12.36	8.92	3.10	13.66	21.68
CAO	3.99	2.42	3.85	8.78	4.07	6.77	6.24	7.05	7.26	7.34	5.86
NA2O	0.91	0.09	0.02	1.15	1.30	1.30	0.41	1.07	2.03	2.36	1.56
K2O	1.68	0.00	0.10	0.08	1.63	0.63	0.15	0.22	0.94	0.56	0.51
MNO	0.09	0.06	0.23	0.14	0.09	0.10	0.10	0.11	0.11	0.14	0.22
P2O5	0.14	0.00	0.05	0.31	0.19	0.21	0.07	0.13	0.23	0.09	0.16
BA	257	55	79	13	219	71	47	33	59	85	45
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	14	82	176	65	26	44	70	57	49	38	49
CR	214	2189	2819	330	230	207	1865	615	282	356	314
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	14	29	145	38	18	43	47	35	40	14	12
GA	12	6	9	14	15	17	15	18	14	10	7
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	72	1910	3036	709	73	129	891	344	159	301	414
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	15	6	4	6	18	4	7	7	9	11	11
RB	53	5	6	5	46	22	12	10	28	11	9
SC	23	33	42	65	25	82	54	70	55	38	31
SR	149	52	60	140	174	307	127	240	343	149	66
S	168	205	268	23	88	211	1336	517	142	261	222
SN	3	2	0	5	2	2	3	0	0	0	0
V	177	109	161	404	240	385	280	254	364	118	88
W	3	5	2	1	2	0	0	0	2	0	1
Y	28	8	13	18	28	28	17	21	21	11	10
ZN	43	63	72	63	41	47	67	57	53	92	249
ZR	337	54	62	103	308	177	85	72	137	33	27

		NAS147	NAS145				NAS145				
Var.\ID:	BXS3047c	BXB3047	BXS3110	BXS3110B	BXS3110C	BXS3110D	BXB3110	BXS3181A	BXS3181B	BXS3181C	BXS3181D
SIO2	47.27	46.67	57.50	55.12	55.70	53.38	53.93	64.07	57.43	57.27	56.42
AL2O3	3.39	5.02	22.36	25.68	23.83	22.03	19.61	19.32	27.49	28.33	27.98
TIO2	0.18	0.25	1.41	1.15	1.31	1.63	1.66	2.13	1.66	0.85	1.14
FE2O3	12.11	11.07	9.67	11.73	10.76	10.64	9.60	8.96	13.28	11.54	11.79
MGO	31.56	32.65	2.35	1.49	1.98	2.97	4.51	0.00	0.00	0.00	0.00
CAO	2.29	3.07	6.72	7.38	7.31	7.73	8.57	3.64	4.82	5.54	6.75
NA2O	0.11	0.03	0.22	0.36	0.74	1.42	2.09	0.22	0.22	1.18	0.80
K2O	0.02	0.00	0.41	0.00	0.09	0.04	0.08	1.05	0.15	0.33	0.00
MNO	0.15	0.15	0.18	0.13	0.14	0.15	0.15	0.04	0.02	0.02	0.03
P2O5	0.00	0.01	0.36	0.25	0.26	0.22	0.17	0.20	0.23	0.19	0.18
BA	7	12	208	149	144	46	59	183	134	138	127
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	71	91	41	45	40	39	35	10	20	25	20
CR	2082	1166	282	258	200	147	145	212	233	144	130
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	63	28	21	19	13	13	27	47	25	18
GA	6	5	19	19	20	20	18	12	18	19	20
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1835	1276	148	150	129	118	104	56	82	97	116
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	8	26	12	3	7	7	8	19	10	2	5
RB	3	2	27	14	15	9	7	48	24	24	15
SC	17	18	45	67	57	54	48	22	74	62	60
SR	15	33	115	116	130	161	184	39	49	142	121
S	36	78	351	116	149	58	35	372	264	172	229
SN	0	2	4	3	2	0	0	53	10	2	0
V	56	51	138	149	133	152	157	103	158	127	119
W	5	7	3	6	0	5	5	6	5	5	7
Y	6	6	32	57	59	51	38	18	27	36	30
ZN	191	180	83	56	58	54	41	44	62	77	63
ZR	19	21	205	272	228	205	183	278	148	59	112

Var.\ID:	BXS3181E	BXS3181F	BXS3181G	BXS3181H	BXS3181I	BXS3181J	BXS3182A	BXS3182B	BXS3182C	BXS3182D	BXS3182E
SIO2	57.55	52.85	53.83	53.02	53.28	50.99	55.30	56.32	56.12	55.54	54.84
AL2O3	24.56	17.28	18.06	19.92	18.34	15.70	20.31	20.56	19.62	19.20	18.47
TIO2	1.47	0.95	0.94	0.78	0.86	0.69	1.24	0.99	0.67	0.75	0.84
FE2O3	12.51	14.93	12.99	13.18	10.27	10.17	11.77	10.11	8.42	9.12	9.72
MGO	0.00	4.76	4.45	3.24	4.98	7.39	3.25	3.28	5.71	5.92	6.55
CAO	5.57	6.03	7.08	6.43	8.67	9.10	6.99	7.08	8.76	8.60	8.77
NA2O	0.45	1.29	1.13	0.92	1.61	1.40	0.89	1.28	1.45	1.28	0.97
K2O	0.21	0.17	0.12	0.05	0.05	0.07	0.16	0.21	0.07	0.09	0.04
MNO	0.04	0.11	0.09	0.08	0.10	0.12	0.13	0.12	0.15	0.16	0.13
P2O5	0.18	0.11	0.09	0.12	0.08	0.06	0.15	0.14	0.10	0.10	0.08
BA	103	117	90	92	71	61	122	111	60	70	78
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	23	85	48	49	43	43	45	37	37	41	44
CR	183	190	154	145	132	154	283	218	187	249	444
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	41	24	26	16	7	12	35	39	25	33	33
GA	17	14	15	15	14	16	16	18	17	15	15
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	91	151	130	145	110	124	111	95	100	118	189
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	12	5	7	2	6	7	9	6	6	5	5
RB	21	13	10	13	8	5	14	15	9	9	8
SC	60	67	57	57	54	58	65	54	52	51	58
SR	71	164	159	148	212	171	137	163	188	183	162
S	222	39	53	44	25	3	169	114	63	48	71
SN	11	0	2	1	0	0	7	1	0	0	0
V	129	140	135	103	122	131	152	115	124	131	132
W	4	5	2	4	1	1	4	4	5	0	5
Y	26	31	25	26	21	21	26	23	23	22	21
ZN	63	95	75	70	55	50	59	49	37	40	41
ZR	135	58	67	54	78	47	92	77	37	50	64

Var.\ID:	BXS3182F	BXS3206	BXS3206B	BXS3206C	BXS3206D	BXS3206E	BXS3206F	BXB3206
SIO2	53.48	54.30	55.41	55.19	55.00	55.46	53.68	53.12
AL2O3	16.73	25.83	25.05	25.05	23.31	24.68	19.95	20.40
TIO2	0.74	1.01	0.88	0.92	0.81	0.44	0.72	0.75
FE2O3	10.00	10.82	10.95	10.46	10.00	8.67	9.98	8.72
MGO	8.21	3.92	5.08	4.99	6.74	6.46	8.23	8.02
CAO	8.79	8.23	7.24	7.71	8.09	8.54	8.56	9.53
NA2O	1.32	0.00	0.00	0.00	0.00	0.06	0.41	0.34
K2O	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MNO	0.14	0.20	0.20	0.19	0.21	0.18	0.18	0.19
P2O5	0.07	0.27	0.24	0.25	0.23	0.18	0.17	0.16
BA	64	204	180	159	147	132	118	124
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	42	44	50	50	44	43	46	49
CR	390	443	425	388	465	525	512	586
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	26	7	6	6	6	6	6	8
GA	14	19	20	19	19	16	16	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	165	203	230	207	238	294	222	211
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	5	9	5	11	8	6	8	8
RB	9	20	13	10	12	15	10	10
SC	50	43	36	38	31	23	43	47
SR	208	189	143	154	165	119	184	190
S	53	140	78	59	84	49	30	21
SN	2	3	0	5	6	2	3	2
V	147	149	122	132	132	102	165	147
W	3	2	2	6	0	2	4	9
Y	19	18	25	29	24	11	21	17
ZN	36	95	99	86	100	85	71	74
ZR	47	97	90	94	72	40	74	60

Remaining soil data

This Appendix includes all the geochemical data from the residual soils of the Lizard Complex which were used in the mapping process and were not listed in the previous two Appendices.

Traverse line	Sample numbers	Location	No.of samples
NAS124.	S181-205.	Predannack Head. (LL)	(21)
NAS126.	S231-255.	N.of Mullion Cove. (LL)	(21)
NAS130.	S372-389.	Goonhilly Downs traverse. (KE/UB)	(18)
NAS131.	S646-631. S390-408. S618-630.	Goonhilly (S) to Trerise. (UB/KE/UB)	(48)
NAS132.	S409-433.	Gwendreath to Kuggar (NE-SW). (KE)	(25)
NAS133.	S448-443.	St.Keverne Beacon (-->SW). (GR)	(35)
NAS138.	S503-520. S728-730.	Crousa Common (-->E). (GR)	(21)
NAS139.	S531-546. S904-911. S1060-1086.	Tredinnick (N) to Trevean (S). (UL/TQ/UG)	(51)
NAS140.	S1345-1337. S811-795. S760-748. S587-602.	Chywoone (S) to Lesneague (N). (UG/UL)	(55)
NAS141.	S611-617. S1120-1142.	Lanarth Farm traverse (S-N). (UG/UL)	(30)
NAS142.	S657-671.	Crousa Down (-->SW). (GR)	(15)
NAS162.	S711-698. S991-1006. S853-876.	Goonhilly Downs-Traboe Cross-Trelaminney. (S) (UB/CUM/UL) (N)	(54)
NAS168.	S547-563.	Crousa Common to Tremenhere (N). (GR)	(17)
NAS169.	S564-576.	Crousa Common towards Coverack. (GR)	(13)
NAS170.	S577-586. S720-727.	Lanarth Gate traverse (S-N). (GR)	(18)
NAS171.	S656-647. S609-610. S1106-1119.	Roscarnon Plantation (S) towards Roscruge (N). (MS/UL)	(26)
NAS172.	S672-685.	Coastal path from Porthkerris to Porthallow. (UL/UB)	(13)
NAS173.	S686-697.	Crousa Common (-->W). (GR)	(12)
NAS174.	S719-712. S1143-1165.	Goonhilly Sat.Stn.towards Trewince (S-N). (CUM/UL)	(31)
NAS176.	S761-782.	Tregaminion Farm traverse (W-E). (UL/MS)	(22)
NAS177.	S1037-1024. S783-794.	Porthkerris radar stn.traverse (W-E). (UL/MS)	(26)
NAS178.	S812-823.	Liz-Land traverse (SE-NW). (GR)	(12)
NAS179.	S824-836.	Rosuic (W) to Roskilly (E). (UL/UG)	(13)
NAS180.	S837-852.	Traboe towards Tregeage (S-N). (CUM/UL)	(15)

NAS181.	S903-892. S1007-1023. S877-891.	Goonhilly Downs(Trevassack)-Higher Relowas. (S) (UB/UL) (N)	(44)
NAS182.	S912-921.	Crousa Common (-->SE). (GR)	(10)
NAS183.	S926-922. S1166-1183.	Penhallick traverse (N-S). (LG/UB)	(23)
NAS184.	S940-951.	Penmarth traverse (S-N). (UB/LG)	(11)
NAS185.	S952-963.	Gwenter Farm Traverse (E-W). (HA/LH)	(12)
NAS186.	S964-973.	N.of Cadgwith (S-N). (LL/UB)	(10)
NAS187.	S974-981.	Gwavas Farm traverse (E-W). (LL/LH)	(8)
NAS188.	S982-990.	Prazegooth traverse (E-W). (LL/LH)	(9)
NAS189.	S1038-1059.	West of Trelan Farm (W-E). (GA/UB)	(22)
NAS190.	S1087-1105.	Trembraze traverse (E-W). (UL/TQ)	(19)
NAS191.	S1207-1225.	Eastern Cliff traverse (NE-SW). (GA/UB)	(19)
NAS192.	S1274-1283.	Little Trevothan Caravan Park (N-S). (LG/UB)	(10)
NAS199.	S1336-1332. S1316-1331.	Carrick Luz (E-W). (UB/GA/UB)	(21)

Var.\ID:	NAS124 S-181	S-182	S-185	S-186	S-187	S-188	S-189	S-190	S-191	S-192	S-193	S-194
SIO2	53.32	53.90	53.63	54.30	54.06	53.78	54.50	54.20	54.15	53.92	53.70	53.29
AL2O3	22.77	16.15	16.87	17.10	17.42	17.52	16.53	16.64	16.08	19.45	21.02	17.38
TIO2	0.78	1.71	1.63	1.66	1.52	1.60	1.65	1.72	1.69	1.13	1.00	1.55
FE2O3	11.06	10.76	10.82	10.46	10.15	10.85	10.59	10.81	10.69	10.11	10.77	10.09
MGO	5.01	5.56	6.62	5.68	6.24	5.92	5.77	5.25	5.55	6.22	5.82	6.95
CAO	6.93	7.38	7.09	7.33	7.61	7.60	7.36	7.49	7.68	8.25	7.46	8.26
NA2O	0.73	0.74	0.84	0.89	0.78	0.88	0.78	0.81	0.69	0.75	0.70	0.82
K2O	0.75	1.05	1.18	1.14	1.10	1.09	1.05	0.98	0.93	0.82	0.48	0.84
MNO	0.10	0.17	0.18	0.19	0.20	0.20	0.19	0.18	0.18	0.18	0.15	0.24
P2O5	0.20	0.37	0.30	0.33	0.31	0.31	0.34	0.34	0.37	0.23	0.21	0.32
BA	121	109	94	97	96	98	111	91	107	126	114	74
CE	24	25	26	47	32	30	28	10	15	37	11	49
CO	47	48	45	50	57	52	46	48	51	59	56	58
CR	350	402	411	387	397	403	409	403	431	524	756	444
CS	3	3	2	5	2	3	2	2	4	3	4	2
CU	48	56	52	65	58	58	57	67	64	58	79	53
GA	16	15	16	15	16	16	16	17	15	17	16	16
LA	10	1	15	14	1	5	13	19	8	1	7	11
NI	305	185	194	183	186	181	176	169	178	183	210	207
NB	2	5	4	4	4	4	3	4	4	2	2	4
PB	7	20	13	21	12	7	16	13	22	10	8	9
RB	28	32	35	33	34	30	32	30	28	25	18	25
SC	24	36	37	35	36	38	38	37	38	52	54	39
SR	273	190	203	228	208	212	197	202	183	232	155	204
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	91	167	156	155	152	159	162	166	166	146	126	161
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	14	26	20	20	19	22	24	24	25	17	11	17
ZN	68	90	108	106	94	89	93	92	96	72	71	78
ZR	65	145	124	135	116	126	139	150	150	81	64	110

Var.\ID:	S-195	S-196	S-199	S-200	S-201	S-202	S-203	S-204	NAS124 S-205	NAS126 S-231	S-234	S-235
SIO2	55.49	55.07	52.96	54.18	54.27	53.71	54.32	54.26	53.57	51.71	51.83	52.44
AL2O3	16.08	16.05	17.27	17.25	17.08	16.96	16.83	17.33	17.38	17.53	17.85	16.96
TIO2	1.60	1.66	1.39	1.49	1.49	1.72	1.75	1.71	1.76	1.53	1.42	1.44
FE2O3	10.22	10.52	10.85	10.68	10.67	10.93	10.91	11.21	11.55	10.91	10.69	10.18
MGO	5.19	5.41	7.34	6.42	6.30	6.00	5.52	5.47	5.47	6.76	6.89	7.36
CAO	7.21	7.41	7.83	7.53	7.26	7.58	7.40	7.88	8.21	8.14	8.26	8.38
NA2O	0.57	0.64	0.70	0.71	0.76	0.83	0.70	0.76	0.69	1.14	1.07	1.12
K2O	0.94	0.88	0.75	0.95	1.01	0.99	1.05	0.92	0.88	0.66	0.59	0.73
MNO	0.18	0.18	0.20	0.19	0.18	0.20	0.19	0.19	0.19	0.17	0.18	0.19
P2O5	0.40	0.40	0.29	0.29	0.30	0.32	0.35	0.30	0.31	0.25	0.27	0.26
BA	105	107	137	96	95	88	109	90	82	72	139	147
CE	32	24	19	22	20	24	36	18	31	39	17	45
CO	54	48	62	52	54	51	53	49	52	56	54	52
CR	413	411	409	401	372	397	404	420	372	520	485	489
CS	3	5	3	4	4	2	4	1	2	3	2	3
CU	57	58	61	56	55	59	62	63	64	58	58	53
GA	14	17	16	15	17	17	17	17	16	12	14	16
LA	15	0	10	0	12	4	3	9	5	3	0	4
NI	183	179	244	210	192	176	165	167	159	251	240	252
NB	6	6	3	3	5	6	5	5	4	5	4	4
PB	22	18	13	13	15	11	16	15	10	14	23	25
RB	33	29	23	28	31	29	32	30	24	23	20	25
SC	34	36	34	35	35	39	39	41	44	39	35	38
SR	167	172	192	194	171	183	176	177	179	175	176	171
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	149	158	143	149	147	167	165	154	171	161	156	171
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	26	26	21	20	20	25	24	27	24	19	21	20
ZN	91	93	82	91	94	89	95	86	87	76	98	89
ZR	172	157	115	120	121	143	149	161	147	106	104	106

Var.\ID:	NAS126/cont. S-236	S-237	S-238	S-239	S-240	S-241	S-242	S-243	S-244	S-245	S-248	S-249
SIO2	51.84	53.33	53.04	53.28	53.62	53.38	53.48	54.57	53.82	53.15	53.83	53.01
AL2O3	15.87	17.39	16.19	17.34	16.17	17.75	18.00	18.38	16.89	16.17	18.15	15.72
TIO2	1.64	1.37	1.63	1.44	1.62	1.37	1.14	1.15	1.71	1.61	1.31	1.66
FE2O3	10.67	9.86	10.15	9.78	9.65	9.59	9.53	8.91	10.27	9.66	9.36	10.06
MGO	7.09	6.91	6.88	6.56	7.18	6.40	6.63	6.56	5.93	6.85	6.78	7.00
CAO	8.27	8.23	8.13	8.35	8.24	8.52	8.30	7.69	7.94	8.13	7.42	8.00
NA2O	1.07	0.90	1.06	1.02	1.09	0.95	1.00	1.01	1.19	1.07	0.94	0.96
K2O	0.75	0.74	0.85	0.67	0.84	0.67	0.59	0.83	0.85	0.83	0.82	0.87
MNO	0.20	0.19	0.21	0.20	0.23	0.19	0.17	0.17	0.19	0.21	0.16	0.21
P2O5	0.35	0.29	0.33	0.29	0.30	0.29	0.26	0.24	0.30	0.32	0.27	0.36
BA	100	150	85	150	95	143	142	146	97	90	156	100
CE	31	3	16	49	36	21	11	31	0	20	12	30
CO	50	47	55	54	55	50	49	52	54	51	48	49
CR	471	518	463	477	469	491	543	532	428	470	450	474
CS	0	2	2	3	1	0	3	2	2	1	2	0
CU	58	59	56	53	57	58	60	64	56	52	53	54
GA	16	15	16	16	16	15	14	15	16	15	15	16
LA	21	9	1	15	17	9	7	2	9	4	11	12
NI	208	239	198	198	176	194	205	213	182	183	259	196
NB	5	3	5	5	4	4	3	4	5	6	4	6
PB	13	12	18	10	13	12	12	14	11	15	24	20
RB	28	29	30	26	28	26	24	29	29	27	27	27
SC	39	39	39	38	37	38	39	40	39	38	36	39
SR	183	178	171	182	182	196	185	206	183	183	188	198
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	173	154	177	158	181	159	135	142	179	166	143	161
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	24	21	28	22	26	19	18	18	26	24	19	28
ZN	92	87	92	74	91	79	69	77	95	97	126	101
ZR	142	121	144	125	146	120	97	101	157	147	126	155

Var.\ID:	S-250	S-251	S-252	S-253	S-254	NAS126 S-255	NAS130 S-372	S-373	S-374	S-375	S-376	S-377
SIO2	53.08	52.92	53.08	52.78	52.39	52.04	48.07	57.37	57.09	62.26	51.23	62.29
AL2O3	16.27	16.09	15.06	14.85	14.68	14.65	4.78	12.78	11.53	12.38	7.10	12.34
TIO2	1.48	1.48	1.93	2.09	2.31	2.32	0.39	0.93	0.93	1.12	0.40	0.95
FE2O3	9.11	9.30	10.90	11.28	11.74	12.24	15.11	14.73	13.40	10.36	17.83	10.95
MGO	7.63	7.52	6.89	6.46	6.44	5.96	24.82	6.42	8.94	5.86	18.68	6.26
CAO	8.32	8.09	7.79	7.99	7.80	7.62	2.60	2.64	2.66	2.85	2.55	2.69
NA2O	1.25	1.20	0.95	1.01	1.05	0.98	0.05	0.57	0.57	0.96	0.08	0.78
K2O	0.85	1.04	0.88	0.93	0.97	0.89	0.52	1.12	1.10	1.55	0.38	1.65
MNO	0.22	0.21	0.23	0.23	0.26	0.23	0.40	0.12	0.14	0.08	0.22	0.11
P2O5	0.30	0.32	0.39	0.39	0.42	0.45	0.16	0.11	0.11	0.07	0.04	0.07
BA	146	164	102	104	94	121	192	287	254	297	130	298
CE	17	25	27	17	34	39	28	29	43	54	22	60
CO	51	49	45	49	47	54	190	87	69	39	137	60
CR	476	453	409	390	339	350	3582	2858	2164	2169	3984	1963
CS	2	6	2	0	5	2	4	6	9	13	6	7
CU	46	48	61	56	65	67	28	27	22	19	38	28
GA	15	14	17	16	18	18	8	11	8	11	8	12
LA	10	2	8	13	14	11	14	14	12	18	4	13
NI	205	202	187	155	138	143	2627	1416	934	496	3083	1063
NB	5	5	5	7	6	7	1	8	8	9	3	9
PB	13	15	16	16	18	18	7	20	16	73	17	27
RB	28	31	29	30	33	33	15	44	37	61	18	68
SC	40	37	36	36	37	38	33	28	21	21	34	23
SR	213	245	170	180	158	159	24	70	59	103	24	102
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	144	150	158	167	184	176	96	105	87	96	95	88
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	22	23	27	29	33	35	9	16	14	20	15	22
ZN	93	85	101	104	112	112	72	59	56	127	78	63
ZR	135	136	173	193	211	207	44	231	202	226	48	248

	NAS130/cont.											NAS130
Var.\ID:	S-378	S-379	S-380	S-381	S-382	S-383	S-384	S-385	S-386	S-387	S-388	S-389
SIO2	69.73	56.29	63.56	50.08	49.40	60.99	66.53	63.44	63.80	52.17	64.22	57.70
AL2O3	12.33	10.93	12.93	5.30	3.51	10.89	9.28	11.61	12.94	6.87	10.11	9.00
TIO2	0.96	0.86	1.01	0.47	0.29	0.80	1.02	0.91	1.04	0.82	0.86	1.05
FE2O3	6.88	13.18	11.67	16.99	14.73	10.81	1.70	8.41	9.42	15.32	9.20	9.32
MGO	2.48	10.00	4.80	23.08	25.73	7.91	11.42	7.21	5.53	19.62	8.89	13.56
CAO	2.53	3.27	2.29	2.56	3.27	2.55	3.86	3.16	3.05	4.33	2.42	3.63
NA2O	1.02	0.75	1.01	0.00	0.00	0.92	0.84	0.97	0.70	0.31	0.71	0.96
K2O	1.74	0.80	1.90	0.75	0.31	1.65	2.41	1.51	1.20	0.84	1.55	1.44
MNO	0.04	0.11	0.06	0.43	0.34	0.14	0.39	0.08	0.08	0.44	0.13	0.23
P2O5	0.01	0.06	0.05	0.15	0.07	0.08	0.21	0.04	0.06	0.16	0.05	0.14
BA	312	195	338	169	91	296	419	277	272	291	303	288
CE	45	31	37	40	37	60	56	39	36	34	38	34
CO	15	58	47	196	179	52	76	40	41	173	58	85
CR	1069	2080	2074	4087	3963	1721	1251	1705	1467	3918	1591	2025
CS	10	8	6	1	3	9	14	16	21	4	7	10
CU	9	15	18	35	19	16	13	15	20	27	20	15
GA	10	10	12	8	6	11	13	11	14	11	9	10
LA	15	10	17	11	6	15	14	17	15	9	18	12
NI	251	942	506	2415	2360	727	506	639	802	1532	965	796
NB	11	6	10	3	2	8	8	8	9	5	9	6
PB	26	22	26	12	8	21	33	26	44	29	21	34
RB	66	37	75	24	7	68	91	63	60	24	50	57
SC	14	29	16	29	32	21	20	21	28	24	18	19
SR	111	104	88	24	15	108	154	142	106	60	96	133
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	78	112	89	119	94	89	74	72	71	137	64	83
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	24	16	15	8	7	22	19	19	27	11	17	14
ZN	43	74	66	68	61	57	57	52	101	87	93	94
ZR	318	143	223	56	34	195	190	198	185	95	218	149

	NAS131											
Var.\ID:	S-646	S-645	S-644	S-643	S-642	S-641	S-640	S-639	S-638	S-637	S-636	S-635
SIO2	73.25	64.91	68.57	57.77	64.70	63.00	67.70	60.26	63.95	60.53	56.79	55.18
AL2O3	12.80	16.07	12.45	16.14	12.49	13.34	13.57	11.52	13.58	11.37	18.31	15.63
TIO2	0.98	0.95	0.86	1.99	0.97	1.03	0.96	0.86	0.95	1.00	1.66	1.92
FE2O3	8.22	12.18	7.89	9.87	6.74	6.32	6.68	8.12	7.87	8.71	12.12	10.06
MGO	1.69	1.10	5.78	3.27	3.82	3.61	2.42	8.97	5.00	9.87	2.48	5.14
CAO	2.53	2.37	2.81	2.87	2.90	2.82	2.31	2.90	3.07	3.53	3.72	5.09
NA2O	0.45	0.50	0.30	1.42	1.14	1.81	1.48	0.92	1.05	0.69	1.08	1.74
K2O	1.60	1.72	1.71	2.92	2.16	2.56	2.38	1.51	1.83	1.66	1.71	1.62
MNO	0.07	0.05	0.20	0.08	0.09	0.08	0.05	0.14	0.06	0.23	0.07	0.13
P2O5	0.00	0.08	0.08	0.22	0.12	0.15	0.09	0.14	0.10	0.17	0.21	0.24
BA	381	380	424	345	373	486	455	334	384	345	313	289
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	39	55	64	32	56	39	37	102	38	99	57	41
CR	734	1319	1112	488	792	619	753	1065	1220	1894	893	585
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	11	16	14	11	12	9	8	11	15	15	18	20
GA	11	12	12	16	11	13	12	13	12	12	15	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	344	404	869	480	272	289	255	653	513	965	461	531
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	25	27	22	17	21	18	21	25	23	18	21	17
RB	61	69	71	120	84	94	86	56	70	64	72	53
SC	14	13	18	25	16	11	11	14	18	15	27	22
SR	72	64	72	271	171	234	173	174	165	142	178	256
S	128	297	177	253	174	216	282	355	343	352	279	237
SN	2	0	3	6	0	1	3	2	4	3	0	3
V	93	107	97	123	89	82	68	72	77	108	118	120
W	6	7	5	4	6	4	4	6	6	0	2	3
Y	28	23	26	17	22	17	17	16	17	17	13	14
ZN	54	80	81	77	61	49	38	54	65	71	59	73
ZR	361	364	274	193	266	245	250	202	221	203	211	205

NAS131/cont.

Var.\ID:	S-634	S-633	S-632	S-631	S-390	S-391	S-392	S-393	S-394	S-395	S-396	S-397
SIO2	53.31	50.96	55.81	66.57	61.91	56.94	64.74	60.26	62.74	54.47	60.16	60.50
AL2O3	7.00	4.70	8.75	10.72	13.84	12.48	12.47	11.82	12.61	14.44	12.28	11.94
TIO2	0.60	0.39	0.75	0.94	1.17	1.86	1.17	1.26	1.32	1.84	1.40	1.27
FE2O3	12.62	11.74	11.57	7.68	8.15	10.09	7.06	7.70	9.00	9.06	7.82	7.49
MGO	19.87	27.12	16.62	6.05	6.00	6.82	5.14	7.59	5.45	6.91	6.71	8.18
CAO	3.96	2.40	4.05	3.05	3.71	4.52	3.51	3.90	3.54	5.87	4.50	4.46
NA2O	0.24	0.01	0.38	1.11	1.11	1.20	1.14	0.91	1.10	0.87	0.60	0.54
K2O	0.73	0.45	1.20	1.86	2.17	1.72	1.89	1.71	1.72	1.78	1.83	1.67
MNO	0.25	0.23	0.30	0.12	0.15	0.18	0.10	0.14	0.09	0.20	0.16	0.17
P2O5	0.13	0.11	0.16	0.06	0.18	0.25	0.17	0.26	0.12	0.62	0.44	0.35
BA	194	118	235	345	389	294	362	329	350	199	288	300
CE	n.a	n.a	n.a	n.a	72	44	19	49	41	71	58	47
CO	132	119	164	49	61	54	29	41	38	45	41	46
CR	3002	3725	2820	1195	991	708	866	794	848	402	570	634
CS	n.a	n.a	n.a	n.a	4	9	13	10	8	8	12	9
CU	29	20	21	12	24	18	16	23	19	47	29	38
GA	7	6	11	10	14	14	12	13	14	16	14	12
LA	n.a	n.a	n.a	n.a	23	9	18	15	29	25	22	22
NI	1889	2648	1459	437	658	390	392	515	486	348	399	459
NB	n.a	n.a	n.a	n.a	8	8	10	8	10	10	8	9
PB	15	14	20	19	20	18	21	21	18	18	21	35
RB	28	17	45	69	81	61	75	74	74	79	77	71
SC	29	26	20	17	23	27	17	20	22	27	22	22
SR	105	60	118	179	209	272	228	195	205	214	162	170
S	412	430	389	276	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	4	1	3	12	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	96	86	99	88	64	97	57	62	70	104	69	69
W	1	0	8	2	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	10	6	13	19	27	17	19	19	23	30	24	22
ZN	70	64	118	52	66	64	60	83	73	96	98	105
ZR	111	70	172	283	223	226	258	227	249	197	231	218

Var.\ID:	S-398	S-399	S-400	S-401	S-402	S-403	S-404	S-405	S-406	*-407	S-408	S-618
SIO2	60.38	61.28	47.87	63.51	57.14	52.34	51.50	48.38	48.36	48.62	53.50	55.92
AL2O3	12.74	10.10	10.93	8.47	6.67	14.81	11.76	3.44	12.31	1.64	8.18	10.46
TIO2	1.19	1.03	0.65	1.10	0.99	1.35	1.76	0.43	1.56	0.20	0.38	1.34
FE2O3	7.15	8.16	9.00	7.13	7.80	9.24	10.53	15.23	7.84	9.08	9.17	9.65
MGO	7.77	10.23	24.85	10.94	17.06	9.63	11.05	30.76	20.50	39.08	22.92	10.41
CAO	4.70	3.52	4.63	3.64	3.95	3.12	5.04	2.39	5.70	1.62	3.18	4.42
NA2O	0.89	0.77	0.00	0.67	0.47	1.92	1.46	0.00	0.31	0.00	0.17	0.81
K2O	1.66	1.64	0.12	1.76	1.49	1.53	2.01	0.49	0.70	0.15	0.23	1.49
MNO	0.17	0.18	0.19	0.26	0.33	0.09	0.15	0.38	0.17	0.23	0.13	0.15
P2O5	0.30	0.15	0.15	0.15	0.21	0.28	0.29	0.12	0.20	0.02	0.02	0.23
BA	269	302	85	303	253	242	156	102	42	34	63	239
CE	47	40	16	68	40	40	33	37	0	0	31	n.a
CO	44	64	70	79	95	57	42	181	43	148	69	66
CR	644	1369	547	1309	1774	195	516	3869	389	2673	1735	1145
CS	4	8	2	11	6	6	7	4	6	1	6	n.a
CU	34	21	29	23	28	19	24	44	40	152	17	20
GA	13	11	7	10	11	20	17	7	11	4	14	12
LA	9	15	9	22	11	26	5	4	11	0	4	n.a
NI	396	764	1225	793	1160	355	418	3034	905	3313	1637	720
NB	8	8	1	10	6	7	7	3	2	0	4	n.a
PB	19	22	9	29	23	15	14	17	9	15	13	44
RB	70	64	9	61	55	61	83	19	34	4	13	61
SC	21	22	28	21	24	21	29	26	32	25	19	25
SR	173	155	44	136	130	168	185	57	46	15	57	165
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	760
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	0
V	68	66	60	69	72	72	102	75	101	45	53	91
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	5
Y	18	21	7	24	18	14	27	9	22	3	10	21
ZN	84	99	49	85	120	169	103	159	97	176	236	104
ZR	210	214	58	275	181	195	182	46	127	19	49	181

Var.\ID:	NAS131/cont. S-619	S-620	S-621	S-622	S-623	S-624	S-625	S-626	S-627	S-628	S-629	NAS131 S-630
SIO2	62.26	66.07	74.82	72.07	63.72	63.92	53.97	61.90	63.16	54.59	69.74	59.92
AL2O3	13.10	14.18	11.00	12.39	10.86	11.97	6.30	13.41	12.93	13.65	13.98	5.29
TIO2	1.14	0.85	0.86	0.93	1.07	0.95	0.65	0.82	0.99	0.88	0.87	0.85
FE2O3	9.11	9.36	5.52	6.51	7.68	8.84	9.25	7.40	8.99	12.85	7.42	7.83
MGO	5.61	3.14	1.37	1.80	7.23	6.21	21.42	6.38	5.32	10.15	1.94	19.58
CAO	3.65	2.87	2.42	2.82	3.65	3.61	3.72	4.72	3.41	4.18	3.06	5.12
NA2O	0.68	0.61	0.71	0.68	0.84	0.57	0.21	1.09	0.96	0.58	0.86	0.09
K2O	1.35	1.83	1.70	1.79	1.51	1.36	0.89	1.43	1.64	1.36	1.89	1.44
MNO	0.15	0.11	0.06	0.09	0.14	0.10	0.29	0.10	0.10	0.25	0.05	0.58
P2O5	0.18	0.10	0.00	0.05	0.15	0.12	0.19	0.10	0.10	0.19	0.05	0.28
BA	291	358	329	355	309	275	231	265	351	286	356	314
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	90	53	17	27	55	45	110	32	35	151	24	230
CR	1057	1043	602	690	1038	1292	2338	1116	1250	2521	853	3064
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	22	35	10	10	22	23	22	13	18	42	12	18
GA	12	12	10	10	12	11	8	11	12	12	10	7
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	688	376	204	228	542	638	1668	449	592	1649	284	1081
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	20	22	18	21	25	27	23	21	21	17	19	28
RB	50	70	66	71	55	57	34	51	56	52	68	42
SC	18	16	8	12	20	21	22	23	17	39	17	18
SR	134	115	99	113	184	115	108	170	168	130	129	131
S	425	197	181	185	392	453	631	504	267	179	297	598
SN	3	1	5	1	7	1	11	2	0	3	4	5
V	75	65	47	58	72	74	70	80	75	101	60	82
W	4	6	4	4	2	6	3	0	9	1	7	8
Y	21	23	24	23	20	19	12	16	18	17	21	16
ZN	66	56	37	41	75	83	82	65	63	74	40	116
ZR	281	339	392	367	260	245	120	190	265	148	315	172

Var.\ID:	NAS132 S-409	S-410	S-411	S-412	S-413	S-414	S-415	S-416	S-417	S-418	S-419	S-420
SIO2	66.71	64.26	63.45	59.29	55.78	62.41	55.37	54.87	58.87	53.08	59.47	53.06
AL2O3	8.32	9.98	9.95	7.38	6.99	8.88	7.05	10.03	13.84	10.89	8.60	11.26
TIO2	0.77	0.88	0.75	0.81	0.69	0.98	0.61	1.20	1.14	0.98	0.88	1.41
FE2O3	6.78	9.73	9.68	6.94	8.09	6.59	7.35	7.55	5.07	7.81	5.97	8.94
MGO	9.30	7.70	8.44	14.06	17.86	10.62	20.08	13.11	5.01	10.89	12.56	12.62
CAO	2.41	2.59	2.36	3.09	2.29	3.05	2.94	3.87	3.10	4.69	3.32	3.34
NA2O	0.56	0.66	0.57	0.26	0.40	0.90	0.36	0.70	2.49	0.69	0.50	0.85
K2O	1.87	1.61	1.61	1.57	1.14	2.06	1.27	1.66	3.35	1.47	1.76	1.94
MNO	0.22	0.12	0.10	0.23	0.13	0.18	0.13	0.15	0.11	0.12	0.17	0.13
P2O5	0.14	0.09	0.09	0.32	0.17	0.18	0.27	0.44	0.37	0.43	0.38	0.29
BA	325	301	308	301	203	313	276	307	470	251	316	293
CE	44	52	39	34	42	35	15	42	58	32	33	32
CO	84	65	51	72	73	55	65	47	19	39	52	47
CR	1813	1550	1893	1466	1601	1263	1484	762	180	679	945	874
CS	3	14	8	11	10	10	14	11	8	10	6	3
CU	13	19	16	20	19	14	29	27	24	44	26	17
GA	10	11	10	10	10	10	11	14	15	13	9	16
LA	18	22	12	16	15	12	15	14	28	20	5	13
NI	655	768	859	826	1103	468	1121	623	120	499	733	682
NB	8	8	9	7	5	7	4	6	5	5	7	5
PB	28	27	30	58	27	55	27	38	25	42	33	29
RB	64	70	64	61	40	76	52	68	85	58	74	90
SC	13	21	20	18	17	17	19	21	19	22	16	24
SR	95	126	119	123	102	187	184	241	359	185	163	195
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	58	70	62	63	55	64	53	81	62	78	50	78
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	19	20	21	18	15	18	15	19	13	21	15	13
ZN	87	65	86	124	68	74	92	100	48	182	121	143
ZR	302	248	220	185	174	203	100	143	102	141	183	132

	NAS132/cont.											
Var.\ID:	S-421	S-422	S-423	S-424	S-425	S-426	S-427	S-428	S-429	S-430	S-431	S-432
SIO2	56.62	51.90	55.66	59.67	54.37	64.52	62.28	59.24	58.76	51.21	55.93	53.78
AL2O3	8.45	4.41	6.30	7.94	11.77	13.23	11.73	9.61	9.63	7.99	7.67	6.08
TIO2	0.62	0.52	0.71	0.66	1.40	0.93	1.04	1.08	0.92	0.81	0.75	0.37
FE2O3	6.43	10.26	8.79	0.00	7.51	6.48	8.05	8.03	8.17	9.18	8.08	12.57
MGO	15.99	23.72	18.37	18.97	10.69	4.83	7.36	10.18	11.04	21.51	17.07	22.25
CAO	3.05	3.74	3.18	3.83	2.92	2.74	3.18	3.53	3.15	4.04	2.76	2.59
NA2O	0.83	0.00	0.22	1.05	1.41	0.87	0.81	0.95	0.86	0.54	0.82	0.04
K2O	1.52	1.00	1.15	2.72	1.72	2.28	1.65	1.55	1.61	0.76	1.30	0.39
MNO	0.12	0.43	0.29	0.51	0.11	0.10	0.09	0.14	0.12	0.19	0.13	0.13
P2O5	0.19	0.25	0.24	0.37	0.26	0.16	0.16	0.20	0.16	0.16	0.15	0.01
BA	281	208	221	340	356	452	340	279	277	178	215	73
CE	16	16	30	42	36	71	44	34	44	38	33	29
CO	48	158	105	62	37	34	53	54	49	79	69	86
CR	1160	2951	2146	1109	603	616	994	1191	1379	1428	1603	2674
CS	7	5	12	12	8	12	11	12	18	7	8	6
CU	14	22	19	32	15	23	22	22	21	22	28	21
GA	11	8	10	18	17	13	12	12	11	11	8	8
LA	9	1	8	12	16	24	18	15	5	8	9	7
NI	852	2369	1423	1077	557	408	559	608	672	1075	1141	1712
NB	5	2	5	7	7	8	8	7	7	5	5	1
PB	25	29	27	22	16	24	22	25	23	22	24	11
RB	68	37	43	109	76	81	67	61	56	30	42	19
SC	16	26	23	16	25	23	21	21	21	20	18	22
SR	179	87	108	145	304	184	171	188	180	117	137	41
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	45	72	62	44	73	60	77	75	70	64	64	60
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	13	11	13	13	13	26	19	19	18	13	13	9
ZN	139	108	119	115	119	67	107	89	79	70	89	207
ZR	125	83	136	115	155	282	197	198	209	122	142	44

	NAS132	NAS133										
Var.\ID:	S-433	S-448	S-449	S-450	S-451	S-452	S-453	S-454	S-455	S-456	S-457	S-458
SIO2	51.76	72.74	63.47	70.89	69.68	68.55	63.99	68.77	69.55	64.75	69.58	68.18
AL2O3	6.24	15.35	19.63	16.03	16.85	15.87	16.70	15.29	16.99	18.97	15.50	14.59
TIO2	0.57	1.00	1.65	1.03	1.03	1.02	1.25	1.13	1.26	1.51	1.36	1.36
FE2O3	8.90	4.82	10.35	6.13	7.30	7.03	9.34	6.94	6.35	6.81	5.33	6.08
MGO	20.96	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	1.07	0.14
CAO	2.64	2.80	3.25	2.48	2.58	2.40	2.59	2.93	3.20	4.23	3.58	3.40
NA2O	0.35	0.42	0.03	0.44	0.39	0.44	0.37	0.37	0.62	1.00	0.70	0.91
K2O	1.49	1.61	0.68	1.75	1.83	1.83	1.55	1.78	1.71	1.08	1.80	1.40
MNO	0.18	0.03	0.03	0.02	0.03	0.04	0.04	0.10	0.04	0.08	0.16	0.09
P2O5	0.28	0.07	0.17	0.08	0.10	0.12	0.15	0.15	0.11	0.17	0.14	0.11
BA	174	310	140	315	346	332	286	316	322	127	338	256
CE	12	43	13	45	46	48	23	34	18	6	46	38
CO	84	22	48	15	32	13	27	25	33	42	52	40
CR	1939	113	173	110	117	111	148	128	119	159	151	141
CS	8	7	9	5	10	7	8	8	8	7	7	5
CU	30	10	16	6	11	10	9	11	11	9	13	9
GA	7	10	12	11	11	9	11	11	10	10	10	10
LA	3	10	10	12	23	14	14	15	18	9	14	13
NI	1619	40	63	28	35	34	43	38	42	53	45	45
NB	4	11	7	13	14	11	11	13	14	7	13	10
PB	19	49	14	19	18	18	28	23	17	16	16	17
RB	44	57	26	67	71	62	52	64	57	27	54	39
SC	22	12	25	10	13	11	14	12	13	17	17	16
SR	105	60	22	51	55	51	40	58	72	86	90	81
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	61	58	192	71	61	53	76	64	62	73	76	71
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	10	20	10	19	23	21	16	20	20	13	19	15
ZN	87	29	31	25	35	39	37	43	43	25	37	33
ZR	109	328	144	364	407	377	250	359	350	187	337	262

Var.\ID:	NAS133/cont. S-459	S-460	S-461	S-462	S-463	S-464	S-465	S-466	S-467	S-468	S-469	S-470
SIO2	59.15	62.29	65.12	66.71	65.43	64.39	67.55	64.24	60.79	65.70	68.34	62.35
AL2O3	20.09	20.22	17.89	17.76	18.62	18.65	15.49	18.11	20.74	13.16	13.57	19.54
TIO2	1.10	1.08	1.03	1.05	1.08	1.07	1.15	1.04	0.92	1.20	1.06	0.95
FE2O3	8.98	10.30	8.12	5.39	6.82	8.43	3.50	7.12	7.95	1.24	3.94	8.44
MGO	2.01	0.00	0.30	1.47	0.41	1.20	4.69	1.13	1.72	10.03	3.23	1.06
CAO	5.71	4.10	4.07	4.24	4.01	4.18	4.82	4.47	4.94	5.91	4.38	5.16
NA2O	0.69	0.71	0.84	0.66	0.72	0.74	0.63	0.90	0.83	0.73	1.15	0.66
K2O	0.52	0.98	1.23	1.60	1.45	1.36	1.60	1.37	1.03	1.51	1.53	1.00
MNO	0.12	0.04	0.06	0.14	0.09	0.09	0.28	0.09	0.10	0.51	0.18	0.07
P2O5	0.17	0.13	0.10	0.16	0.14	0.12	0.20	0.13	0.17	0.28	0.12	0.12
BA	181	234	252	285	294	240	273	253	209	244	244	220
CE	31	31	29	54	35	32	38	38	27	13	36	21
CO	45	24	27	35	55	33	43	35	53	81	33	30
CR	300	215	200	164	179	202	168	178	188	188	158	239
CS	4	4	3	5	5	5	4	5	4	5	6	5
CU	25	26	18	19	18	12	14	14	16	22	11	23
GA	13	13	11	11	12	12	12	12	14	10	11	13
LA	7	9	16	10	11	15	13	10	5	2	15	11
NI	143	98	82	73	78	85	82	79	116	86	69	84
NB	5	8	9	11	10	9	10	10	6	8	10	7
PB	14	15	15	17	15	15	19	16	14	10	19	15
RB	22	40	43	50	50	48	47	46	36	38	45	39
SC	44	33	21	22	24	27	21	21	31	26	18	32
SR	100	80	86	92	86	78	87	100	108	116	109	125
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	127	97	86	75	83	91	86	78	89	85	71	94
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	14	15	17	20	19	16	18	17	13	14	19	17
ZN	33	36	43	43	51	55	69	51	46	40	34	36
ZR	145	226	280	299	279	253	305	264	200	228	324	214

Var.\ID:	S-471	S-472	S-434	S-435	S-436	S-437	S-438	S-439	S-440	S-441	S-442	NAS133 S-443
SIO2	65.99	65.65	65.60	68.77	57.77	66.86	66.15	60.16	63.30	67.13	60.41	55.70
AL2O3	18.04	17.17	16.73	16.43	21.95	17.28	17.59	21.15	18.95	17.29	20.82	21.57
TIO2	1.03	0.94	0.95	0.99	0.85	0.93	0.94	0.80	0.92	0.94	0.93	0.76
FE2O3	6.89	7.14	7.05	5.95	6.88	4.80	5.25	7.97	5.94	5.41	6.52	11.54
MGO	0.00	0.66	1.23	0.00	1.43	0.17	1.23	0.22	0.95	0.00	0.40	1.41
CAO	4.25	4.14	4.48	3.83	6.76	4.67	4.75	5.34	4.99	4.41	5.86	4.91
NA2O	0.96	0.97	1.13	1.12	1.36	1.20	1.11	1.01	1.06	1.33	1.49	1.28
K2O	1.36	1.41	1.39	1.47	0.72	1.22	1.33	0.75	1.27	1.35	0.74	0.67
MNO	0.05	0.05	0.05	0.05	0.06	0.05	0.11	0.04	0.09	0.04	0.06	0.05
P2O5	0.10	0.09	0.07	0.07	0.17	0.09	0.12	0.14	0.14	0.07	0.15	0.16
BA	277	262	261	282	144	223	254	166	240	255	157	147
CE	36	29	47	32	32	43	44	22	36	10	16	10
CO	24	32	21	19	39	21	42	22	39	30	34	41
CR	179	183	207	170	281	206	221	260	244	202	334	394
CS	6	4	5	4	1	6	6	3	2	3	5	3
CU	14	21	28	13	31	13	18	41	25	13	25	39
GA	13	11	12	11	13	12	11	12	13	10	13	14
LA	18	21	22	19	11	5	4	2	10	16	5	0
NI	69	69	79	59	137	68	68	96	79	56	101	126
NB	11	10	9	11	5	9	8	6	7	8	6	4
PB	16	17	15	14	13	13	14	14	12	12	10	11
RB	46	48	46	49	28	40	43	28	41	41	23	24
SC	20	23	29	17	34	20	22	35	31	23	33	40
SR	101	111	147	110	163	124	128	147	156	156	197	166
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	82	78	97	70	99	72	78	89	89	65	93	100
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	18	19	24	18	14	20	16	13	18	19	13	9
ZN	34	40	38	36	52	32	36	33	31	26	31	50
ZR	316	283	268	343	141	299	271	174	232	272	160	110

Var.\ID:	NAS138 S-503	S-504	S-505	S-506	S-507	S-508	S-509	S-510	S-511	S-512	S-513	S-514
SIO2	71.26	63.71	68.22	67.85	66.71	65.50	68.22	61.41	56.69	67.32	64.38	62.35
AL2O3	16.38	21.73	17.29	17.96	17.84	16.92	16.73	18.74	22.68	15.97	17.35	19.13
TIO2	1.32	1.31	1.63	1.38	1.46	1.39	1.30	1.70	1.15	1.18	1.31	1.29
FE2O3	5.92	9.86	8.80	7.97	7.80	7.29	7.07	8.20	9.17	6.00	7.20	7.06
MGO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57	2.11	1.48	1.67	1.93
CAO	3.44	3.85	3.68	3.52	3.80	4.29	3.73	5.57	6.59	4.00	4.92	5.45
NA2O	0.23	0.13	0.22	0.31	0.32	0.51	0.54	0.57	0.16	0.51	0.56	0.53
K2O	1.33	1.08	1.21	1.37	1.22	1.30	1.60	1.10	0.51	1.75	1.45	1.14
MNO	0.04	0.02	0.04	0.04	0.04	0.07	0.06	0.14	0.14	0.13	0.13	0.16
P2O5	0.11	0.19	0.14	0.14	0.18	0.20	0.16	0.23	0.29	0.20	0.25	0.25
BA	278	205	203	301	223	272	326	191	179	325	294	265
CE	18	33	32	32	38	41	27	40	32	39	44	41
CO	9	9	9	12	12	14	16	45	45	26	28	33
CR	140	270	172	163	173	156	140	208	248	141	167	220
CS	8	7	7	7	10	8	9	4	4	7	3	4
CU	11	31	15	18	22	26	23	49	58	28	37	42
GA	9	11	10	10	13	11	11	14	14	11	14	14
LA	20	13	15	16	18	18	19	16	13	19	17	11
NI	59	51	50	47	65	58	59	99	115	61	83	102
NB	10	8	14	14	13	11	13	9	6	11	11	9
PB	17	20	17	15	19	21	20	16	14	20	19	18
RB	49	46	49	56	53	49	62	42	29	64	51	44
SC	15	32	19	18	24	24	19	43	50	21	27	38
SR	54	54	63	64	66	93	91	100	114	96	98	114
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	68	93	87	73	78	84	73	113	120	71	89	99
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	15	12	17	20	19	22	24	24	21	27	22	23
ZN	32	61	35	36	38	49	49	59	58	62	73	66
ZR	231	225	254	310	268	297	327	202	139	315	258	228

Var.\ID:	S-515	S-516	S-517	S-518	S-519	S-520	S-728	S-729	NAS138 S-730	NAS139 S-531	S-532	S-533
SIO2	60.83	60.52	57.67	60.39	55.37	55.03	58.84	58.49	57.80	48.29	52.03	51.75
AL2O3	18.58	16.48	22.32	17.75	24.46	18.77	19.72	18.51	17.55	15.13	16.35	15.99
TIO2	1.22	1.34	1.33	1.38	0.85	1.44	1.47	1.51	1.55	2.56	1.86	2.08
FE2O3	7.48	6.64	8.76	6.74	9.12	8.13	7.72	7.29	7.17	14.03	12.05	12.40
MGO	2.63	3.52	2.02	2.86	2.51	3.52	2.53	3.40	3.57	7.41	6.36	6.50
CAO	5.61	5.65	6.52	5.88	7.68	6.49	6.37	6.53	6.50	8.33	7.25	7.16
NA2O	0.43	0.62	0.47	0.56	0.49	0.60	0.54	0.48	0.67	0.45	0.43	0.46
K2O	1.06	1.09	0.71	1.06	0.22	0.73	0.74	0.81	0.85	0.84	0.92	0.90
MNO	0.15	0.18	0.16	0.18	0.14	0.18	0.17	0.19	0.19	0.25	0.23	0.25
P2O5	0.32	0.33	0.29	0.34	0.26	0.39	0.33	0.37	0.37	0.46	0.47	0.48
BA	210	232	188	238	111	180	159	136	125	104	159	139
CE	18	35	25	34	27	18	n.a	n.a	n.a	n.a	n.a	n.a
CO	28	33	47	31	34	37	45	49	45	59	50	54
CR	241	246	326	228	480	342	284	271	219	627	248	229
CS	7	6	6	7	1	4	n.a	n.a	n.a	n.a	n.a	n.a
CU	52	41	57	42	71	53	38	39	41	58	44	47
GA	12	13	16	12	15	14	15	15	15	17	17	18
LA	9	22	10	14	8	12	n.a	n.a	n.a	n.a	n.a	n.a
NI	100	103	135	94	148	119	109	108	100	177	116	115
NB	7	8	6	8	2	7	n.a	n.a	n.a	n.a	n.a	n.a
PB	22	21	16	18	13	18	16	38	18	69	17	18
RB	40	40	30	41	17	33	33	36	35	26	36	33
SC	38	33	46	34	54	43	45	39	42	38	33	35
SR	110	115	123	127	136	103	118	114	137	124	156	142
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	651	755	672
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	6	4	4
V	98	98	131	99	112	122	124	132	131	308	191	190
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	0	3	0
Y	23	23	23	22	20	24	24	23	23	20	20	23
ZN	85	82	74	78	52	121	72	81	88	152	149	142
ZR	196	210	150	206	86	161	178	165	183	98	139	155

NAS139/cont.

Var.\ID:	S-534	S-535	S-536	S-537	S-538	S-539	S-540	S-541	S-542	S-543	S-544	S-545
SIO2	51.80	53.76	55.44	55.41	56.96	55.68	54.17	50.91	55.56	54.15	50.37	54.40
AL2O3	15.96	15.25	15.16	15.76	16.47	16.84	15.88	12.47	16.92	16.67	16.54	14.53
TIO2	2.13	2.02	1.92	1.87	1.87	1.88	1.90	1.47	1.84	1.85	1.92	1.78
FE2O3	12.37	10.84	9.26	10.05	9.40	10.09	10.60	11.97	10.17	10.53	15.16	10.55
MGO	6.20	6.78	6.16	6.27	4.86	5.56	7.11	14.13	5.09	5.89	9.95	8.88
CAO	7.25	6.57	5.98	6.13	5.81	6.24	6.51	7.34	6.08	6.32	6.28	6.50
NA2O	0.83	0.44	0.35	0.47	0.30	0.25	0.28	0.34	0.35	0.11	0.27	0.17
K2O	0.87	0.99	0.92	0.81	0.86	0.74	0.77	0.48	0.97	0.97	0.52	0.76
MNO	0.23	0.25	0.22	0.20	0.20	0.20	0.21	0.20	0.18	0.19	0.17	0.21
P2O5	0.47	0.47	0.45	0.45	0.44	0.46	0.44	0.25	0.44	0.43	0.27	0.45
BA	141	147	159	141	167	153	114	121	132	108	63	136
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	49	45	45	39	35	39	45	62	44	46	66	44
CR	224	254	302	324	268	301	410	757	304	349	538	533
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	42	37	32	40	35	37	31	22	27	25	23	44
GA	18	16	16	16	15	16	16	13	17	16	19	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	112	131	176	202	151	184	250	574	166	197	551	373
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	15	15	18	21	15	15	17	12	20	23	18	27
RB	32	36	35	33	36	30	33	12	40	40	22	32
SC	36	31	28	28	27	30	30	36	32	32	39	29
SR	161	137	112	123	108	113	99	61	120	120	77	117
S	562	531	494	563	460	410	355	181	551	483	56	266
SN	5	3	6	6	14	30	13	3	9	9	4	18
V	188	149	124	126	122	131	139	178	133	138	129	133
W	0	2	4	3	0	0	1	0	3	0	0	3
Y	28	24	26	27	25	27	25	23	28	24	32	26
ZN	134	140	116	119	113	112	128	168	126	135	172	167
ZR	178	211	261	228	257	239	222	124	233	217	197	211

Var.\ID:	S-546	S-904	S-905	S-906	S-907	S-908	S-909	S-910	S-911	S-1060	S-1061	S-1062
SIO2	53.36	53.98	54.70	52.94	51.95	51.83	52.85	55.65	55.67	56.40	55.57	58.92
AL2O3	19.58	17.43	15.35	16.68	16.43	17.12	19.57	16.02	17.12	16.26	15.86	14.92
TIO2	1.06	1.16	1.89	1.84	1.77	1.87	1.95	1.77	1.90	1.92	1.83	1.83
FE2O3	10.08	9.27	10.38	10.68	10.60	11.09	11.87	9.40	9.51	9.76	9.57	8.71
MGO	5.42	6.38	5.65	5.53	5.58	4.74	3.58	4.56	3.69	3.33	3.31	2.73
CAO	7.11	6.11	6.55	6.61	6.96	6.93	7.32	6.25	5.96	5.18	5.26	4.94
NA2O	0.94	0.73	0.44	0.36	0.40	0.37	0.23	0.24	0.55	0.80	0.50	0.39
K2O	1.13	1.13	0.88	0.81	0.76	0.68	0.58	0.96	1.01	1.31	0.99	1.15
MNO	0.12	0.14	0.17	0.20	0.19	0.18	0.17	0.22	0.20	0.18	0.20	0.18
P2O5	0.28	0.35	0.41	0.45	0.46	0.48	0.46	0.54	0.46	0.47	0.61	0.54
BA	143	169	136	137	127	124	115	146	156	172	186	209
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	46	48	58	44	47	46	46	33	39	54	36	35
CR	285	425	388	321	325	281	255	251	239	188	171	183
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	24	23	27	26	27	27	30	29	28	33	43	40
GA	16	14	16	16	16	17	21	17	16	17	16	15
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	222	204	218	191	198	153	136	112	104	89	87	71
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	20	23	28	28	27	36	31	26	26	23	37	35
RB	33	40	32	35	31	31	31	46	46	53	47	54
SC	31	28	30	36	34	37	38	35	37	36	37	29
SR	236	153	101	117	117	114	98	108	114	114	113	107
S	265	356	482	417	762	685	399	476	348	n.a	n.a	n.a
SN	14	4	6	5	6	9	8	10	5	n.a	n.a	n.a
V	142	126	148	149	142	148	163	140	131	140	116	119
W	0	1	5	2	7	5	4	0	1	n.a	n.a	n.a
Y	21	22	27	25	26	29	32	32	32	43	42	34
ZN	77	129	115	126	121	112	128	125	126	96	112	100
ZR	98	140	217	197	190	195	225	281	354	385	344	291

NAS139/cont.

Var.\ID:	S-1063	S-1064	S-1065	S-1066	S-1067	S-1068	S-1069	S-1070	S-1071	S-1072	S-1073	S-1074
SIO2	54.90	54.55	51.55	48.26	50.86	51.04	51.31	59.12	49.88	52.91	52.50	55.99
AL2O3	14.88	16.06	15.23	15.17	14.75	17.04	16.77	15.61	16.43	16.95	16.75	16.51
TIO2	2.29	2.12	2.41	4.04	3.21	3.45	3.23	2.46	3.20	2.62	2.74	2.43
FE2O3	10.99	11.22	11.50	13.01	12.55	13.52	12.44	9.61	14.11	11.78	11.57	10.20
MGO	3.22	2.91	3.15	1.64	3.55	1.53	1.86	0.00	1.96	2.04	1.98	1.98
CAO	5.65	5.85	6.11	6.53	6.02	6.60	6.21	5.14	7.94	6.48	6.25	5.89
NA2O	0.49	0.53	0.40	0.97	0.67	0.48	0.49	0.42	0.09	0.27	0.40	0.19
K2O	0.92	0.88	0.73	0.70	0.78	0.66	0.78	0.93	0.40	0.67	0.78	0.93
MNO	0.20	0.19	0.20	0.21	0.21	0.20	0.20	0.10	0.22	0.19	0.19	0.19
P2O5	0.64	0.66	0.82	0.78	0.66	0.65	0.60	0.44	1.11	0.75	0.71	0.65
BA	176	177	146	111	126	136	159	155	133	138	151	213
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	34	35	43	54	54	48	52	36	48	43	49	44
CR	181	174	180	160	193	153	185	163	111	173	164	161
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	43	44	43	50	45	49	53	32	45	41	40	41
GA	16	18	18	19	17	18	18	17	19	19	19	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	72	82	81	72	134	80	100	64	52	75	78	78
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	49	48	44	28	17	18	26	27	19	26	23	30
RB	42	41	34	29	33	33	37	38	27	33	34	41
SC	38	39	42	56	51	53	58	37	46	51	49	43
SR	108	134	124	153	127	129	135	107	131	122	121	114
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	138	142	187	290	279	298	278	203	330	226	230	192
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	45	42	45	41	45	50	54	47	78	52	48	44
ZN	110	107	117	110	105	99	106	77	121	112	99	109
ZR	277	299	229	210	221	203	199	230	222	223	231	248

Var.\ID:	S-1075	S-1076	S-1077	S-1078	S-1079	S-1080	S-1081	S-1082	S-1083	S-1084	S-1085	NAS139 S-1086
SIO2	54.83	57.59	52.80	57.98	56.76	55.56	56.88	55.12	57.61	53.85	54.73	53.61
AL2O3	16.78	16.74	18.21	16.68	17.54	17.60	16.04	15.98	14.35	15.09	17.99	19.94
TIO2	3.07	2.21	2.65	2.27	2.32	2.61	2.62	2.93	3.39	3.86	2.99	2.12
FE2O3	11.39	9.60	11.16	9.11	9.91	9.92	8.79	9.16	8.23	9.62	10.43	9.84
MGO	1.16	1.89	1.55	1.82	1.76	2.07	2.45	2.35	1.66	1.51	1.49	2.21
CAO	5.89	5.83	7.07	5.78	6.17	6.30	6.07	6.14	5.93	6.29	6.42	7.19
NA2O	0.36	0.32	0.38	0.29	0.29	0.30	0.45	0.56	0.56	0.75	0.71	1.12
K2O	0.96	1.05	0.85	1.08	0.93	0.89	0.98	0.91	1.14	0.97	0.93	0.58
MNO	0.19	0.17	0.17	0.17	0.17	0.19	0.20	0.20	0.21	0.20	0.17	0.09
P2O5	0.61	0.51	0.68	0.49	0.50	0.50	0.41	0.44	0.47	0.49	0.43	0.22
BA	166	180	158	190	178	166	177	136	169	146	154	94
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	48	35	40	35	32	48	41	54	42	57	50	39
CR	151	174	182	208	217	244	222	226	208	205	212	223
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	38	36	37	36	38	42	38	42	35	41	42	26
GA	18	16	21	15	17	16	16	15	14	14	18	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	73	84	97	80	95	105	102	112	83	104	116	123
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	20	22	20	21	20	21	17	21	16	21	17	11
RB	42	45	35	45	40	37	40	36	43	36	38	24
SC	46	40	45	41	49	46	50	48	37	56	49	60
SR	104	119	143	114	131	119	120	113	109	118	111	156
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	215	154	207	145	177	176	192	194	180	229	200	182
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	51	43	51	36	40	37	26	29	25	29	27	18
ZN	91	90	95	84	99	94	90	88	88	97	85	45
ZR	248	245	206	257	240	225	233	221	275	235	205	140

NAS140/cont.

Var.\ID:	S-796	S-795	S-760	S-759	S-758	S-757	S-756	S-755	S-754	S-753	S-752	S-751
SIO2	58.29	59.48	58.82	60.18	58.56	57.18	59.79	59.11	52.12	54.76	54.24	54.85
AL2O3	17.95	16.40	17.13	16.21	16.93	15.97	16.32	16.27	15.26	16.27	15.93	15.43
TIO2	1.83	1.84	1.67	1.97	1.88	2.43	2.14	1.53	2.23	1.75	1.67	1.96
FE2O3	8.38	7.55	7.15	6.32	8.28	7.70	7.98	7.97	10.60	9.80	9.83	9.91
MGO	2.93	3.44	3.07	3.42	2.22	3.05	1.82	2.43	3.72	2.61	3.02	3.20
CAO	5.87	5.89	5.74	5.79	5.72	5.84	5.56	5.36	6.71	6.20	6.00	6.01
NA2O	0.60	0.60	0.48	0.58	0.74	0.79	0.78	0.60	0.62	0.58	0.89	0.91
K2O	1.01	1.09	1.02	1.21	0.96	1.03	1.08	1.02	0.73	0.62	0.61	0.70
MNO	0.20	0.22	0.20	0.24	0.16	0.23	0.16	0.15	0.22	0.17	0.18	0.20
P2O5	0.38	0.42	0.45	0.44	0.42	0.46	0.46	0.48	1.02	0.83	0.80	0.81
BA	163	164	174	168	155	134	160	187	103	150	129	137
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	34	35	35	33	42	50	36	32	53	34	30	31
CR	191	208	196	160	176	187	175	154	127	148	139	121
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	46	40	40	34	32	31	28	32	44	33	36	37
GA	16	15	15	15	15	16	15	16	21	19	20	20
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	94	96	99	81	85	84	80	74	66	70	65	54
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	20	18	20	15	18	18	17	18	18	22	14	15
RB	42	43	39	44	37	34	41	37	31	34	33	32
SC	35	30	29	33	32	26	25	27	31	29	31	25
SR	125	141	118	129	131	117	114	120	123	128	129	119
S	454	680	904	709	838	657	699	622	730	919	773	611
SN	13	12	2	5	8	4	5	11	2	10	17	4
V	130	122	126	135	140	163	135	123	194	142	130	142
W	4	5	5	8	13	14	13	9	20	7	14	5
Y	25	27	26	25	31	33	35	40	74	59	63	65
ZN	92	100	92	93	84	80	77	76	118	100	101	102
ZR	257	267	223	281	248	263	277	260	264	279	298	313

Var.\ID:	S-750	S-749	S-748	S-587	S-588	S-589	S-590	S-591	S-592	S-593	S-594	S-595
SIO2	59.16	56.91	54.95	50.81	53.69	54.85	53.53	55.42	58.01	56.93	63.71	56.11
AL2O3	15.75	15.94	16.40	17.08	18.40	17.66	18.70	18.05	16.42	15.95	15.11	15.78
TIO2	1.78	1.78	1.94	1.79	1.72	1.72	1.65	1.61	1.64	1.52	1.58	1.58
FE2O3	8.29	8.99	10.26	11.43	10.76	9.46	10.49	9.91	9.16	8.94	8.35	9.84
MGO	3.19	3.34	2.92	3.69	3.28	2.78	3.30	3.41	3.42	4.23	2.09	3.16
CAO	5.62	6.07	6.83	7.76	7.07	6.77	6.77	6.56	5.57	5.27	4.26	5.26
NA2O	0.53	0.39	0.06	0.18	0.40	0.88	1.07	0.64	0.78	0.74	0.87	0.73
K2O	1.03	0.90	0.64	0.47	0.56	0.77	0.74	0.80	0.77	1.13	1.68	1.35
MNO	0.21	0.20	0.20	0.20	0.19	0.17	0.17	0.18	0.15	0.24	0.17	0.19
P2O5	0.60	0.66	0.89	1.06	0.72	0.66	0.59	0.56	0.42	0.45	0.28	0.48
BA	167	172	162	116	134	152	144	139	166	245	246	242
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	31	45	130	37	30	37	37	37	23	33	31	31
CR	139	188	172	167	193	161	208	204	265	175	114	141
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	40	47	53	78	66	60	55	52	43	44	33	38
GA	18	18	18	19	20	19	19	20	16	17	13	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	61	68	73	90	91	70	79	84	122	63	46	52
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	14	18	25	25	17	18	11	17	23	27	21	23
RB	45	41	36	33	26	33	29	35	28	37	60	46
SC	24	25	33	32	31	25	29	30	27	28	20	27
SR	114	116	120	147	125	158	151	132	116	139	98	101
S	584	648	820	851	605	669	566	749	775	796	293	1214
SN	9	3	6	6	6	9	9	13	9	7	1	3
V	133	148	163	171	162	144	172	156	123	118	116	126
W	10	12	17	0	0	0	0	0	0	5	1	0
Y	46	46	56	63	52	46	42	39	34	25	27	27
ZN	98	109	118	135	115	88	97	97	94	97	92	102
ZR	302	256	246	239	259	304	242	255	260	185	312	229

	NAS140/cont.						NAS140	NAS141				
Var.\ID:	S-596	S-597	S-598	S-599	S-600	S-601	S-602	S-611	S-612	S-613	S-614	S-615
SI02	53.51	54.69	56.25	55.12	52.22	56.80	56.35	57.22	58.39	58.79	61.17	63.29
AL203	16.15	16.70	15.79	15.22	15.71	15.34	14.99	14.90	15.29	13.65	14.15	13.91
TI02	1.72	1.67	1.78	1.73	1.95	1.83	2.01	1.48	1.47	1.43	1.43	1.50
FE203	11.04	11.07	10.15	9.79	11.36	9.46	10.09	8.78	8.80	7.59	7.08	6.59
MGO	3.13	3.61	3.95	4.25	4.80	4.41	4.72	7.19	6.09	5.85	4.87	4.07
CAO	5.84	5.93	5.78	5.73	6.65	5.92	6.42	6.03	5.63	5.02	4.76	4.50
NA20	1.02	0.83	0.55	0.49	0.87	0.55	0.63	0.35	0.46	0.44	0.42	0.49
K20	1.17	1.20	1.28	1.24	1.05	1.24	1.21	0.92	0.90	1.01	1.20	1.27
MNO	0.18	0.20	0.23	0.24	0.25	0.26	0.28	0.23	0.20	0.19	0.19	0.19
P205	0.46	0.45	0.49	0.49	0.50	0.46	0.47	0.47	0.36	0.34	0.32	0.29
BA	218	298	227	202	144	175	178	186	218	213	259	211
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	31	37	40	41	44	41	37	47	43	36	41	30
CR	102	120	161	159	163	154	165	444	406	397	345	296
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	42	47	56	54	75	57	48	76	74	52	41	36
GA	18	17	17	17	19	17	16	14	14	14	13	14
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	45	48	66	66	73	63	61	310	270	243	205	154
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	18	20	20	21	18	19	13	18	19	42	21	21
RB	36	41	47	43	36	45	41	40	40	41	47	52
SC	31	33	34	30	34	29	31	32	28	25	25	21
SR	127	133	109	110	138	127	135	105	100	98	95	100
S	1021	725	852	935	746	631	612	577	549	473	529	483
SN	4	2	4	11	11	4	6	11	3	18	12	11
V	140	147	147	148	173	138	166	119	113	96	100	91
W	1	0	6	0	4	0	0	0	0	0	1	0
Y	33	28	30	29	27	28	27	24	25	24	27	26
ZN	104	116	118	110	121	125	127	117	108	99	86	78
ZR	220	189	217	218	180	225	232	220	266	272	298	319

Var.\ID:	S-616	S-617	S-1120	S-1121	S-1122	S-1123	S-1124	S-1125	S-1126	S-1127	S-1128	S-1129
SI02	62.37	60.13	58.67	58.34	56.11	55.32	56.77	57.33	58.01	56.35	55.85	54.31
AL203	14.52	15.55	17.70	15.49	14.96	16.19	16.27	16.00	16.28	16.45	16.38	16.34
TI02	1.48	1.42	1.62	1.72	1.71	1.93	1.64	1.56	1.89	1.95	2.14	2.13
FE203	7.54	8.43	10.14	8.31	9.04	9.74	8.41	8.34	8.22	9.53	9.72	10.46
MGO	3.08	3.93	2.71	4.80	5.05	4.97	5.20	5.42	5.22	4.34	4.87	4.58
CAO	4.31	4.68	4.49	5.64	5.42	6.23	5.85	5.84	6.36	6.11	6.51	6.93
NA20	0.34	0.44	0.50	0.30	0.50	0.40	0.24	0.15	0.14	0.27	0.14	0.13
K20	1.35	1.27	1.20	1.02	0.96	0.73	0.85	0.81	0.96	0.87	0.82	0.67
MNO	0.17	0.17	0.16	0.26	0.23	0.26	0.26	0.24	0.31	0.26	0.28	0.25
P205	0.33	0.35	0.37	0.44	0.43	0.46	0.43	0.45	0.45	0.46	0.48	0.55
BA	240	277	244	207	201	197	213	200	228	214	199	164
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	28	29	31	49	47	50	50	51	42	43	46	53
CR	232	233	181	209	221	213	219	251	202	193	217	218
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	31	41	39	46	56	56	49	51	39	49	65	58
GA	14	15	17	16	15	18	17	15	17	19	17	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	113	136	98	118	132	130	140	171	99	112	119	127
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	19	22	22	21	31	28	24	26	19	21	22	34
RB	63	61	50	45	43	34	35	34	40	39	35	33
SC	20	27	26	29	35	42	31	32	30	32	37	38
SR	100	109	99	121	108	131	115	105	118	119	121	116
S	566	578	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	7	7	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	93	107	122	120	136	139	120	110	123	129	147	151
W	0	2	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	29	26	35	30	30	28	30	28	27	29	31	34
ZN	72	90	82	100	99	109	104	104	111	108	119	119
ZR	307	242	216	225	198	192	203	199	228	210	215	200

Var.\ID:	NAS141/cont. S-1130	S-1131	S-1132	S-1133	S-1134	S-1135	S-1136	S-1137	S-1138	S-1139	S-1140	S-1141
SI02	55.40	57.19	58.00	57.63	59.57	59.81	63.47	59.11	60.13	58.39	56.85	52.55
AL203	17.07	15.92	16.12	16.08	16.25	15.06	15.57	13.94	15.49	15.97	14.37	14.59
TI02	2.23	1.80	1.85	2.09	1.89	1.71	1.48	1.50	1.39	1.36	1.49	2.11
FE203	10.16	8.13	8.47	9.89	7.77	7.76	6.80	6.34	6.74	7.28	6.29	9.17
MGO	4.37	5.03	4.52	3.36	4.43	4.47	3.60	4.99	4.27	4.59	5.46	6.65
CAO	6.61	5.90	5.82	5.85	5.62	5.47	5.17	4.93	5.02	4.98	5.24	6.82
NA20	0.17	0.12	0.26	0.31	0.21	0.22	0.18	0.26	0.26	0.49	0.18	0.24
K20	0.88	1.01	1.21	1.21	1.39	1.37	1.52	1.39	1.39	1.14	1.19	0.90
MNO	0.30	0.32	0.29	0.24	0.32	0.29	0.27	0.31	0.28	0.29	0.33	0.38
P205	0.51	0.50	0.48	0.43	0.44	0.45	0.39	0.46	0.43	0.42	0.50	0.55
BA	249	238	284	256	276	295	354	354	336	311	303	193
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	66	61	45	50	36	34	33	23	21	20	24	43
CR	175	146	158	162	128	136	118	114	110	99	121	192
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	59	42	41	36	38	39	32	33	35	40	30	47
GA	18	17	18	18	17	16	15	17	15	17	15	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	67	56	64	62	47	51	41	38	41	38	42	59
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	21	19	22	18	17	21	24	17	19	14	16	12
RB	39	42	49	47	52	54	59	53	52	41	45	33
SC	36	31	28	33	34	29	21	23	29	30	23	40
SR	102	97	103	94	96	100	108	97	97	105	88	105
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	145	117	130	133	119	116	97	101	98	106	103	163
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	29	26	28	29	27	29	31	31	29	31	27	28
ZN	123	104	102	99	103	102	89	96	96	85	90	116
ZR	207	209	231	242	241	236	270	238	247	201	216	180

Var.\ID:	NAS141 S-1142	NAS142 S-657	S-658	S-659	S-660	S-661	S-662	S-663	S-664	S-665	S-666	S-667
SI02	54.20	62.08	59.93	63.11	60.74	59.30	63.93	67.49	62.14	65.86	63.88	59.07
AL203	15.65	22.38	23.48	19.18	23.50	22.06	19.24	18.55	18.25	17.10	19.53	23.93
TI02	1.82	1.52	1.10	1.70	1.28	1.48	1.13	1.22	1.26	1.08	1.07	1.41
FE203	9.27	9.01	11.64	7.26	9.19	7.93	6.38	5.01	9.47	6.46	6.24	8.63
MGO	6.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	6.33	4.28	4.10	3.90	4.64	5.55	4.63	4.68	4.17	3.90	4.23	5.51
NA20	0.28	0.58	0.51	0.81	0.55	0.74	0.86	1.18	1.05	0.87	0.63	0.80
K20	0.92	0.72	0.87	1.30	0.82	0.95	1.32	1.27	1.31	1.48	1.51	0.93
MNO	0.32	0.03	0.03	0.06	0.03	0.08	0.05	0.04	0.04	0.07	0.07	0.04
P205	0.50	0.17	0.17	0.18	0.18	0.22	0.16	0.10	0.12	0.14	0.22	0.21
BA	216	160	236	172	214	161	263	266	269	286	286	221
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	37	15	28	32	23	39	27	15	17	29	21	35
CR	244	377	360	265	351	348	232	247	273	195	194	381
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	38	24	30	23	24	31	19	15	13	12	12	29
GA	15	14	15	10	13	14	12	13	11	12	13	15
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	89	90	106	78	109	148	81	70	59	67	76	138
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	12	16	13	13	13	13	12	16	14	14	12
RB	35	32	40	39	35	38	45	42	47	51	61	39
SC	35	33	27	21	32	24	16	15	23	11	15	26
SR	100	58	61	64	66	93	112	139	142	113	101	132
S	n.a	470	395	347	404	508	874	619	412	1138	881	464
SN	n.a	13	4	7	7	2	4	3	7	15	4	1
V	139	82	84	80	75	93	68	60	87	72	61	102
W	n.a	0	0	0	1	3	0	0	5	5	0	0
Y	26	15	13	15	15	18	19	20	19	21	20	15
ZN	110	30	45	32	36	56	35	25	25	41	54	54
ZR	201	203	209	226	203	210	253	295	291	327	321	181

	NAS142/cont.			NAS142	NAS162							
Var.\ID:	S-668	S-669	S-670	S-671	S-711	S-710	S-709	S-708	S-707	S-706	S-705	S-704
SIO2	63.22	59.59	58.48	51.97	69.08	71.34	74.63	67.07	72.77	73.54	73.11	67.21
AL2O3	20.74	22.19	24.37	20.97	16.64	17.20	13.19	15.40	13.42	13.01	15.83	11.26
TIO2	1.25	1.16	1.16	1.76	0.90	0.87	0.85	0.96	0.83	0.88	1.00	1.10
FE2O3	6.70	8.18	9.08	14.83	8.82	7.67	6.05	8.55	6.98	5.84	6.60	9.08
MGO	0.00	1.09	0.00	2.39	0.00	0.00	2.57	3.45	1.94	2.61	0.00	7.63
CAO	5.06	5.73	5.52	5.01	2.30	2.45	2.65	3.04	2.49	2.77	2.61	3.47
NA2O	0.98	0.92	0.79	1.04	0.48	0.50	0.44	0.29	0.37	0.37	0.51	0.25
K2O	1.09	0.87	0.87	0.46	2.02	2.07	2.07	2.05	1.83	1.81	1.80	1.57
MNO	0.05	0.06	0.04	0.09	0.02	0.02	0.13	0.22	0.09	0.14	0.02	0.28
P2O5	0.14	0.17	0.19	0.21	0.08	0.06	0.02	0.16	0.02	0.04	0.04	0.10
BA	236	189	205	91	393	396	428	397	398	407	372	398
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	39	41	37	82	9	7	28	86	21	27	13	110
CR	322	351	374	537	193	141	309	566	253	359	381	1595
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	20	25	30	46	7	11	9	14	12	10	11	19
GA	12	13	13	16	11	11	11	12	11	10	11	10
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	109	151	177	229	75	74	271	217	221	219	152	826
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	14	10	13	13	19	22	17	29	21	20	26	34
RB	38	31	34	20	78	79	73	76	70	66	70	52
SC	23	28	22	47	12	10	10	15	14	11	12	22
SR	148	159	136	257	63	67	76	63	72	74	70	70
S	542	715	605	483	489	434	113	579	189	157	428	178
SN	7	3	9	3	3	0	3	4	5	3	2	3
V	82	93	91	145	55	59	55	74	64	59	60	93
W	1	0	1	1	11	3	12	15	4	7	5	4
Y	12	14	11	13	23	24	28	23	29	33	27	34
ZN	35	40	42	75	43	39	41	51	48	52	38	101
ZR	227	154	161	133	397	396	348	357	369	411	483	337

Var.\ID:	S-703	S-702	S-701	S-700	S-699	S-698	S-991	S-992	S-993	S-994	S-995	S-996
SIO2	70.04	72.20	71.48	69.82	63.06	66.33	53.54	64.06	60.22	59.06	61.89	62.16
AL2O3	15.20	13.04	15.95	10.99	14.86	12.80	10.27	15.02	7.79	11.68	14.62	10.16
TIO2	0.97	0.92	0.84	0.86	0.99	0.92	1.88	1.20	0.78	1.42	1.21	0.81
FE2O3	8.32	6.44	6.90	7.66	13.59	11.33	9.61	9.44	11.52	8.65	10.32	13.08
MGO	0.81	3.68	0.00	5.34	3.00	5.78	16.98	3.11	14.01	9.73	5.26	9.61
CAO	2.57	2.90	2.30	2.73	2.67	3.12	4.20	4.26	3.48	5.07	4.02	3.12
NA2O	0.55	0.39	0.61	0.39	0.53	0.35	0.02	0.80	0.10	0.72	0.76	0.34
K2O	1.83	1.95	2.10	1.70	1.45	1.79	0.53	1.28	1.24	1.62	1.77	1.32
MNO	0.05	0.16	0.02	0.15	0.05	0.18	0.28	0.08	0.37	0.36	0.16	0.17
P2O5	0.05	0.06	0.05	0.04	0.04	0.06	0.20	0.08	0.12	0.23	0.12	0.03
BA	408	436	393	357	314	379	117	282	288	374	327	282
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	26	44	8	53	36	120	96	36	153	113	75	99
CR	640	545	174	801	1714	1203	641	1015	2770	1168	1167	2330
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	16	13	9	12	20	24	63	26	26	23	32	35
GA	10	10	10	10	11	11	11	13	10	14	15	11
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	392	417	77	527	507	811	722	366	1739	441	475	1606
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	27	24	21	18	29	27	22	14	23	23	21	17
RB	66	70	77	58	56	64	14	37	40	40	51	46
SC	15	16	8	16	24	23	43	28	29	25	25	27
SR	76	73	67	69	63	66	34	115	66	181	190	75
S	212	86	338	147	163	142	n.a	n.a	n.a	n.a	n.a	n.a
SN	3	33	1	4	2	4	n.a	n.a	n.a	n.a	n.a	n.a
V	66	60	53	66	95	86	133	118	100	127	124	102
W	12	4	6	4	9	6	n.a	n.a	n.a	n.a	n.a	n.a
Y	36	29	24	27	24	26	24	25	20	25	29	26
ZN	59	56	36	65	102	104	146	51	182	79	68	90
ZR	426	371	422	328	288	249	131	284	186	277	278	196

NAS162/cont.

Var.\ID:	S-997	S-998	S-999	S-1000	S-1001	S-1002	S-1003	S-1004	S-1005	S-1006	S-853	S-854
SIO2	69.16	63.00	62.96	68.11	57.08	65.28	55.05	66.12	56.47	51.49	56.59	59.26
AL2O3	12.82	15.47	13.76	15.37	18.49	14.21	12.82	12.13	16.45	16.92	17.27	14.21
TIO2	0.94	0.98	0.97	1.00	1.05	0.94	0.83	1.01	1.06	1.64	1.04	1.06
FE2O3	7.44	10.82	9.79	7.59	13.01	9.29	20.28	10.59	13.55	14.61	12.03	8.84
MGO	1.56	2.84	6.38	0.10	3.26	2.16	5.19	4.18	5.86	8.26	5.14	5.85
CAO	2.43	2.83	3.48	2.58	4.12	3.25	1.98	2.52	4.07	5.53	5.09	5.21
NA2O	0.83	0.55	0.45	0.64	0.53	0.74	0.55	0.60	0.48	0.29	0.36	0.46
K2O	1.82	1.67	1.68	1.95	1.07	1.64	1.28	1.64	1.41	0.91	1.14	1.28
MNO	0.07	0.10	0.18	0.04	0.11	0.07	0.12	0.10	0.18	0.30	0.19	0.17
P2O5	0.05	0.11	0.12	0.09	0.17	0.07	0.10	0.04	0.17	0.27	0.21	0.24
BA	340	345	317	347	290	311	288	319	261	154	245	236
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	36	87	112	18	57	33	67	50	93	195	71	53
CR	698	1106	1115	367	1068	957	3047	1425	1600	1281	830	665
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	16	20	44	15	46	23	17	26	43	69	49	35
GA	10	13	14	12	13	12	9	12	15	17	14	13
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	239	639	934	115	507	301	506	1211	778	595	439	333
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	20	19	19	16	17	22	16	17	21	16	22
RB	60	63	63	75	43	54	53	58	47	32	40	42
SC	12	23	25	15	25	23	22	24	42	53	45	26
SR	78	77	80	72	86	95	60	85	86	77	93	96
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	316	763
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	5	7
V	69	91	99	64	131	102	117	87	148	210	163	118
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	5	11
Y	27	23	28	27	16	22	18	32	23	19	16	18
ZN	39	59	71	47	63	46	77	53	89	84	66	75
ZR	450	311	260	464	203	296	259	356	203	171	216	238

Var.\ID:	S-855	S-856	S-857	S-858	S-859	S-860	S-861	S-862	S-863	S-864	S-865	S-866
SIO2	55.17	58.06	57.48	57.34	54.64	54.06	53.22	51.32	46.01	52.48	53.59	46.17
AL2O3	16.14	16.24	16.85	16.45	18.03	16.52	16.02	15.13	18.87	15.92	15.91	18.77
TIO2	1.06	1.48	1.87	1.83	1.89	2.25	2.58	2.78	3.74	3.29	3.06	3.62
FE2O3	9.33	9.52	11.48	10.24	11.51	10.77	11.39	11.50	16.83	12.17	11.99	17.41
MGO	7.44	4.47	2.91	4.62	3.87	4.35	4.55	5.10	3.04	3.96	4.00	4.22
CAO	6.47	5.45	5.20	5.45	5.48	5.58	6.14	6.56	7.34	6.46	6.46	8.11
NA2O	0.39	0.44	0.71	0.41	0.37	0.43	0.44	0.39	0.38	0.08	0.04	0.05
K2O	1.09	1.39	1.13	1.33	1.20	1.10	1.10	1.06	0.46	0.86	0.73	0.19
MNO	0.25	0.21	0.14	0.24	0.23	0.25	0.27	0.30	0.27	0.32	0.31	0.29
P2O5	0.27	0.35	0.27	0.36	0.39	0.42	0.45	0.53	0.50	0.56	0.55	0.50
BA	202	209	162	187	185	191	155	145	92	128	133	96
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	65	47	36	46	49	43	49	47	56	52	47	67
CR	623	412	423	393	422	337	328	311	264	292	279	322
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	36	34	40	39	47	43	48	53	76	56	56	100
GA	14	15	16	15	18	20	19	20	23	21	21	22
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	343	255	163	171	177	149	130	128	95	111	110	112
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	12	21	23	21	21	22	22	24	22	19	20	11
RB	39	55	43	56	56	45	42	41	23	38	39	20
SC	36	29	33	29	34	40	39	42	58	43	39	56
SR	138	108	115	110	98	101	105	118	72	95	110	104
S	386	510	447	504	531	500	504	646	180	666	677	78
SN	4	8	17	8	12	9	13	9	3	10	11	1
V	151	129	162	156	162	161	188	195	280	212	210	299
W	6	8	8	8	4	10	8	5	0	0	8	2
Y	16	24	26	25	25	28	27	28	37	32	39	29
ZN	89	99	104	111	120	122	137	133	150	138	138	107
ZR	180	260	226	234	203	231	231	243	234	288	334	163

	NAS162/cont.									NAS162	NAS168	
Var.\ID:	S-867	S-868	S-869	S-870	S-871	S-872	S-873	S-874	S-875	S-876	S-547	S-548
SIO2	48.93	51.57	53.75	55.42	56.89	56.73	56.65	55.78	55.95	52.71	70.38	70.05
AL2O3	18.33	18.00	15.89	17.07	20.85	16.90	17.62	16.08	15.72	14.71	16.05	16.75
TIO2	3.73	2.83	2.76	2.66	2.04	2.48	2.39	2.74	2.74	2.95	1.68	1.63
FE2O3	17.85	13.29	12.51	12.42	12.31	11.18	10.33	10.41	10.29	10.98	6.93	7.38
MGO	3.02	3.73	4.03	2.80	1.25	3.03	4.06	4.60	4.76	6.02	0.00	0.00
CAO	5.90	6.59	6.47	5.91	4.93	5.38	5.64	6.09	6.11	6.66	2.98	3.12
NA2O	0.05	0.14	0.04	0.03	0.00	0.03	0.00	0.00	0.03	0.02	0.45	0.31
K2O	0.91	0.46	0.73	0.73	1.51	1.01	1.11	1.21	1.21	1.31	1.54	1.29
MNO	0.27	0.26	0.27	0.24	0.17	0.26	0.30	0.34	0.34	0.38	0.04	0.03
P2O5	0.62	0.55	0.52	0.49	0.44	0.48	0.51	0.54	0.56	0.64	0.09	0.09
BA	103	131	141	145	210	165	173	181	203	188	245	202
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	49	49	44	38	34	39	40	47	41	49	13	10
CR	190	233	242	219	193	194	252	236	236	217	153	174
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	66	66	58	58	47	49	50	52	55	55	10	11
GA	27	24	20	19	21	21	19	20	19	20	10	11
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	79	115	92	84	73	76	105	88	95	89	42	45
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	15	20	18	21	20	16	19	19	19	18	20	17
RB	43	28	35	40	78	48	54	52	54	52	56	46
SC	61	41	38	36	39	31	36	34	29	37	20	17
SR	73	106	92	90	63	81	83	101	102	114	61	42
S	176	494	571	498	313	457	478	520	580	531	250	289
SN	7	9	9	8	51	14	13	17	16	19	43	10
V	253	184	186	173	164	147	150	167	174	195	83	89
W	8	12	4	11	9	6	7	1	9	7	5	22
Y	79	62	43	46	39	46	41	33	33	25	20	14
ZN	143	131	123	123	108	127	131	134	143	152	29	31
ZR	365	456	336	374	299	365	289	307	294	266	269	241

Var.\ID:	S-549	S-550	S-551	S-552	S-553	S-554	S-555	S-556	S-557	S-558	S-559	S-560
SIO2	73.26	70.84	68.30	74.62	57.00	65.22	67.63	68.16	62.32	61.91	65.61	65.59
AL2O3	16.42	15.54	17.97	11.52	21.76	17.55	17.21	18.08	17.92	19.77	17.11	17.08
TIO2	1.07	1.22	1.76	1.61	2.37	1.54	1.58	1.54	1.88	1.62	2.27	1.97
FE2O3	5.75	5.83	8.04	5.38	16.39	10.90	8.47	7.30	12.65	13.06	8.14	8.72
MGO	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	2.78	3.50	3.75	2.63	3.48	3.84	3.50	3.91	3.34	3.43	4.09	4.31
NA2O	0.35	0.56	0.77	0.73	0.45	0.74	0.66	0.76	0.85	0.71	0.72	0.67
K2O	1.80	1.91	1.55	1.34	0.91	0.97	1.29	1.28	1.54	1.55	1.40	1.30
MNO	0.02	0.11	0.05	0.05	0.03	0.04	0.03	0.03	0.04	0.03	0.09	0.09
P2O5	0.05	0.09	0.10	0.00	0.21	0.07	0.08	0.09	0.14	0.14	0.20	0.17
BA	342	387	248	174	105	134	191	192	231	223	222	225
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	15	20	20	13	22	17	20	16	15	18	29	31
CR	112	138	183	109	224	128	143	166	154	201	162	192
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	10	15	20	7	18	28	14	15	12	18	19	26
GA	11	11	12	6	14	12	11	12	13	14	14	13
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	35	61	67	30	86	72	46	47	52	64	56	75
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	18	17	16	14	17	19	19	16	18	16	19	20
RB	71	67	53	37	33	38	38	42	55	62	52	49
SC	10	18	25	8	35	29	24	27	19	23	20	25
SR	55	93	93	64	49	94	89	116	100	93	103	99
S	466	321	269	217	408	227	308	235	250	339	519	499
SN	4	7	18	8	3	44	591	3	2	16	2	2
V	68	72	91	49	109	95	76	71	86	94	95	101
W	20	17	14	19	7	12	13	10	10	3	12	23
Y	20	30	19	17	17	36	24	21	17	21	21	21
ZN	33	32	43	22	97	67	38	40	50	54	41	43
ZR	322	330	255	326	175	195	227	246	280	262	280	278

	NAS168/cont.		NAS168	NAS169								
Var.\ID:	S-561	S-562	S-563	S-564	S-565	S-566	S-567	S-568	S-569	S-570	S-571	S-57?
SI02	64.90	64.88	63.87	72.46	63.88	74.05	70.40	67.45	76.80	75.96	73.47	68.50
AL203	16.82	16.00	15.95	14.40	19.94	13.12	16.01	18.51	9.06	11.47	12.89	14.63
TI02	1.86	1.83	1.86	1.43	1.53	1.49	1.17	1.75	1.24	1.70	1.45	1.16
FE203	5.96	6.56	6.68	6.41	11.61	5.23	5.92	6.93	3.71	4.33	4.80	5.28
MGO	1.84	2.13	2.19	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	1.53
CAO	4.68	5.03	5.02	3.31	3.46	3.03	3.14	3.94	2.57	3.08	3.50	3.72
NA20	0.50	0.36	0.37	0.35	0.33	0.25	0.39	0.57	0.35	0.56	0.73	0.56
K20	1.61	1.29	1.31	1.43	1.25	1.08	1.75	0.97	0.91	1.05	1.25	1.66
MNO	0.19	0.18	0.18	0.04	0.03	0.04	0.10	0.03	0.06	0.05	0.06	0.12
P205	0.28	0.33	0.34	0.05	0.14	0.07	0.12	0.14	0.00	0.02	0.03	0.13
BA	247	214	198	220	230	192	329	142	202	177	183	330
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	33	37	41	11	16	9	31	17	13	14	16	31
CR	183	203	184	186	219	164	116	233	190	148	184	185
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	30	34	31	10	15	9	12	10	6	8	9	16
GA	14	13	13	7	13	9	10	10	6	9	8	11
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	85	95	96	43	57	66	38	112	112	80	101	70
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	20	20	18	17	19	19	22	18	14	25	18	21
RB	56	51	51	47	56	36	63	34	25	35	34	58
SC	28	24	28	13	24	14	13	22	6	12	13	23
SR	99	102	102	78	61	55	66	66	46	71	85	90
S	401	602	562	385	377	411	174	429	447	366	414	353
SN	4	12	7	20	20	18	19	15	10	21	16	2
V	95	101	104	59	117	62	63	83	44	52	67	77
W	25	29	16	51	18	38	21	43	33	19	18	17
Y	26	25	25	18	16	15	19	15	11	19	19	25
ZN	63	78	79	27	28	18	34	39	16	18	21	34
ZR	292	287	284	251	224	269	346	197	184	300	231	323

				NAS169	NAS170							
Var.\ID:	S-573	S-574	S-575	S-576	S-577	S-578	S-579	S-580	S-581	S-582	S-583	S-584
SI02	72.56	59.13	64.90	66.11	61.65	68.03	68.87	57.43	62.90	66.91	71.74	70.68
AL203	14.98	23.73	13.36	13.51	18.20	15.54	16.50	21.90	18.48	18.77	17.51	17.02
TI02	1.35	0.89	1.69	1.41	2.13	1.74	1.70	1.53	1.82	1.57	1.32	1.35
FE203	5.75	8.22	6.10	7.21	8.88	7.66	7.25	10.21	7.32	6.13	5.51	6.31
MGO	0.00	1.49	1.78	1.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	3.80	7.30	4.96	4.51	4.93	3.93	3.77	6.07	5.57	4.28	3.21	3.44
NA20	0.70	0.59	1.13	0.92	0.63	0.38	0.51	1.30	1.02	0.69	0.60	0.52
K20	1.36	0.17	0.84	1.21	1.11	1.40	1.45	0.23	0.82	1.51	1.88	1.58
MNO	0.04	0.15	0.09	0.08	0.09	0.09	0.05	0.05	0.06	0.04	0.02	0.03
P205	0.05	0.17	0.12	0.08	0.24	0.26	0.21	0.19	0.16	0.14	0.09	0.09
BA	299	127	125	250	191	251	249	103	162	310	429	417
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	9	39	25	19	24	18	12	22	19	15	8	9
CR	149	317	247	173	231	124	124	288	233	148	103	102
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	8	30	13	14	13	19	14	24	16	14	11	14
GA	11	15	10	9	13	14	13	16	17	15	14	14
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	56	113	124	81	76	47	44	82	67	52	28	33
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	11	15	17	16	24	21	11	13	23	24	21
RB	52	16	25	38	43	59	61	18	30	62	72	63
SC	17	43	23	17	24	20	17	40	35	28	17	22
SR	102	141	112	110	82	81	88	182	167	117	95	94
S	500	192	572	385	1032	906	909	246	623	582	258	619
SN	12	3	13	5	3	9	4	2	25	4	5	4
V	66	128	90	88	124	103	89	125	132	91	80	104
W	40	8	14	21	19	2	4	0	9	5	8	5
Y	26	14	14	18	21	41	32	22	24	30	33	40
ZN	26	23	29	30	55	56	37	33	36	52	38	42
ZR	374	98	223	287	236	328	316	149	208	325	383	331

	NAS170/cont.									NAS170	NAS171	
Var.\ID:	S-585	S-586	S-720	S-721	S-722	S-723	S-724	S-725	S-726	S-727	S-656	S-655
SIO2	75.01	59.49	63.53	57.44	65.41	63.59	60.31	57.51	59.47	55.91	59.26	56.99
AL2O3	17.07	15.68	15.75	19.28	17.30	14.49	15.28	18.70	15.28	16.33	18.56	17.51
TIO2	1.30	2.56	2.06	2.03	1.67	2.17	2.42	2.10	2.20	2.21	1.58	1.75
FE2O3	4.96	12.25	9.52	9.57	8.79	8.44	9.97	10.38	9.14	11.50	8.93	8.93
MGO	0.00	0.59	0.60	3.48	0.92	2.16	2.88	2.20	3.29	3.68	2.31	3.33
CAO	3.25	4.64	4.00	6.08	4.16	4.59	5.25	5.82	5.38	6.47	5.42	5.70
NA2O	0.57	0.59	0.43	0.44	0.40	0.29	0.24	0.40	0.51	0.52	0.73	0.61
K2O	1.54	1.05	1.62	1.04	1.73	1.63	1.26	0.83	0.95	0.70	1.44	1.25
MNO	0.02	0.14	0.13	0.22	0.14	0.21	0.25	0.18	0.19	0.21	0.15	0.19
P2O5	0.05	0.35	0.32	0.38	0.28	0.44	0.52	0.41	0.41	0.56	0.40	0.48
BA	397	197	269	145	272	258	216	172	179	153	197	178
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	8	30	34	55	36	33	41	52	49	45	32	54
CR	97	119	127	241	127	123	155	178	260	216	205	214
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	8	35	32	53	30	27	39	45	41	47	36	36
GA	14	16	15	16	15	13	17	17	14	17	16	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	23	49	46	119	62	55	73	107	148	135	86	89
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	19	25	19	16	23	20	16	18	23	14	20	19
RB	60	42	63	46	68	64	54	40	41	33	49	42
SC	15	37	25	36	29	21	30	43	32	32	25	27
SR	93	96	82	89	86	86	88	83	95	119	123	128
S	178	542	430	375	286	479	634	586	712	646	623	835
SN	2	5	7	5	0	1	16	3	10	9	18	6
V	83	193	150	152	116	136	175	185	174	188	121	136
W	7	16	5	3	10	4	7	15	5	4	2	4
Y	40	70	39	30	32	40	46	34	33	43	32	32
ZN	25	90	81	83	84	101	110	83	88	109	80	88
ZR	417	297	368	211	306	363	318	224	262	210	273	253

Var.\ID:	S-654	S-653	S-652	S-651	S-650	S-649	S-648	S-647	S-609	S-610	S-1106	S-1107
SIO2	69.91	54.89	53.11	55.32	54.04	55.76	58.51	55.03	57.65	56.49	49.63	49.97
AL2O3	15.60	17.63	14.50	15.26	16.41	16.89	16.01	15.99	15.59	16.03	15.26	15.73
TIO2	1.35	1.85	1.67	2.04	2.38	2.20	2.07	2.17	2.18	2.13	2.48	2.43
FE2O3	6.32	12.73	9.31	10.95	12.41	11.69	10.50	11.50	10.57	10.70	12.02	12.53
MGO	0.00	3.20	5.96	3.74	3.33	3.24	3.66	4.45	4.45	4.09	4.81	4.81
CAO	3.31	4.05	4.10	5.47	6.28	6.45	6.02	6.84	6.27	6.23	6.93	6.72
NA2O	1.01	1.37	1.18	0.94	0.61	0.44	0.55	0.53	0.60	0.57	0.73	0.91
K2O	1.75	1.55	1.45	1.30	1.26	1.20	1.36	1.30	1.43	1.33	1.26	1.22
MNO	0.04	0.17	0.30	0.22	0.22	0.23	0.26	0.28	0.29	0.26	0.26	0.26
P2O5	0.08	0.29	0.60	0.46	0.51	0.50	0.44	0.49	0.44	0.46	0.52	0.46
BA	380	267	134	202	184	205	236	210	210	220	178	157
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	23	57	67	47	42	46	174	47	37	54	51	48
CR	141	155	85	127	122	164	132	199	177	178	176	183
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	10	51	33	37	47	65	43	49	52	51	56	97
GA	11	18	17	17	15	16	17	17	17	15	19	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	46	61	30	51	52	63	53	72	68	75	73	74
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	18	20	46	22	25	34	15	23	25	22	19	15
RB	51	38	41	39	36	41	48	43	46	46	37	37
SC	22	33	28	31	33	35	26	32	26	34	44	47
SR	121	116	116	105	91	96	122	150	132	130	134	124
S	233	511	1866	1012	1000	815	866	952	830	823	n.a	n.a
SN	1	4	3	4	4	1	7	4	11	8	n.a	n.a
V	72	137	106	137	167	163	134	152	152	154	184	187
W	3	5	4	4	5	0	8	3	1	12	n.a	n.a
Y	34	26	20	27	36	31	29	23	24	27	27	31
ZN	36	69	124	103	116	123	112	119	130	127	124	118
ZR	379	209	161	227	222	225	248	204	228	224	181	166

	NAS171/cont.											NAS171
Var.\ID:	S-1108	S-1109	S-1110	S-1111	S-1112	S-1113	S-1114	S-1115	S-1116	S-1117	S-1118	S-1119
SIO2	52.19	53.84	48.92	54.97	49.21	54.47	56.77	58.12	56.77	52.80	56.01	52.00
AL2O3	14.52	15.37	18.57	15.24	17.22	15.15	15.12	15.42	14.79	14.65	14.75	15.00
TIO2	2.22	2.24	3.34	2.05	2.35	2.16	2.06	2.14	2.25	2.54	2.07	1.84
FE2O3	10.39	10.57	14.95	10.61	12.59	10.17	9.40	9.33	10.09	11.84	9.70	10.45
MGO	4.66	4.07	2.79	3.73	4.73	3.90	3.73	3.06	3.06	3.45	3.32	3.58
CAO	5.34	5.68	6.20	5.65	5.73	5.44	5.42	5.14	5.17	5.88	5.09	5.32
NA2O	0.57	0.54	0.82	0.58	1.09	0.65	0.56	0.45	0.51	0.52	0.57	0.71
K2O	1.37	1.33	1.27	1.18	1.32	1.21	1.22	1.31	1.30	1.05	1.35	1.03
MNO	0.27	0.25	0.23	0.23	0.26	0.25	0.25	0.25	0.23	0.23	0.22	0.21
P2O5	0.51	0.48	0.43	0.44	0.45	0.50	0.44	0.44	0.46	0.55	0.50	0.49
BA	215	208	171	219	205	197	201	229	206	177	222	157
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	42	31	45	37	45	29	29	28	25	31	26	29
CR	163	170	184	161	211	145	139	124	132	145	134	113
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	54	51	90	52	66	40	37	38	43	53	45	53
GA	16	16	22	17	20	18	16	16	15	17	17	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	63	63	71	69	77	57	56	49	49	54	47	47
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	18	7	33	18	22	20	17	19	16	17	18
RB	46	44	39	43	44	45	46	52	48	40	50	33
SC	31	39	62	39	54	35	30	28	26	40	31	34
SR	94	97	87	112	108	100	104	92	94	99	86	118
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	158	153	235	142	192	142	131	127	136	158	135	122
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	28	27	36	28	26	33	35	35	34	36	33	35
ZN	127	114	149	118	121	104	103	93	92	101	96	100
ZR	200	203	149	217	138	242	270	290	271	229	278	208

	NAS172											
Var.\ID:	S-672	S-673	S-674	S-675	S-676	S-677	S-679	S-680	S-681	S-682	S-683	S-684
SIO2	52.39	52.90	50.15	50.54	53.21	54.12	49.67	57.21	51.93	54.97	55.54	57.86
AL2O3	6.17	15.94	13.78	13.47	10.91	11.08	12.09	11.85	9.63	13.15	13.17	17.32
TIO2	0.66	0.89	0.98	0.98	0.98	0.85	1.11	1.18	0.89	1.50	1.55	1.33
FE2O3	10.06	9.61	9.42	9.72	9.04	9.80	10.01	9.33	9.70	9.29	8.87	7.62
MGO	23.28	8.94	9.98	10.01	12.50	14.98	7.36	5.37	15.25	9.35	9.09	6.17
CAO	5.00	7.54	8.37	6.25	5.59	5.78	6.23	4.47	3.81	4.91	5.06	4.24
NA2O	0.00	0.24	0.44	0.23	0.32	0.30	0.61	0.35	0.14	0.63	0.61	1.12
K2O	0.80	1.00	0.87	0.88	0.99	1.10	0.93	1.28	0.80	1.39	1.39	2.51
MNO	0.42	0.28	0.26	0.25	0.29	0.30	0.22	0.17	0.19	0.21	0.23	0.21
P2O5	0.33	0.44	0.36	0.43	0.33	0.23	0.34	0.36	0.32	0.39	0.40	0.41
BA	188	434	256	248	177	167	185	266	179	255	261	497
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	121	65	69	63	86	105	46	37	86	59	52	49
CR	2097	455	584	772	1034	1353	219	256	906	425	403	267
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	140	85	63	62	43	32	23	20	38	41	40	29
GA	9	13	14	13	11	11	14	12	11	15	15	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	2025	193	237	256	422	535	72	94	544	265	222	164
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	132	108	79	54	65	25	21	81	47	39	39	27
RB	25	35	28	28	25	28	26	47	28	54	51	93
SC	39	35	33	32	28	37	33	27	24	26	27	27
SR	62	125	131	75	62	67	81	66	51	117	110	101
S	696	1552	1411	1712	1671	733	1935	1768	1386	982	864	642
SN	14	73	38	19	14	0	7	7	4	8	2	4
V	116	160	154	150	133	151	144	109	101	121	128	103
W	2	5	2	2	4	6	6	1	2	3	3	6
Y	10	13	15	14	13	10	14	19	15	23	24	23
ZN	389	242	219	207	173	193	68	69	105	238	130	111
ZR	71	94	98	111	128	114	145	245	132	159	172	148

Var.\ID:	NAS172 #-685	NAS173 S-686	S-687	S-688	S-689	S-690	S-691	S-692	S-693	S-694	S-695	S-696
SIO2	57.73	59.96	63.33	68.04	69.44	59.10	65.82	58.39	60.45	64.76	64.07	62.49
AL2O3	18.54	24.19	18.65	17.64	16.23	26.62	17.86	24.35	22.38	16.92	16.71	17.87
TIO2	1.34	1.65	1.77	1.46	1.49	1.49	1.87	2.37	1.59	1.50	1.66	1.53
FE2O3	7.81	9.09	9.38	7.21	6.98	10.76	6.17	11.59	10.59	8.08	6.96	7.80
MGO	4.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.18	0.80
CAO	3.63	5.59	4.34	3.57	2.96	4.79	3.98	5.16	5.04	4.28	4.72	5.06
NA2O	0.76	0.50	0.49	0.39	0.63	0.77	0.57	0.59	0.79	0.59	0.52	0.55
K2O	3.27	0.57	0.86	1.57	1.76	0.63	1.14	0.81	0.83	1.05	0.94	0.78
MNO	0.16	0.14	0.08	0.10	0.04	0.01	0.06	0.04	0.04	0.08	0.10	0.11
P2O5	0.44	0.25	0.23	0.16	0.11	0.22	0.19	0.25	0.19	0.19	0.26	0.31
BA	648	160	189	282	268	179	171	155	162	194	183	174
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	62	106	39	36	25	20	23	25	19	19	22	29
CR	246	415	246	155	125	374	196	319	227	193	198	218
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	48	32	18	14	14	36	8	19	10	16	18	22
GA	19	15	11	11	9	16	12	15	15	13	12	13
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	119	123	80	47	38	126	81	114	108	94	97	126
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	53	12	20	23	20	10	15	14	16	18	18	23
RB	111	31	38	66	63	35	42	43	41	47	45	39
SC	24	40	23	14	21	38	19	24	31	24	31	32
SR	88	73	65	73	70	87	71	86	115	98	103	98
S	923	196	569	531	275	598	505	569	339	528	633	719
SN	14	4	7	5	5	14	2	5	0	7	7	5
V	94	98	99	74	60	89	81	130	94	80	85	91
W	5	0	7	6	2	7	12	10	5	7	13	10
Y	26	17	21	23	26	16	18	16	14	22	21	21
ZN	124	38	38	38	34	44	33	43	38	42	46	53
ZR	167	184	240	339	382	182	278	219	203	272	266	234

Var.\ID:	NAS173 S-697	NAS174 S-719	S-718	S-717	S-716	S-715	S-714	S-713	S-712	S-1143	S-1144	S-1145
SIO2	63.23	64.07	70.07	66.13	70.32	70.66	64.87	59.40	62.93	60.05	58.24	54.06
AL2O3	20.21	13.49	9.91	12.02	11.50	11.78	11.13	7.49	14.64	11.04	10.36	7.28
TIO2	1.76	1.04	0.90	1.01	0.88	1.00	0.86	0.75	1.33	1.12	1.12	0.48
FE2O3	8.72	10.62	9.08	9.16	9.62	8.37	11.56	13.16	10.27	9.50	6.97	14.91
MGO	0.35	5.50	5.30	6.36	3.08	4.73	8.85	10.13	5.74	10.33	13.17	15.29
CAO	5.23	3.16	2.82	3.14	2.96	3.25	3.22	2.86	4.15	5.14	5.84	3.57
NA2O	0.56	0.43	0.35	0.42	0.24	0.44	0.26	0.52	0.49	0.19	0.52	0.05
K2O	1.16	1.66	1.41	1.60	0.84	1.48	1.55	0.89	1.68	0.83	1.36	0.68
MNO	0.14	0.22	0.15	0.23	0.08	0.17	0.26	0.19	0.20	0.42	0.48	0.32
P2O5	0.25	0.13	0.01	0.10	0.00	0.03	0.08	0.06	0.14	0.20	0.25	0.11
BA	217	401	300	370	247	334	335	219	354	273	282	163
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	38	90	64	140	50	90	111	65	79	61	88	128
CR	193	1351	1255	1340	1360	1349	1642	2367	1058	599	1361	4111
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	22	24	15	21	10	17	20	14	40	19	25	30
GA	15	11	9	12	10	10	11	7	14	12	13	8
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	98	695	576	927	582	601	1090	649	752	302	776	1979
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	28	27	28	18	26	27	35	21	8	12	35
RB	49	53	44	52	30	50	56	25	56	20	28	21
SC	27	25	14	23	20	20	22	18	33	29	37	43
SR	103	76	70	69	63	74	59	52	143	96	132	35
S	450	285	254	264	566	217	277	1320	264	n.a	n.a	n.a
SN	6	0	0	3	3	1	5	6	0	n.a	n.a	n.a
V	101	104	94	95	75	84	95	100	124	295	139	99
W	14	9	10	8	11	21	8	5	12	n.a	n.a	n.a
Y	19	24	24	36	21	27	28	12	33	22	19	12
ZN	55	79	76	81	95	75	92	110	71	99	68	146
ZR	234	311	275	267	204	294	212	206	229	118	165	89

	NAS174/cont.											
Var.\ID:	S-1146	S-1147	S-1148	S-1149	S-1150	S-1151	S-1152	S-1153	S-1154	S-1155	S-1156	S-1157
SI02	53.88	53.33	52.42	57.36	47.81	51.30	53.49	52.74	54.11	56.75	53.97	54.75
AL203	17.55	17.43	6.35	13.78	5.25	10.63	14.05	22.41	14.89	14.83	15.01	15.24
TI02	1.04	1.03	0.87	0.93	0.97	0.84	1.24	0.72	1.44	1.49	1.67	2.64
FE203	14.35	14.49	7.47	10.61	12.02	10.18	10.75	11.55	9.86	10.09	10.73	11.99
MGO	5.43	3.74	21.00	5.83	23.77	12.20	8.41	4.79	6.53	5.11	6.46	3.21
CAO	4.73	4.23	5.39	3.87	4.15	5.67	6.34	5.21	5.96	5.95	6.12	6.52
NA2O	0.53	0.47	0.10	0.59	0.12	0.67	0.77	1.08	0.58	0.73	0.82	0.13
K20	1.00	1.19	1.06	1.23	0.55	1.03	1.41	0.79	1.43	1.36	1.39	0.95
MNO	0.12	0.10	0.51	0.15	0.34	0.19	0.23	0.14	0.21	0.16	0.25	0.22
P205	0.16	0.20	0.28	0.15	0.20	0.17	0.30	0.23	0.34	0.25	0.29	0.50
BA	240	235	158	242	140	120	171	106	195	149	181	150
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	59	39	156	100	127	51	105	63	104	42	51	39
CR	1153	1077	2380	1045	3279	1060	735	348	633	667	605	343
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	64	37	18	27	25	29	37	53	30	24	33	46
GA	15	15	9	11	8	9	14	16	14	15	17	20
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	442	466	754	403	1148	377	254	362	212	201	200	112
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	18	19	11	27	9	15	19	8	19	18	19	28
RB	36	42	24	39	14	23	36	27	41	37	34	33
SC	56	33	27	26	35	37	37	37	39	33	39	35
SR	67	61	55	62	58	74	160	323	129	136	164	118
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	172	140	126	121	113	143	167	101	145	147	172	190
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	19	16	10	16	13	14	20	9	21	21	23	31
ZN	68	92	110	80	93	86	99	56	115	86	77	131
ZR	127	154	109	178	103	102	142	46	177	203	173	243

								NAS174	NAS176			
Var.\ID:	S-1158	S-1159	S-1160	S-1161	S-1162	S-1163	S-1164	S-1165	S-761	S-762	S-763	S-764
SI02	52.22	53.19	51.40	51.87	49.44	51.62	51.73	52.12	55.94	56.26	53.03	55.45
AL203	15.29	15.49	15.26	15.41	18.87	16.11	15.85	15.09	15.79	15.71	14.88	15.40
TI02	3.20	3.06	2.97	3.06	3.04	3.31	3.00	3.05	2.01	1.96	1.97	2.00
FE203	12.82	12.32	12.25	12.25	16.81	14.10	12.24	11.93	9.53	9.96	10.52	10.31
MGO	4.48	4.11	4.49	4.57	4.51	4.56	4.32	4.61	5.59	5.19	5.65	5.97
CAO	6.93	6.66	6.68	7.04	6.63	6.07	6.18	6.42	6.06	5.83	6.32	6.11
NA2O	0.13	0.10	0.12	0.10	0.27	0.05	0.21	0.12	0.64	0.67	0.51	0.64
K20	1.03	1.09	1.02	0.98	0.89	0.86	1.01	1.03	1.76	1.71	1.42	1.77
MNO	0.30	0.29	0.29	0.30	0.25	0.34	0.31	0.31	0.26	0.23	0.23	0.26
P205	0.56	0.52	0.59	0.57	0.41	0.56	0.55	0.57	0.48	0.49	0.62	0.49
BA	109	142	121	113	84	150	137	153	204	203	161	196
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	45	46	45	44	60	47	44	40	35	34	35	37
CR	255	249	282	267	333	214	233	242	162	157	148	159
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	58	56	62	66	61	226	67	69	71	72	56	64
GA	22	24	20	24	26	24	24	22	18	17	16	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	93	87	109	103	95	76	78	101	74	71	76	78
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	21	19	22	19	16	29	24	23	17	22	23	23
RB	40	40	40	36	25	36	37	38	50	48	46	48
SC	46	45	44	43	66	43	43	43	33	34	39	34
SR	106	115	100	117	76	106	99	101	139	124	129	139
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	595	706	1342	557
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	6	0	5	5
V	221	203	208	216	280	223	200	199	161	155	159	163
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	9	6	10	10
Y	31	36	37	36	37	43	39	35	24	26	25	23
ZN	151	143	149	146	227	328	166	172	137	136	145	154
ZR	279	300	284	278	175	341	337	305	180	181	164	178

Var.\ID:	NAS176/cont. S-765	S-766	S-767	S-768	S-769	S-770	S-771	S-772	S-773	S-774	S-775	S-776
SIO2	53.69	52.65	56.55	56.63	57.03	54.09	57.86	59.09	59.41	57.87	59.39	61.56
AL203	14.76	14.59	16.09	16.17	15.50	14.54	15.42	15.27	15.27	14.87	15.58	14.89
TIO2	2.23	2.03	1.85	1.69	1.86	1.90	1.81	1.50	1.58	1.62	1.32	1.18
FE203	11.45	10.97	10.56	9.94	10.30	10.98	9.49	7.89	8.36	8.54	7.23	6.90
MGO	6.62	6.41	5.14	5.15	5.27	6.43	5.27	5.70	4.72	5.23	4.86	4.66
CAO	7.21	6.92	5.87	4.72	4.92	5.15	4.85	4.95	4.62	4.57	3.73	4.18
NA20	0.61	0.77	0.85	1.11	0.79	0.35	0.98	0.89	0.68	0.73	1.09	0.58
K20	1.46	1.45	1.96	2.12	1.71	1.95	2.01	1.96	1.80	1.92	2.09	2.11
MNO	0.26	0.26	0.22	0.22	0.22	0.22	0.23	0.26	0.22	0.24	0.25	0.22
P205	0.49	0.57	0.47	0.46	0.46	0.64	0.46	0.47	0.49	0.51	0.43	0.46
BA	149	182	234	261	243	380	266	272	287	284	409	392
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	44	41	40	36	34	46	32	28	31	34	42	29
CR	190	155	164	134	175	204	145	135	139	144	109	163
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	68	64	64	74	53	50	39	40	36	38	33	24
GA	18	17	18	18	15	16	16	14	16	17	17	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	85	72	70	69	79	100	65	61	66	65	46	72
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	16	16	21	22	22	107	22	21	29	26	27	28
RB	46	45	56	61	51	62	62	65	64	60	70	81
SC	35	38	30	34	31	39	26	26	25	27	26	20
SR	162	170	141	127	124	127	123	129	120	125	93	109
S	530	744	548	433	621	1208	670	723	896	819	1024	804
SN	6	5	8	2	8	12	7	1	3	8	8	9
V	190	166	155	137	143	148	142	128	124	128	105	106
W	6	12	13	4	6	11	7	12	12	14	6	8
Y	27	24	26	25	26	30	27	24	26	29	27	26
ZN	172	158	148	125	123	190	118	108	109	114	97	79
ZR	167	149	173	154	180	167	186	185	201	190	197	245

Var.\ID:	S-777	S-778	S-779	S-780	S-781	NAS176 S-782	NAS177 S-1037	S-1036	S-1035	S-1034	S-1033	S-1032
SIO2	58.90	59.50	56.87	54.48	55.25	51.96	51.76	50.20	52.77	51.99	52.93	53.01
AL203	14.05	13.47	13.80	12.95	13.81	14.13	15.43	14.63	15.58	15.93	15.54	15.69
TIO2	1.26	1.51	1.41	0.91	1.11	1.06	2.05	2.23	2.18	2.43	2.40	2.38
FE203	7.09	8.17	9.23	10.67	9.76	10.60	11.49	11.48	11.41	12.24	11.27	11.85
MGO	5.39	6.31	7.75	9.09	8.65	9.37	6.83	7.21	5.25	5.32	5.38	5.16
CAO	4.53	5.23	5.51	5.88	6.09	7.09	6.19	6.46	6.61	7.00	6.62	6.69
NA20	0.42	0.46	0.36	0.45	0.29	0.36	0.74	0.89	1.07	0.64	0.54	0.67
K20	2.00	1.63	1.47	0.98	1.22	1.08	1.62	1.32	1.19	1.22	1.38	1.47
MNO	0.24	0.22	0.20	0.16	0.22	0.23	0.22	0.25	0.21	0.21	0.23	0.21
P205	0.64	0.35	0.38	0.26	0.42	0.44	0.53	0.49	0.48	0.50	0.50	0.41
BA	383	247	305	203	235	199	155	129	146	146	164	162
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	34	36	35	51	41	50	37	39	37	43	42	44
CR	184	288	413	813	601	494	224	219	177	189	181	197
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	30	33	40	42	47	56	67	54	53	61	63	77
GA	16	14	14	12	14	14	20	17	17	19	16	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	84	129	200	348	231	205	112	100	82	95	91	92
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	33	26	24	23	29	29	22	19	20	20	24	18
RB	74	58	53	32	39	35	49	44	45	46	47	53
SC	21	27	27	33	35	41	34	40	38	37	34	41
SR	101	123	119	105	97	117	151	156	157	140	127	143
S	1343	786	920	871	1090	1017	n.a	n.a	n.a	n.a	n.a	n.a
SN	6	7	7	2	7	6	n.a	n.a	n.a	n.a	n.a	n.a
V	105	121	133	143	145	176	172	177	157	175	163	174
W	11	13	13	5	12	5	n.a	n.a	n.a	n.a	n.a	n.a
Y	26	25	21	15	16	15	26	21	30	28	28	28
ZN	100	98	111	95	118	132	160	164	120	131	128	127
ZR	211	228	183	131	145	103	163	152	219	187	201	202

Var.\ID:	NAS177/cont. S-1031	S-1030	S-1029	S-1028	S-1027	S-1026	S-1025	S-1024	S-783	S-784	S-785	S-786
SIO2	52.47	52.50	51.90	53.31	52.61	51.46	52.75	54.64	53.24	58.74	60.98	60.32
AL2O3	15.31	15.40	15.35	15.96	16.04	15.87	15.61	17.60	15.30	15.60	14.85	15.15
TIO2	2.51	2.43	2.58	2.10	2.20	2.21	2.04	1.70	2.46	1.78	1.66	1.60
FE2O3	11.91	11.57	12.15	11.19	11.65	11.91	11.57	11.37	11.47	9.49	8.47	8.35
MGO	6.04	5.87	5.54	4.96	6.13	6.33	6.11	5.45	5.12	4.22	3.60	3.77
CAO	6.44	6.55	6.26	6.11	6.71	6.68	6.88	5.75	6.83	5.58	5.07	5.15
NA2O	0.55	0.72	0.64	0.61	0.64	0.68	0.70	1.32	0.53	0.57	0.39	0.40
K2O	1.80	1.76	1.53	1.49	1.46	1.27	1.16	0.93	1.23	1.62	1.58	1.56
MNO	0.25	0.24	0.23	0.20	0.22	0.24	0.23	0.25	0.23	0.21	0.20	0.21
P2O5	0.47	0.45	0.55	0.47	0.50	0.46	0.46	0.38	0.49	0.42	0.40	0.43
BA	158	152	162	180	163	146	154	196	179	262	277	286
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	44	44	41	39	40	50	35	36	41	31	26	29
CR	195	184	179	174	212	201	184	114	181	176	150	143
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	66	72	72	62	64	58	52	103	42	41	30	38
GA	18	18	18	17	18	21	18	21	18	16	15	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	90	92	82	89	104	104	96	63	81	76	60	63
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	17	19	25	19	22	16	15	12	24	19	23	25
RB	66	62	57	51	49	44	41	29	45	59	61	60
SC	43	42	42	32	36	36	38	35	38	32	22	26
SR	137	143	139	146	168	160	165	181	158	132	116	123
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	641	584	624	636
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	4	1	6	7
V	179	175	190	162	180	186	169	141	158	130	116	111
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	10	3	10	9
Y	28	28	28	25	25	25	25	30	28	27	26	28
ZN	140	131	151	142	145	138	131	115	170	119	100	107
ZR	174	188	173	202	165	174	170	158	203	221	271	260

Var.\ID:	S-787	S-788	S-789	S-790	S-791	S-792	S-793	NAS177 S-794	NAS178 S-812	S-813	S-814	S-815
SIO2	62.58	61.64	61.15	60.57	58.15	59.27	51.81	53.56	64.57	61.73	62.51	58.77
AL2O3	15.77	14.70	15.11	15.06	15.50	16.94	16.75	14.38	20.10	22.27	21.27	26.78
TIO2	1.40	1.44	1.52	1.55	1.59	1.72	1.88	1.70	1.11	1.39	1.67	1.56
FE2O3	6.89	6.27	6.48	6.67	7.94	8.75	12.37	9.10	9.64	9.73	8.61	12.30
MGO	4.31	5.33	5.43	5.92	6.26	4.69	6.24	6.03	0.00	0.00	0.00	0.00
CAO	5.04	4.92	5.09	5.30	5.84	5.74	7.85	5.72	3.08	4.23	4.37	4.68
NA2O	0.36	0.45	0.47	0.38	0.30	0.35	0.66	0.41	0.33	0.41	0.36	0.11
K2O	1.52	1.59	1.67	1.60	1.48	1.75	1.05	1.61	1.65	1.09	1.03	0.72
MNO	0.26	0.31	0.31	0.33	0.30	0.27	0.23	0.25	0.02	0.03	0.03	0.03
P2O5	0.41	0.44	0.46	0.47	0.47	0.44	0.34	0.53	0.15	0.19	0.21	0.25
BA	415	348	263	284	259	255	144	216	329	290	178	172
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	26	20	31	23	40	34	46	37	15	22	24	26
CR	113	114	123	159	212	186	277	205	158	247	294	329
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	56	40	39	34	35	30	21	37	14	23	21	22
GA	15	15	16	16	16	18	19	16	14	14	14	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	50	50	56	66	89	77	123	91	47	92	97	110
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	23	21	25	21	24	20	10	19	17	17	17	16
RB	57	61	62	55	52	59	35	53	72	46	41	44
SC	19	24	25	24	28	30	41	30	17	26	31	36
SR	116	116	112	108	115	113	107	106	58	58	58	68
S	497	536	543	633	616	587	212	683	524	572	627	353
SN	6	12	6	24	11	17	6	4	7	14	21	11
V	99	101	100	111	121	134	194	134	76	89	88	107
W	7	6	10	9	6	12	14	2	0	10	3	0
Y	24	24	24	26	22	26	23	24	20	15	16	20
ZN	120	118	121	131	141	132	146	149	41	43	43	47
ZR	229	239	225	221	202	212	144	172	304	212	202	202

Var.\ID:	NAS178/cont. S-816	S-817	S-818	S-819	S-820	S-821	S-822	NAS178 S-823	NAS179 S-824	S-825	S-826	S-827
SIO2	64.53	65.39	62.31	61.71	60.28	66.05	62.00	65.04	53.37	55.84	50.72	50.07
AL2O3	16.34	16.12	17.07	17.95	16.92	17.48	18.39	15.03	16.49	18.58	17.55	16.42
TIO2	1.95	1.75	1.90	1.85	1.70	1.58	1.87	1.66	1.64	1.64	2.18	2.18
FE2O3	7.38	7.51	7.86	7.90	8.04	7.06	7.99	6.17	10.57	8.59	12.78	12.20
MGO	0.00	0.00	0.39	0.42	0.88	0.00	0.00	0.54	5.20	4.96	4.72	5.40
CAO	4.35	4.38	4.74	5.07	4.68	3.79	4.68	4.02	5.76	5.10	6.69	6.75
NA2O	0.37	0.44	0.32	0.17	0.16	0.20	0.16	0.17	0.44	0.65	1.20	0.91
K2O	1.04	1.14	1.02	0.90	0.83	1.42	0.84	0.99	1.32	2.64	0.84	0.95
MNO	0.09	0.09	0.14	0.17	0.16	0.09	0.15	0.16	0.21	0.25	0.23	0.23
P2O5	0.33	0.29	0.40	0.44	0.45	0.27	0.39	0.33	0.53	0.47	0.43	0.49
BA	194	208	192	172	165	246	174	183	201	392	121	126
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	16	16	27	27	25	15	28	28	52	47	53	55
CR	160	148	168	183	354	203	199	170	360	200	239	284
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	16	17	21	22	24	19	18	20	40	27	27	35
GA	14	13	16	15	14	14	17	13	17	20	17	19
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	65	64	81	70	79	54	69	53	146	91	117	128
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	14	17	17	18	20	20	20	18	32	18	11	18
RB	46	50	45	45	42	58	44	42	58	116	30	37
SC	23	19	27	31	30	21	27	26	36	27	34	37
SR	94	99	93	89	86	73	80	69	114	108	160	158
S	618	513	597	672	556	231	542	503	1021	494	407	681
SN	11	10	19	27	25	36	35	50	13	9	0	9
V	100	97	113	118	141	84	136	107	138	130	181	190
W	8	2	14	5	5	11	6	6	11	6	7	6
Y	44	41	45	44	47	25	29	25	23	22	23	21
ZN	52	50	67	66	65	52	58	50	139	124	102	117
ZR	330	338	310	297	240	274	276	306	139	152	166	132

Var.\ID:	S-828	S-829	S-830	S-831	S-832	S-833	S-834	S-835	NAS179 S-836	NAS180 S-837	S-839	S-840
SIO2	44.88	49.22	51.40	66.93	62.92	58.52	53.79	51.73	51.45	58.80	57.13	57.49
AL2O3	14.81	15.63	15.85	15.31	15.17	16.10	16.21	16.17	19.91	11.64	15.13	16.25
TIO2	4.06	2.80	3.17	1.47	1.86	2.23	2.47	2.17	1.00	1.00	1.11	1.69
FE2O3	15.34	13.64	12.23	8.86	7.85	8.91	10.23	10.93	9.62	9.28	9.21	10.47
MGO	3.92	4.88	3.23	0.00	1.34	2.66	3.58	4.29	5.65	8.47	6.69	4.59
CAO	7.19	7.17	6.57	3.04	4.29	5.41	5.76	5.80	6.56	5.01	5.59	5.73
NA2O	0.84	0.87	1.47	0.75	0.79	1.04	1.28	1.16	1.44	0.42	0.60	0.56
K2O	0.82	0.84	0.98	1.63	1.48	1.20	1.11	0.90	0.74	1.26	1.33	1.22
MNO	0.25	0.22	0.17	0.06	0.14	0.18	0.19	0.19	0.14	0.19	0.22	0.20
P2O5	0.61	0.48	0.33	0.13	0.32	0.41	0.46	0.48	0.31	0.25	0.23	0.34
BA	107	117	121	279	222	162	141	109	102	218	209	162
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	62	61	53	19	36	39	40	40	40	63	66	47
CR	192	291	432	133	147	189	176	189	247	1176	763	409
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	53	45	22	6	14	21	24	27	20	34	35	47
GA	20	18	16	14	15	18	20	20	19	11	15	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	99	129	152	34	52	77	85	91	138	465	265	180
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	14	22	17	22	19	18	21	19	9	49	29	26
RB	31	31	29	59	59	47	40	35	29	38	41	46
SC	42	38	37	15	25	31	32	34	47	25	35	32
SR	127	145	177	91	106	130	132	135	269	133	128	129
S	767	681	392	215	298	440	452	394	37	870	329	528
SN	8	11	26	8	12	11	4	7	0	11	7	5
V	309	232	237	88	130	173	212	227	151	120	141	159
W	11	5	13	19	11	12	9	6	7	3	1	3
Y	22	25	26	26	31	33	37	40	40	17	19	24
ZN	109	114	101	41	69	87	95	105	52	139	111	129
ZR	127	139	169	411	394	327	274	252	90	199	213	201

Var.\ID:	NAS180/cont. S-841	S-842	S-843	S-844	S-845	S-846	S-847	S-848	S-849	S-850	S-851	NAS180 S-852
SI02	56.75	54.16	50.04	53.86	55.45	51.96	52.87	53.44	47.77	53.88	53.37	51.30
AL203	16.17	15.76	21.96	14.86	15.31	15.56	14.77	14.69	18.78	15.01	15.19	15.23
TI02	1.73	2.33	3.77	1.87	2.27	2.55	2.71	2.60	3.45	2.46	2.54	2.72
FE203	10.13	11.89	18.02	10.64	9.94	11.65	11.18	11.34	17.18	11.35	11.81	12.05
MGO	4.50	4.65	0.26	4.64	4.94	4.91	5.48	5.10	3.26	4.48	4.52	5.10
CAO	5.61	6.22	5.67	4.94	6.29	6.59	7.23	6.92	6.07	6.56	7.17	7.55
NA20	0.54	0.62	0.00	0.46	0.42	0.60	0.37	0.40	0.46	0.30	0.18	0.30
K20	1.27	1.33	1.63	1.97	1.41	1.94	1.19	1.08	0.94	1.10	1.03	0.94
MNO	0.21	0.23	0.22	0.20	0.28	0.23	0.32	0.27	0.25	0.25	0.25	0.28
P205	0.37	0.48	0.77	0.60	0.52	0.49	0.54	0.49	0.54	0.56	0.57	0.57
BA	161	134	111	160	193	152	119	141	89	136	137	128
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	35	47	61	33	40	47	44	38	57	44	44	47
CR	350	316	374	299	268	313	263	318	191	279	336	315
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	46	51	100	68	50	83	56	57	84	54	58	58
GA	16	16	25	15	18	19	19	18	27	18	19	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	141	122	88	130	93	99	86	120	76	102	121	115
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	22	56	24	27	23	21	13	20	11	22	22	24
RB	45	43	83	62	52	60	42	41	32	45	43	39
SC	34	39	59	33	32	40	38	39	59	36	36	42
SR	132	142	55	129	132	136	133	129	134	120	123	129
S	509	471	265	758	491	460	418	484	158	639	718	717
SN	10	10	5	9	15	7	12	11	3	13	9	12
V	152	188	260	152	163	207	196	183	263	172	184	201
W	4	1	1	6	5	2	3	8	5	1	15	13
Y	22	28	43	29	28	27	28	24	51	36	36	30
ZN	132	147	189	146	145	160	141	138	187	133	132	147
ZR	205	172	176	182	226	186	261	270	268	315	263	234

Var.\ID:	NAS181 S-903	S-902	S-901	S-900	S-899	S-898	S-897	S-896	S-895	S-894	S-893	S-892
SI02	63.01	66.08	66.73	54.79	65.34	71.22	66.30	69.37	68.15	58.86	64.14	59.37
AL203	15.52	16.14	15.94	4.52	15.78	10.69	16.08	14.82	11.54	9.92	13.73	9.89
TI02	1.09	0.92	0.94	0.64	0.96	0.97	0.95	0.94	0.89	0.66	1.00	0.83
FE203	10.88	9.16	7.60	11.01	10.43	9.19	9.59	8.18	9.14	14.66	11.97	10.85
MGO	4.12	0.41	0.00	23.73	1.93	3.65	0.82	0.95	2.64	9.81	3.83	9.83
CAO	3.26	2.63	2.29	4.76	2.82	2.87	2.67	2.66	2.68	2.23	2.82	2.85
NA20	0.35	0.55	0.52	0.00	0.47	0.32	0.53	0.56	0.39	0.30	0.49	0.33
K20	1.83	1.85	1.82	0.82	1.50	1.26	1.73	1.75	1.17	0.88	1.41	1.11
MNO	0.18	0.05	0.03	0.62	0.09	0.15	0.07	0.09	0.06	0.09	0.11	0.22
P205	0.16	0.10	0.13	0.22	0.09	0.00	0.09	0.06	0.01	0.02	0.06	0.12
BA	391	344	384	271	394	303	349	345	269	181	341	234
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	126	41	31	195	53	67	42	38	31	66	58	74
CR	1300	491	288	3553	1097	1462	940	645	1047	2375	1837	2625
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	33	18	6	53	21	17	20	21	17	45	31	20
GA	13	11	12	9	14	12	12	11	11	8	13	9
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	593	232	123	2824	839	579	441	255	357	1096	723	1059
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	22	20	22	10	21	22	21	25	24	73	29	37
RB	62	61	63	22	61	47	63	60	38	28	53	37
SC	27	11	12	38	22	14	16	11	19	25	21	25
SR	65	65	57	25	69	67	66	68	78	44	70	55
S	260	196	845	103	257	318	153	139	469	20	174	476
SN	4	3	6	3	3	8	0	4	7	3	4	7
V	95	61	90	103	81	77	71	73	79	75	94	97
W	4	8	10	0	7	4	7	9	1	0	9	2
Y	29	20	22	17	27	25	23	20	26	16	27	21
ZN	79	53	35	70	59	57	55	50	75	164	116	213
ZR	288	323	378	61	300	305	369	359	334	160	331	235

NAS181/cont.

Var.\ID:	S-1007	S-1008	S-1009	S-1010	S-1011	S-1012	S-1013	S-1014	S-1015	S-1016	S-1017	S-1018
SIO2	50.68	60.26	58.57	61.34	68.05	66.77	63.18	58.17	59.63	54.33	55.43	46.57
AL2O3	18.40	12.25	15.22	11.11	12.82	13.16	13.14	13.92	13.62	13.96	14.33	24.90
TIO2	2.39	1.38	1.84	1.50	1.29	1.29	1.66	1.94	1.73	1.59	1.93	3.81
FE2O3	15.84	8.27	10.54	9.29	9.72	8.88	8.77	10.33	8.57	11.53	10.14	21.30
MGO	3.62	7.71	4.62	6.71	2.43	3.17	2.63	3.57	5.15	8.45	7.40	0.00
CAO	5.26	4.54	5.08	4.34	3.13	3.30	3.88	4.91	4.85	5.58	5.73	6.31
NA2O	1.22	0.47	0.75	0.70	0.64	0.69	0.62	0.90	0.44	0.17	0.20	0.26
K2O	0.79	1.28	1.18	1.33	1.57	1.69	1.26	1.11	1.10	0.75	0.82	0.00
MNO	0.17	0.25	0.20	0.26	0.12	0.16	0.15	0.18	0.25	0.29	0.34	0.19
P2O5	0.29	0.28	0.27	0.23	0.09	0.14	0.23	0.31	0.34	0.34	0.44	0.49
BA	111	252	182	205	348	353	242	174	202	155	202	85
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	55	73	62	77	55	61	34	44	42	89	78	83
CR	622	997	834	1119	857	793	462	460	487	963	889	194
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	71	39	46	25	19	22	26	43	35	55	51	99
GA	23	12	13	11	12	12	13	14	15	15	17	26
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	651	447	482	376	299	287	198	199	202	558	454	239
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	40	38	71	33	23	28	22	20	18	17	20	14
RB	24	44	39	39	54	60	49	42	42	32	32	10
SC	43	21	30	21	15	20	22	23	24	34	30	71
SR	350	115	169	120	99	96	89	110	84	86	92	133
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	190	95	133	112	76	85	99	139	113	152	139	409
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	22	23	25	23	28	26	29	31	27	23	24	24
ZN	111	115	107	93	66	71	72	90	86	95	110	107
ZR	241	292	278	318	418	403	347	299	272	173	188	75

Var.\ID:	S-1019	S-1020	S-1021	S-1022	S-1023	S-877	S-878	S-879	S-880	S-881	S-882	S-883
SIO2	52.96	52.42	55.71	55.17	52.15	52.81	52.17	55.27	59.13	58.13	58.10	56.25
AL2O3	20.23	15.92	17.00	13.94	16.31	15.18	18.10	15.10	13.92	14.06	14.11	14.14
TIO2	2.16	2.55	2.01	1.54	1.05	1.24	1.53	1.79	1.82	2.02	2.11	2.11
FE2O3	12.83	11.87	12.45	9.75	11.11	10.06	11.11	9.56	7.96	9.40	9.66	10.33
MGO	2.91	6.28	2.21	5.41	7.70	6.90	4.94	5.48	4.21	3.86	3.86	4.20
CAO	5.56	7.12	5.66	5.83	6.68	7.08	6.45	6.45	5.17	5.65	5.67	5.55
NA2O	0.52	0.88	1.00	1.00	0.99	0.51	0.68	0.47	0.42	0.44	0.56	0.41
K2O	0.56	0.63	0.51	0.57	0.64	0.74	0.61	0.90	1.35	1.22	1.18	1.11
MNO	0.22	0.26	0.10	0.15	0.21	0.22	0.21	0.26	0.24	0.22	0.23	0.24
P2O5	0.37	0.34	0.19	0.24	0.25	0.34	0.40	0.46	0.42	0.47	0.46	0.49
BA	149	121	110	138	173	174	165	180	226	224	190	162
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	60	65	38	42	63	46	47	45	32	35	42	44
CR	394	519	509	720	741	565	358	360	239	233	231	236
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	58	52	31	32	46	47	51	46	40	46	48	82
GA	20	16	14	15	17	14	17	17	16	16	16	16
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	206	329	180	274	366	248	186	141	90	96	100	85
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	11	14	12	29	17	12	13	14	22	22	18	17
RB	27	21	23	18	22	29	30	38	56	49	46	49
SC	35	40	29	38	43	34	31	28	26	29	31	30
SR	98	136	144	142	174	140	121	127	112	115	114	116
S	n.a	n.a	n.a	n.a	n.a	583	400	556	383	558	466	446
SN	n.a	n.a	n.a	n.a	n.a	10	9	14	9	10	8	11
V	177	212	160	139	156	145	138	150	123	135	148	159
W	n.a	n.a	n.a	n.a	n.a	0	4	8	3	13	10	7
Y	19	21	19	22	17	19	22	28	28	32	32	34
ZN	85	93	65	76	85	100	102	119	104	117	123	157
ZR	158	150	177	166	110	142	151	218	313	310	314	310

	NAS181/cont.							NAS181	NAS182			
Var.\ID:	S-884	S-885	S-886	S-887	S-888	S-889	S-890	S-891	S-912	S-913	S-914	S-915
SIO2	61.97	61.38	57.46	55.30	53.30	53.40	54.77	53.70	63.93	67.23	66.88	60.96
AL2O3	13.19	13.98	13.74	14.34	15.02	14.61	14.40	14.90	17.70	15.51	15.60	19.89
TIO2	1.71	1.94	2.17	2.27	2.52	2.42	2.40	2.58	0.96	1.21	1.19	1.21
FE2O3	7.96	8.32	9.53	10.40	11.31	11.03	10.73	11.41	9.29	5.40	5.84	8.62
MGO	3.07	3.35	4.26	4.09	4.33	4.23	3.83	4.37	0.00	1.99	0.24	0.00
CAO	4.53	5.10	5.60	6.00	6.70	6.15	5.64	6.33	2.83	3.58	3.36	4.19
NA2O	0.38	0.37	0.41	0.37	0.21	0.72	0.52	0.59	0.54	0.63	0.89	0.79
K2O	1.42	1.42	1.21	1.01	0.85	0.99	1.09	0.99	1.74	1.83	1.71	1.28
MNO	0.19	0.23	0.25	0.25	0.27	0.25	0.24	0.26	0.03	0.17	0.07	0.04
P2O5	0.40	0.39	0.44	0.52	0.62	0.56	0.54	0.50	0.13	0.16	0.11	0.16
BA	228	229	195	168	150	168	163	175	340	366	325	256
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	33	34	41	43	53	40	46	42	17	51	22	24
CR	191	193	229	248	215	213	189	222	143	150	157	162
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	47	49	49	61	64	56	54	63	13	15	14	22
GA	14	15	17	17	18	19	16	20	13	12	11	14
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	75	68	86	89	82	76	69	81	45	51	57	79
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	25	23	16	21	24	19	19	15	17	20	14	14
RB	57	57	49	43	36	42	41	40	67	65	55	45
SC	23	27	33	35	35	34	34	39	13	19	20	26
SR	104	117	124	117	133	129	108	125	67	86	105	89
S	527	451	532	741	753	756	842	503	396	204	196	474
SN	12	10	13	16	18	19	18	12	19	8	5	8
V	105	130	143	155	165	162	152	184	68	67	68	86
W	7	6	5	0	5	7	8	9	2	13	9	0
Y	32	31	31	33	42	43	42	37	22	25	23	12
ZN	103	134	135	143	143	137	126	128	39	33	30	47
ZR	332	325	317	294	309	325	330	294	351	378	318	226

						NAS182	NAS183					
Var.\ID:	S-916	S-917	S-918	S-919	S-920	S-921	S-926	S-925	S-924	S-923	S-922	S-1166
SIO2	61.49	59.29	62.94	60.32	54.00	60.72	55.12	59.14	55.51	55.29	59.26	55.74
AL2O3	17.44	23.78	17.58	18.63	18.34	17.30	20.36	19.66	22.85	22.19	20.82	18.73
TIO2	1.11	0.86	1.00	1.02	0.70	1.00	1.07	1.07	1.06	1.09	1.11	0.97
FE2O3	7.24	8.64	7.56	7.73	9.73	8.64	7.78	5.22	9.46	10.38	8.01	7.22
MGO	0.84	0.00	1.12	1.52	4.99	1.67	3.70	1.68	0.35	1.58	1.43	5.27
CAO	4.94	4.53	4.48	5.25	7.14	4.85	5.74	6.01	5.96	5.98	5.63	5.36
NA2O	1.27	0.50	0.85	0.96	1.01	1.07	1.05	1.34	1.01	0.95	1.10	1.11
K2O	1.09	1.15	1.42	1.13	0.47	0.99	0.82	1.06	0.54	0.48	0.98	0.99
MNO	0.06	0.03	0.08	0.08	0.11	0.08	0.14	0.11	0.05	0.08	0.12	0.13
P2O5	0.12	0.22	0.12	0.14	0.12	0.12	0.25	0.22	0.21	0.22	0.23	0.21
BA	239	283	294	232	95	199	147	181	148	126	196	159
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	27	28	27	31	32	26	52	25	30	36	46	50
CR	170	170	184	202	279	213	575	388	460	484	494	641
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	10	16	16	16	23	23	28	19	39	49	28	38
GA	12	14	12	14	14	14	13	11	14	13	14	14
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	74	101	63	77	131	77	194	132	176	215	159	236
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	12	14	15	11	12	11	15	14	16	19	20	12
RB	36	53	48	36	16	33	34	34	24	25	37	31
SC	30	19	28	34	52	36	32	20	31	34	25	33
SR	153	82	134	149	210	146	201	202	163	168	187	228
S	486	1250	236	363	99	267	328	407	571	465	659	n.a
SN	3	3	5	4	0	4	3	3	5	2	23	n.a
V	105	80	102	105	120	108	103	78	85	94	100	96
W	2	6	6	2	1	2	0	5	1	1	0	n.a
Y	18	17	23	18	13	17	11	14	11	11	13	12
ZN	25	63	36	35	42	34	48	41	42	86	43	61
ZR	228	210	249	214	53	211	105	161	134	112	140	91

Var.\ID:	NAS183/cont. S-1167	S-1168	S-1169	S-1170	S-1171	S-1172	S-1173	S-1174	S-1175	S-1176	S-1177	S-1178
SIO2	57.60	55.07	57.33	59.19	60.93	60.33	61.21	56.13	62.54	57.54	58.38	57.50
AL2O3	18.69	18.09	18.28	17.54	16.99	16.15	14.53	20.47	15.86	18.70	19.94	17.07
TIO2	1.39	1.06	1.04	0.92	0.92	0.92	0.83	0.65	0.83	0.84	0.81	0.89
FE2O3	7.38	8.68	6.45	8.84	7.09	6.41	6.72	9.78	8.82	11.83	10.09	8.47
MGO	1.94	2.61	2.16	2.04	1.96	2.62	3.51	4.04	1.84	2.36	1.97	1.72
CAO	5.11	5.09	5.59	4.73	4.76	5.11	4.23	4.50	3.61	3.54	3.76	3.46
NA2O	1.17	1.36	1.53	1.30	1.20	1.41	1.19	1.11	0.89	0.92	0.96	0.96
K2O	1.11	0.91	0.96	1.11	1.08	1.05	1.20	0.82	1.18	0.86	0.92	1.23
MNO	0.11	0.08	0.07	0.06	0.07	0.10	0.08	0.05	0.07	0.07	0.08	0.06
P2O5	0.25	0.22	0.20	0.13	0.16	0.15	0.12	0.16	0.15	0.21	0.19	0.23
BA	226	191	182	213	210	205	231	173	231	233	229	254
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	41	24	23	21	27	38	28	36	28	56	52	27
CR	634	694	614	465	525	555	569	425	483	542	411	415
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	20	21	13	33	18	26	26	37	24	30	35	27
GA	15	13	15	15	12	13	12	13	12	14	13	13
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	222	267	216	184	188	188	233	302	192	203	196	204
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	19	18	17	19	22	13	18	11	17	16	11	18
RB	35	30	27	35	34	31	35	28	39	33	38	43
SC	23	27	22	25	22	29	24	42	22	35	49	35
SR	180	175	206	200	175	222	189	144	138	105	119	133
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	96	100	92	96	72	85	71	88	71	85	96	81
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	14	12	15	14	15	14	14	9	15	14	11	16
ZN	50	44	44	40	43	35	37	71	38	49	34	56
ZR	174	164	148	166	194	158	186	102	205	181	172	196

Var.\ID:	S-1179	S-1180	S-1181	S-1182	NAS183 S-1183	NAS184 S-940	S-941	S-942	S-943	S-944	NULL	S-946
SIO2	64.74	61.53	68.92	68.97	72.71	54.27	53.76	54.19	54.06	59.64	n.a	68.84
AL2O3	14.54	15.93	15.04	14.45	14.81	7.38	9.61	8.58	8.14	9.77	n.a	12.95
TIO2	0.87	0.78	0.95	0.94	1.05	0.66	0.73	0.76	0.75	0.90	n.a	0.95
FE2O3	5.96	6.70	5.56	6.14	5.47	9.52	8.85	9.13	9.02	8.24	n.a	5.60
MGO	2.04	2.28	0.27	0.00	0.00	16.40	12.64	13.55	14.31	9.30	n.a	2.77
CAO	3.89	4.26	3.01	2.51	2.43	3.55	5.27	4.81	4.85	4.30	n.a	4.24
NA2O	1.00	1.13	0.71	0.78	0.72	0.23	0.44	0.31	0.28	0.52	n.a	0.82
K2O	1.50	1.13	1.64	1.83	1.80	0.88	0.72	0.77	0.70	0.99	n.a	1.39
MNO	0.05	0.07	0.05	0.04	0.02	0.20	0.19	0.22	0.23	0.16	n.a	0.07
P2O5	0.08	0.12	0.08	0.07	0.04	0.22	0.23	0.24	0.26	0.14	n.a	0.03
BA	255	221	323	355	391	187	174	211	183	213	n.a	251
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	18	19	22	17	15	89	71	76	80	58	n.a	23
CR	445	502	352	228	195	1619	1314	1295	1302	1261	n.a	744
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	8	4	3	4	4	34	40	41	42	31	n.a	19
GA	13	13	12	12	13	8	8	8	8	10	n.a	10
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	172	115	92	65	45	1217	829	844	852	557	n.a	289
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	14	16	17	16	20	30	46	34	59	23	n.a	18
RB	47	35	63	70	75	27	22	23	22	32	n.a	47
SC	25	23	18	13	11	20	21	18	22	17	n.a	17
SR	164	189	112	99	84	86	139	114	111	115	n.a	129
S	n.a	n.a	n.a	n.a	n.a	949	983	920	925	540	n.a	181
SN	n.a	n.a	n.a	n.a	n.a	11	10	10	25	11	n.a	5
V	67	74	59	56	55	58	67	69	67	75	n.a	56
W	n.a	n.a	n.a	n.a	n.a	0	5	0	1	4	n.a	8
Y	19	16	25	23	26	15	13	15	17	18	n.a	24
ZN	46	62	48	33	24	84	74	82	95	71	n.a	54
ZR	234	197	358	371	401	158	158	168	159	228	n.a	344

	NAS184/cont.				NAS184	NAS185						
Var.\ID:	S-947	S-948	S-949	S-950	S-951	S-952	S-953	S-954	S-955	S-956	S-957	S-958
SIO2	57.63	56.24	51.69	53.74	52.33	54.27	47.04	53.97	54.04	62.39	46.24	64.41
AL2O3	12.08	11.76	12.28	15.76	19.41	16.25	15.89	13.74	13.08	13.40	13.72	8.35
TIO2	0.81	0.81	0.50	0.75	0.76	2.79	3.75	2.74	2.78	1.97	5.28	0.99
FE2O3	7.16	6.98	17.95	7.14	8.40	9.02	16.32	9.69	10.26	7.38	12.21	6.24
MGO	7.55	8.88	9.65	6.51	5.59	3.74	2.58	5.41	5.06	3.47	2.61	8.54
CAO	6.36	6.89	5.65	7.65	7.03	7.43	6.93	7.20	6.59	4.25	7.22	2.95
NA2O	0.74	0.61	0.34	0.52	0.92	0.00	0.83	0.00	0.22	0.60	1.75	0.39
K2O	1.01	0.92	0.30	0.57	0.25	1.50	0.50	1.03	0.91	1.69	0.92	1.47
MNO	0.16	0.22	0.14	0.16	0.14	0.13	0.16	0.20	0.21	0.18	0.18	0.23
P2O5	0.20	0.22	0.03	0.37	0.28	0.70	0.60	0.62	0.61	0.27	0.49	0.16
BA	177	184	93	215	102	65	60	120	126	241	76	293
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	38	61	58	38	42	44	54	52	49	42	48	56
CR	804	832	2367	488	338	617	285	602	515	366	628	1454
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	34	49	47	45	18	38	28	31	25	19	9
GA	11	10	10	11	13	14	18	15	14	13	14	10
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	414	460	645	252	223	486	245	392	303	227	415	597
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	18	24	8	51	20	17	12	21	15	17	15	32
RB	33	29	17	24	13	80	30	52	44	57	24	53
SC	25	25	42	28	26	41	74	36	38	31	38	20
SR	187	193	130	186	191	185	272	176	151	123	216	65
S	945	810	85	1025	309	477	263	447	448	203	419	820
SN	8	8	4	15	5	10	1	7	10	3	5	12
V	80	84	155	80	77	205	504	219	238	159	281	70
W	0	0	0	2	0	3	3	8	6	4	2	6
Y	16	16	10	15	12	49	50	42	36	33	17	22
ZN	56	64	55	105	68	75	90	113	101	69	89	96
ZR	196	171	72	129	82	152	120	171	168	343	144	301

					NAS185	NAS186						
Var.\ID:	S-959	S-960	S-961	S-962	S-963	S-964	S-965	S-966	S-967	S-968	S-969	S-970
SIO2	58.54	56.41	64.09	72.71	72.49	54.09	55.74	54.51	56.57	58.46	51.80	64.14
AL2O3	11.51	6.48	7.39	12.04	12.29	11.89	11.14	11.08	7.70	8.14	6.32	8.53
TIO2	0.76	0.91	0.94	0.94	0.92	1.74	1.54	1.39	0.93	0.95	0.65	0.87
FE2O3	12.31	9.65	5.93	5.51	7.20	9.83	8.52	8.92	7.93	5.93	11.60	6.63
MGO	10.79	14.26	8.59	1.02	0.92	8.05	7.55	9.05	13.39	11.56	19.95	8.75
CAO	3.19	3.36	2.53	2.13	2.09	5.70	5.10	5.19	3.97	3.32	3.59	3.00
NA2O	0.00	0.24	0.57	0.61	0.62	1.08	0.97	0.99	0.69	0.88	0.22	0.48
K2O	1.36	1.33	1.77	1.98	1.99	1.44	1.41	1.31	1.35	1.68	0.95	1.60
MNO	0.39	0.37	0.25	0.06	0.07	0.21	0.19	0.19	0.26	0.22	0.34	0.19
P2O5	0.22	0.24	0.18	0.02	0.02	0.33	0.33	0.32	0.24	0.25	0.18	0.21
BA	344	249	279	370	377	147	165	204	215	310	188	301
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	94	153	81	16	27	51	50	53	100	72	171	68
CR	1219	3533	1722	594	612	562	683	888	1722	1362	2806	1481
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	33	10	6	6	6	50	38	40	30	24	31	14
GA	14	8	8	11	11	16	14	13	12	12	9	8
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1449	902	389	212	225	286	305	428	839	667	2189	653
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	24	35	21	20	22	23	26	24	29	31	19	25
RB	65	46	61	76	79	48	53	47	48	56	33	57
SC	45	14	16	13	10	35	26	27	21	16	25	16
SR	47	54	59	79	72	145	134	137	119	147	88	107
S	657	712	627	137	148	394	445	412	421	402	191	613
SN	8	7	6	4	5	6	15	6	3	8	7	8
V	93	91	62	51	53	154	122	114	87	70	79	67
W	6	4	2	2	12	6	3	6	0	2	0	8
Y	34	17	22	27	27	28	23	21	17	19	12	19
ZN	110	169	74	45	42	104	84	89	88	78	72	72
ZR	188	265	363	460	454	190	199	178	195	222	123	275

	NAS186/cont.		NAS186	NAS187							NAS187	NAS188
Var.\ID:	S-971	S-972	S-973	S-974	S-975	S-976	S-977	S-978	S-979	S-980	S-981	S-982
SIO2	60.83	67.11	56.91	63.83	61.92	62.34	71.19	69.04	72.42	70.18	72.69	61.03
AL2O3	9.01	9.44	13.70	9.88	11.69	11.46	10.54	11.35	10.34	10.44	10.17	8.77
TIO2	0.83	0.83	0.99	1.01	1.38	1.39	0.96	1.03	0.91	0.98	0.90	0.93
FE2O3	8.78	6.85	12.85	6.38	8.12	7.58	5.59	5.63	4.67	4.96	4.61	6.17
MGO	10.49	6.43	7.46	7.06	4.67	4.99	2.75	2.47	2.40	2.63	2.43	10.25
CAO	2.89	2.55	3.23	4.01	4.17	3.98	2.85	3.08	2.72	2.78	2.70	3.62
NA2O	0.38	0.67	0.58	0.83	0.96	0.93	0.71	0.58	0.61	0.68	0.69	0.69
K2O	1.45	1.63	1.43	1.51	1.50	1.62	1.77	1.88	1.85	1.81	1.80	1.63
MNO	0.20	0.12	0.14	0.16	0.14	0.14	0.09	0.10	0.10	0.10	0.10	0.23
P2O5	0.18	0.09	0.17	0.12	0.18	0.21	0.09	0.17	0.11	0.12	0.08	0.26
BA	271	300	267	287	278	295	310	334	329	331	328	287
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	101	48	109	40	35	30	21	21	15	17	16	61
CR	1715	989	1500	920	527	483	411	329	307	299	313	1090
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	20	21	23	18	24	29	14	17	17	17	15	24
GA	10	9	13	10	12	12	9	11	10	10	10	11
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1216	511	838	347	254	253	192	150	144	155	158	539
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	24	23	20	21	17	17	22	18	19	21	20	33
RB	54	55	59	52	54	56	65	71	67	65	66	60
SC	20	12	31	17	23	18	12	11	11	9	9	19
SR	94	100	109	126	120	130	106	109	97	101	96	114
S	351	284	197	241	272	289	286	310	253	267	195	548
SN	0	2	5	7	11	10	7	6	12	10	10	6
V	66	54	82	78	103	92	60	58	54	56	47	73
W	3	1	4	8	4	4	10	10	17	7	12	1
Y	16	20	15	25	27	25	23	25	23	24	25	20
ZN	69	55	185	56	63	62	51	53	50	55	51	91
ZR	257	336	196	293	288	269	387	374	400	400	401	243

								NAS188	NAS189			
Var.\ID:	S-983	S-984	S-985	S-986	S-987	S-988	S-989	S-990	S-1038	S-1039	S-1040	S-1041
SIO2	60.86	58.13	69.12	53.53	54.91	73.63	72.09	72.41	52.36	53.45	52.85	50.57
AL2O3	8.92	8.39	10.66	6.03	4.73	11.57	12.75	12.19	14.69	14.18	11.11	12.87
TIO2	0.93	0.79	0.89	0.52	0.66	0.90	0.84	0.86	3.52	3.58	3.15	3.14
FE2O3	6.16	8.85	6.03	13.95	12.42	6.00	5.96	5.30	13.08	13.01	12.64	14.46
MGO	11.33	12.98	4.85	16.99	17.97	0.08	0.00	0.99	3.09	3.81	7.62	5.95
CAO	3.78	3.54	2.88	3.97	4.01	2.19	2.13	2.42	6.23	6.07	5.90	5.64
NA2O	0.63	0.44	0.56	0.20	0.01	0.66	0.67	0.46	0.49	0.53	0.42	0.79
K2O	1.53	1.28	1.94	0.67	1.03	1.93	2.12	2.02	1.01	0.96	0.83	0.70
MNO	0.22	0.21	0.18	0.28	0.43	0.04	0.04	0.07	0.25	0.25	0.28	0.20
P2O5	0.25	0.17	0.12	0.10	0.22	0.04	0.06	0.13	0.68	0.54	0.46	0.43
BA	309	245	373	147	217	345	363	365	101	121	109	84
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	69	83	50	131	189	6	7	13	55	65	81	52
CR	1076	1751	737	2978	2959	289	163	237	247	400	1041	649
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	20	19	15	27	28	5	7	10	53	48	40	42
GA	11	9	10	9	9	10	11	10	20	19	16	18
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	593	988	347	2210	1960	89	60	110	141	240	604	497
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	40	25	25	21	24	24	19	23	21	24	13	12
RB	54	49	71	23	31	69	73	75	32	29	25	20
SC	16	20	14	26	28	7	10	9	58	53	45	51
SR	108	84	95	62	76	82	85	77	118	119	119	122
S	646	402	233	255	426	302	248	368	n.a	n.a	n.a	n.a
SN	8	6	9	5	0	4	5	6	n.a	n.a	n.a	n.a
V	71	75	62	85	83	48	42	42	311	295	249	238
W	14	4	3	5	0	10	11	10	n.a	n.a	n.a	n.a
Y	19	17	23	12	12	23	22	22	46	41	35	46
ZN	88	96	51	59	77	24	32	38	137	130	120	108
ZR	231	208	365	123	149	422	411	407	207	216	207	221

	NAS189/cont.											
Var.\ID:	S-1042	S-1043	S-1044	S-1045	S-1046	S-1047	S-1048	S-1049	S-1050	S-1051	S-1052	S-1053
SIO2	58.05	63.91	49.87	55.16	52.13	60.25	64.39	63.79	60.28	53.59	58.43	55.51
AL2O3	13.93	7.94	10.97	13.10	9.23	6.56	10.54	10.90	10.27	7.18	10.12	11.31
TIO2	3.14	2.27	2.38	2.10	2.29	1.21	1.50	1.42	1.53	1.63	1.25	1.31
FE2O3	10.50	4.21	16.42	13.86	11.53	9.04	9.78	9.28	9.36	11.05	11.35	15.12
MGO	1.85	10.15	6.03	5.14	12.45	15.94	6.68	6.70	9.04	16.91	9.80	7.74
CAO	5.21	4.98	4.53	4.59	5.02	5.36	3.90	3.70	4.66	5.37	4.50	4.01
NA2O	1.12	0.23	0.33	0.51	0.42	0.09	0.46	0.41	0.21	0.11	0.27	0.33
K2O	1.02	1.30	0.77	0.94	1.06	1.40	1.52	1.57	1.21	1.22	1.25	1.05
MNO	0.14	0.49	0.16	0.19	0.30	0.55	0.29	0.28	0.37	0.55	0.33	0.20
P2O5	0.29	0.34	0.66	0.33	0.41	0.28	0.22	0.20	0.31	0.34	0.26	0.22
BA	152	173	145	160	127	326	286	338	239	215	296	266
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	47	45	74	67	94	204	107	109	107	204	126	90
CR	867	1141	629	1260	1727	2871	1158	1382	1496	3763	2869	2736
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	18	23	35	27	25	24	21	26	27	24	27
GA	14	12	15	14	13	11	13	11	10	11	12	11
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	272	455	473	551	718	1087	615	595	699	1431	1117	1304
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	19	21	18	23	21	29	26	27	23	35	33	27
RB	31	33	23	34	33	36	47	50	42	32	38	41
SC	40	27	34	43	38	28	24	28	40	41	32	43
SR	163	92	112	109	106	82	95	88	90	77	82	76
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	198	115	132	181	184	141	113	111	141	155	132	135
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	33	29	72	52	41	27	36	33	45	25	27	29
ZN	91	91	185	124	178	211	92	82	127	187	182	142
ZR	253	277	181	251	182	220	364	368	234	239	248	212

						NAS189	NAS190					
Var.\ID:	S-1054	S-1055	S-1056	S-1057	S-1058	S-1059	S-1087	S-1088	S-1089	S-1090	S-1091	S-1092
SIO2	61.25	61.22	60.74	69.40	68.32	67.37	51.51	54.22	54.33	52.58	51.28	50.90
AL2O3	12.76	11.30	13.94	9.96	10.26	12.61	17.48	16.28	16.53	15.16	14.91	15.47
TIO2	1.33	1.41	1.44	0.95	0.81	0.90	2.78	2.05	2.25	1.93	1.91	1.90
FE2O3	13.27	10.89	12.09	4.56	8.20	6.81	12.50	9.78	10.05	9.88	10.33	11.54
MGO	5.19	6.32	5.48	7.12	5.15	2.16	3.06	4.67	5.00	6.35	6.90	7.95
CAO	3.38	3.97	3.21	3.56	2.44	2.42	5.15	4.97	5.47	5.29	5.43	6.03
NA2O	0.36	0.41	0.37	0.28	0.35	0.44	1.58	0.43	0.42	0.56	0.43	0.61
K2O	1.33	1.16	1.28	1.78	1.59	1.77	0.54	1.03	0.94	0.98	0.76	0.50
MNO	0.18	0.21	0.15	0.31	0.17	0.09	0.18	0.20	0.23	0.21	0.21	0.20
P2O5	0.20	0.20	0.18	0.15	0.06	0.14	0.40	0.45	0.46	0.44	0.45	0.36
BA	303	305	271	417	337	315	108	146	127	114	132	96
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	91	83	79	77	66	31	44	53	42	50	58	64
CR	1956	1977	1251	1137	892	483	166	295	306	379	452	595
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	29	25	24	15	13	9	42	43	42	53	54	63
GA	12	12	12	8	8	9	21	16	19	16	16	17
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1031	717	599	589	521	170	106	159	171	238	305	451
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	27	25	27	23	21	21	37	23	17	18	26	21
RB	53	41	48	60	55	63	32	41	38	37	31	22
SC	36	38	26	14	16	12	40	32	34	31	29	41
SR	76	79	70	87	65	67	149	95	99	96	95	102
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	116	120	100	69	73	55	181	121	137	125	125	136
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	35	33	23	25	23	26	28	26	25	27	28	31
ZN	106	106	99	66	74	42	106	129	128	129	127	119
ZR	295	276	281	341	313	450	240	239	247	206	207	197

	NAS190/cont.											
Var.\ID:	S-1093	S-1094	S-1095	S-1096	S-1097	S-1098	S-1099	S-1100	S-1101	S-1102	S-1103	S-1104
SIO2	52.51	52.45	53.53	52.58	56.29	58.01	57.72	57.63	55.85	57.37	55.91	55.30
AL2O3	14.78	13.40	15.62	15.57	17.26	16.94	13.99	14.57	16.09	15.00	14.68	13.80
TIO2	1.80	1.84	2.02	1.99	1.76	1.67	1.59	1.74	1.55	1.62	1.79	1.61
FE2O3	10.90	10.91	9.96	11.73	9.34	8.55	7.26	8.26	10.98	8.74	9.08	8.75
MGO	8.02	8.29	4.88	6.38	3.76	2.91	3.31	3.56	4.95	4.83	5.61	5.64
CAO	6.10	5.62	5.82	6.01	6.02	5.39	4.25	5.28	5.41	5.44	5.50	5.31
NA2O	0.23	0.37	0.48	0.25	0.39	0.40	0.70	0.49	0.20	0.24	0.20	0.34
K2O	0.61	0.68	0.73	0.60	0.79	1.06	1.33	1.06	0.77	0.90	0.82	0.91
MNO	0.21	0.22	0.20	0.22	0.18	0.17	0.16	0.17	0.17	0.18	0.19	0.19
P2O5	0.50	0.42	0.45	0.46	0.39	0.40	0.41	0.42	0.41	0.41	0.45	0.42
BA	136	126	146	125	163	208	216	190	172	168	176	161
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	53	55	57	54	38	35	34	35	38	43	51	37
CR	591	718	353	503	282	242	203	257	319	384	475	422
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	44	45	28	48	35	30	29	36	36	30	30	31
GA	15	16	16	15	16	15	14	14	17	14	14	14
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	372	406	219	364	201	163	122	152	232	276	316	284
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	31	36	17	20	14	15	19	18	19	17	17	21
RB	30	31	31	28	35	45	49	41	34	39	36	36
SC	37	38	34	35	36	31	26	31	37	27	33	29
SR	99	97	84	88	94	92	92	105	84	95	83	93
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	128	124	125	135	121	107	96	120	124	106	113	111
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	31	34	36	36	39	40	34	33	37	32	31	31
ZN	128	95	82	87	79	81	71	75	87	81	83	79
ZR	197	223	273	236	241	280	328	278	229	267	264	260

	NAS190	NAS191										
Var.\ID:	S-1105	S-1207	S-1208	S-1209	S-1210	S-1211	S-1212	S-1213	S-1214	S-1215	S-1216	S-1217
SIO2	51.67	69.75	74.96	69.10	56.74	64.22	67.32	64.90	60.10	60.29	64.10	64.13
AL2O3	14.62	12.76	13.97	11.63	7.51	13.54	13.34	16.29	15.01	10.23	17.09	13.14
TIO2	1.63	0.92	1.02	0.94	0.70	1.40	1.61	1.34	0.86	0.68	0.79	0.92
FE2O3	11.08	6.51	5.10	6.66	10.86	7.79	5.38	5.78	5.85	7.97	6.75	5.65
MGO	8.07	1.03	0.00	3.33	16.62	1.77	0.80	0.25	4.13	11.49	1.25	7.80
CAO	5.91	2.19	2.34	2.49	3.70	3.69	4.30	4.20	4.61	4.65	4.04	4.85
NA2O	0.13	0.61	0.55	0.50	0.19	0.67	0.79	0.77	1.03	0.28	1.13	0.69
K2O	0.52	2.10	2.01	1.84	0.91	1.42	1.43	1.63	1.48	1.05	1.45	1.56
MNO	0.18	0.05	0.02	0.11	0.25	0.06	0.05	0.04	0.13	0.29	0.06	0.32
P2O5	0.47	0.07	0.03	0.07	0.08	0.09	0.07	0.12	0.16	0.13	0.14	0.20
BA	108	397	374	356	219	292	193	293	232	240	246	274
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	57	33	19	55	112	37	35	41	55	74	24	114
CR	726	398	257	767	2775	845	777	607	628	1287	582	1317
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	48	6	1	6	13	5	5	4	17	23	13	22
GA	12	10	11	11	10	12	12	13	12	10	12	11
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	530	255	95	326	1567	244	178	186	300	668	248	440
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	24	21	18	19	23	19	17	20	28	35	15	27
RB	25	79	82	63	30	50	43	56	45	29	49	42
SC	39	12	11	16	27	24	18	16	21	40	18	24
SR	82	82	75	77	63	116	143	136	172	100	146	134
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	119	49	44	66	120	70	73	73	73	82	61	82
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	31	30	27	29	23	26	30	22	18	19	19	19
ZN	98	56	30	60	186	56	41	38	52	133	43	58
ZR	190	400	410	400	219	370	369	292	236	154	251	241

	NAS191/cont.							NAS191	NAS192			
Var.\ID:	S-1218	S-1219	S-1220	S-1221	S-1222	S-1223	S-1224	S-1225	S-1274	S-1275	S-1276	S-1277
SIO2	67.49	70.11	67.96	69.68	70.94	66.66	73.90	63.26	64.92	62.97	70.95	69.36
AL2O3	14.60	12.94	14.65	13.03	15.46	13.37	14.31	13.82	13.98	15.58	11.41	13.27
TIO2	0.87	0.86	0.85	0.81	0.92	0.81	0.91	0.81	0.97	0.70	0.90	0.90
FE2O3	6.99	4.78	5.95	5.31	6.91	6.45	5.32	4.86	7.69	8.92	5.31	6.82
MGO	0.96	1.23	1.26	1.61	0.06	2.05	0.00	5.36	3.56	2.98	3.87	1.19
CAO	3.18	3.45	3.16	3.46	3.11	2.71	2.50	3.89	4.28	3.21	3.34	2.81
NA2O	0.85	1.02	0.85	0.91	0.67	0.69	0.56	0.93	0.62	0.26	0.56	0.66
K2O	1.56	1.47	1.71	1.50	1.78	1.72	2.00	1.80	1.00	1.11	1.61	1.94
MNO	0.05	0.06	0.07	0.06	0.04	0.07	0.04	0.20	0.12	0.05	0.10	0.05
P2O5	0.10	0.10	0.12	0.08	0.06	0.12	0.04	0.18	0.09	0.10	0.04	0.11
BA	284	264	316	269	362	316	393	313	283	251	303	348
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	30	23	27	36	21	40	12	65	48	41	26	13
CR	634	617	454	666	467	696	268	1140	942	881	750	400
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	14	12	13	13	14	12	7	17	11	7	13	10
GA	10	10	10	10	12	10	11	12	11	13	9	9
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	216	217	179	217	187	259	111	351	316	443	292	182
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	20	23	19	19	20	25	16	21	19	25	18	22
RB	57	47	60	48	70	60	77	56	37	62	53	67
SC	15	6	19	14	12	13	12	20	24	25	15	10
SR	108	130	118	134	111	89	82	171	115	73	97	101
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	59	53	57	57	59	50	48	76	83	65	58	52
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	21	21	23	23	23	22	27	19	20	34	24	24
ZN	39	36	46	39	41	46	37	56	68	91	39	42
ZR	318	329	330	341	317	339	414	270	197	146	361	408

						NAS192	NAS199					
Var.\ID:	S-1278	S-1279	S-1280	S-1281	S-1282	S-1283	S-1336	S-1335	S-1334	S-1333	S-1332	S-1316
SIO2	66.96	69.07	70.81	69.01	66.31	68.58	54.10	50.91	54.88	56.67	50.24	50.72
AL2O3	13.65	14.06	14.58	13.53	13.66	14.71	8.67	3.83	7.18	7.94	6.20	7.34
TIO2	0.92	0.84	0.92	0.89	0.84	0.92	0.65	0.41	0.70	0.79	0.55	0.59
FE2O3	7.51	6.33	6.90	6.46	7.27	6.44	9.40	12.20	9.54	8.42	8.07	6.91
MGO	1.70	0.44	0.00	0.48	2.41	0.07	17.45	27.26	16.85	14.48	20.53	13.99
CAO	2.86	2.49	2.70	2.58	2.57	2.65	4.49	2.09	3.70	4.31	4.42	8.53
NA2O	0.56	0.60	0.49	0.47	0.41	0.46	0.40	0.07	0.21	0.32	0.28	0.47
K2O	1.88	1.94	1.91	1.90	1.87	2.03	0.94	0.58	0.97	1.24	0.79	1.06
MNO	0.07	0.04	0.04	0.05	0.08	0.06	0.16	0.24	0.22	0.23	0.23	0.18
P2O5	0.17	0.15	0.14	0.20	0.20	0.21	0.12	0.09	0.18	0.19	0.18	0.12
BA	342	335	375	358	343	378	148	140	232	263	153	157
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	17	11	14	17	31	18	71	131	101	87	85	57
CR	409	281	266	278	435	236	809	2028	1716	1533	1569	1129
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	11	9	11	9	11	8	20	30	27	24	33	16
GA	10	10	11	11	11	12	8	7	7	8	7	6
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	180	115	103	109	163	72	1121	2751	1113	880	1114	639
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	25	22	23	24	22	18	17	21	37	39	25	16
RB	69	72	76	72	71	76	27	22	32	39	22	27
SC	14	8	10	9	9	12	40	21	24	23	27	23
SR	96	83	81	81	75	81	120	51	93	108	114	331
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	50	48	54	50	54	56	83	63	73	80	82	63
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	24	22	25	24	23	25	18	10	16	19	14	11
ZN	55	44	44	43	43	40	95	107	131	122	126	88
ZR	357	399	386	387	360	386	95	98	159	188	99	104

NAS199/cont.

Var.\ID:	S-1317	S-1318	S-1319	S-1320	S-1321	S-1322	S-1323	S-1324	S-1325	S-1326	S-1327	S-1328
SIO2	52.31	51.04	51.19	51.24	54.72	55.27	56.67	58.18	58.31	57.67	57.64	59.96
AL2O3	3.15	8.35	7.67	5.58	11.87	14.48	13.37	12.32	10.56	11.59	11.38	11.58
TIO2	0.54	0.57	0.63	0.55	0.71	0.64	0.67	0.83	0.77	0.75	0.79	0.87
FE2O3	9.27	8.88	7.73	6.59	6.74	6.83	7.11	7.64	6.81	6.59	5.49	5.51
MGO	26.63	18.00	16.63	23.74	14.17	9.56	10.61	11.21	11.27	10.58	10.40	9.64
CAO	3.21	4.88	4.20	5.80	4.27	5.78	5.09	4.77	4.68	5.35	5.01	4.83
NA2O	0.00	0.74	0.52	0.17	0.67	1.02	0.66	0.42	0.39	0.40	0.53	0.50
K2O	0.46	0.71	0.88	0.81	1.84	1.43	1.54	1.62	1.57	1.51	1.70	1.87
MNO	0.30	0.21	0.22	0.37	0.16	0.12	0.15	0.14	0.19	0.16	0.19	0.18
P2O5	0.13	0.16	0.25	0.20	0.20	0.18	0.18	0.16	0.20	0.19	0.22	0.19
BA	82	117	134	95	101	90	125	131	169	148	169	188
CE	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CO	79	76	67	88	52	43	49	52	57	50	54	52
CR	2208	1465	1213	1657	869	688	919	1133	1121	1104	961	873
CS	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
CU	40	27	26	29	23	16	18	21	25	19	19	18
GA	4	7	6	6	9	11	10	9	9	8	8	10
LA	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
NI	1426	778	622	1241	554	393	487	619	587	541	459	447
NB	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
PB	12	17	24	18	12	13	18	15	23	20	17	18
RB	8	19	21	17	46	42	52	52	46	47	50	55
SC	21	29	27	23	32	33	34	34	24	31	31	32
SR	51	118	102	120	105	133	111	97	108	112	129	136
S	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
SN	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
V	93	88	80	76	83	87	91	88	81	87	84	81
W	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Y	9	12	11	8	12	12	13	17	15	16	19	19
ZN	111	114	131	166	145	94	113	128	121	109	119	118
ZR	56	73	90	68	90	75	104	145	150	151	152	183

Var.\ID:	S-1329	S-1330	NAS199 S-1331
SIO2	65.48	63.79	64.86
AL2O3	11.91	8.63	9.20
TIO2	0.86	0.89	0.89
FE2O3	6.34	5.46	5.39
MGO	7.88	10.25	9.59
CAO	4.12	3.86	4.29
NA2O	0.51	0.43	0.35
K2O	1.84	1.63	1.61
MNO	0.14	0.23	0.21
P2O5	0.08	0.17	0.21
BA	199	228	235
CE	n.a	n.a	n.a
CO	40	65	57
CR	948	1316	1141
CS	n.a	n.a	n.a
CU	21	21	23
GA	9	7	8
LA	n.a	n.a	n.a
NI	415	552	515
NB	n.a	n.a	n.a
PB	20	23	23
RB	63	47	48
SC	27	21	26
SR	104	100	110
S	n.a	n.a	n.a
SN	n.a	n.a	n.a
V	78	75	71
W	n.a	n.a	n.a
Y	21	20	21
ZN	114	117	119
ZR	238	266	261

Sampling and analytical errors data

This Appendix includes the data which were used in Chapter 3.4 for both the random ANOVA test and for the fixed ANOVA test on the monitor data from all the XRFS batch runs.

Analytical errors

File name	Description	No.of samples
NASM1.	Monitor batch 1.	42
NASM2.	Monitor batch 2.	51
NASM3.	Monitor batch 3.	60
NASM4.	Monitor batch 4.	45

Sampling and analytical errors

File name	Sample numbers	Location	No.of samples
NAS50.	S1226-1241.	Porthkerris. (UL)	16
NAS50A.	]		
NAS50B.	]	Sub-samples.	4 x 4
NAS50C.	]		
NAS50D.	]		
NAS50Z.	Analytical replicates.		10
NAS51.	S1242-1257.	Dean Quarry. (GA)	16
NAS51A.	]		
NAS51B.	]	Sub-samples.	4 x 4
NAS51C.	]		
NAS51D.	]		
NAS51Z.	Analytical replicates.		10
NAS52.	S1258-1273.	Goonhilly Downs. (CUM)	16
NAS52A.	]		
NAS52B.	]	Sub-samples.	4 x 4
NAS52C.	]		
NAS52D.	]		
NAS52Z.	Analytical replicates.		10
NAS53.	S1284-1299.	Coverack. (UL)	16
NAS53A.	]		
NAS53B.	]	Sub-samples.	4 x 4
NAS53C.	]		
NAS53D.	]		
NAS53Z.	Analytical replicates.		10

	NASM1														
Var.\ID:	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1
SIO2	53.66	53.82	53.87	53.94	54.06	53.60	54.15	54.29	52.18	52.33	52.32	52.38	52.29	52.25	52.39
AL2O3	13.89	13.85	13.81	13.86	13.89	13.82	13.81	13.87	13.50	13.51	13.46	13.47	13.47	13.40	13.51
TIO2	0.69	0.70	0.69	0.67	0.68	0.68	0.70	0.70	0.69	0.71	0.67	0.68	0.69	0.68	0.70
FE2O3	5.25	5.32	5.28	5.19	5.23	5.20	5.28	5.32	5.26	5.32	5.25	5.26	5.24	5.22	5.28
MGO	3.36	3.37	3.35	3.37	3.40	3.33	3.39	3.28	3.38	3.36	3.39	3.38	3.43	3.39	3.38
CAO	4.73	4.72	4.70	4.69	4.72	4.72	4.68	4.68	4.70	4.72	4.71	4.69	4.69	4.70	4.70
NA2O	3.20	3.21	3.24	3.17	3.18	3.26	3.35	3.22	3.36	3.28	3.30	3.23	3.21	3.36	3.29
K2O	2.00	1.99	2.00	2.00	2.00	2.00	2.01	1.99	2.01	2.02	2.02	2.01	2.00	1.99	2.01
MNO	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
P2O5	0.23	0.23	0.23	0.24	0.23	0.23	0.23	0.24	0.23	0.23	0.23	0.24	0.23	0.23	0.23
BA	968	976	985	946	981	992	941	976	960	960	957	977	966	953	964
CO	44	41	46	42	46	47	45	41	45	43	46	44	44	45	48
CR	75	79	87	77	82	83	78	78	76	72	78	74	77	71	80
CU	66	63	66	65	63	66	63	66	66	64	63	64	66	63	65
GA	53	52	51	52	51	52	53	54	51	52	52	53	49	52	52
NI	63	64	61	58	64	60	65	66	64	61	63	64	64	63	62
PB	51	52	53	50	52	53	53	52	52	47	49	48	48	49	50
RB	88	89	89	87	90	85	89	89	89	90	88	88	88	88	88
SC	12	12	12	12	12	13	12	12	12	12	12	12	13	12	13
SR	807	812	808	796	803	803	807	809	805	810	806	810	799	801	800
V	94	101	104	96	98	104	102	102	93	98	106	97	105	103	98
Y	72	74	74	73	72	72	73	74	74	73	73	73	75	71	72
ZN	92	90	91	91	93	90	91	91	93	94	91	93	91	90	91
ZR	183	186	188	182	182	180	183	187	181	179	179	182	178	181	183

Var.\ID:	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1
SIO2	52.35	52.25	52.63	52.55	52.38	52.38	52.49	52.65	52.55	52.57	52.41	52.44	52.40	52.28	52.35
AL2O3	13.47	13.37	13.42	13.46	13.40	13.40	13.40	13.42	13.42	13.42	13.42	13.39	13.39	13.35	13.35
TIO2	0.70	0.70	0.69	0.71	0.70	0.69	0.69	0.70	0.68	0.70	0.69	0.68	0.69	0.68	0.67
FE2O3	5.30	5.23	5.25	5.26	5.26	5.23	5.25	5.26	5.23	5.26	5.21	5.15	5.25	5.17	5.08
MGO	3.35	3.41	3.42	3.49	3.44	3.45	3.47	3.46	3.39	3.42	3.47	3.52	3.41	3.43	3.48
CAO	4.71	4.71	4.72	4.73	4.72	4.71	4.71	4.70	4.72	4.73	4.72	4.73	4.73	4.72	4.72
NA2O	3.39	3.22	3.32	3.25	3.19	3.22	3.25	3.19	3.26	3.30	3.24	3.19	3.21	3.20	3.30
K2O	2.01	2.00	2.00	2.01	2.01	2.01	2.00	2.01	2.01	2.02	2.02	2.00	1.99	2.00	2.00
MNO	0.10	0.09	0.09	0.10	0.10	0.10	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09
P2O5	0.23	0.22	0.22	0.22	0.22	0.22	0.23	0.23	0.22	0.22	0.23	0.22	0.22	0.22	0.22
BA	960	961	966	960	972	948	975	961	966	939	954	960	978	971	952
CO	44	40	45	41	45	43	44	45	39	44	41	45	49	42	43
CR	76	72	77	76	67	72	76	72	77	74	74	74	80	78	76
CU	65	63	64	63	61	63	65	64	65	63	63	67	64	68	66
GA	52	52	53	53	53	54	53	53	56	54	54	53	53	52	50
NI	62	58	59	60	64	61	64	63	61	63	63	61	64	64	61
PB	47	48	52	46	46	48	47	48	48	47	47	47	49	48	49
RB	89	86	87	89	89	88	89	89	89	88	89	88	89	87	86
SC	12	11	11	11	12	12	12	13	11	12	12	11	13	12	12
SR	805	798	793	784	784	798	801	795	803	790	797	793	808	803	789
V	98	100	104	105	101	104	101	101	104	102	101	107	98	101	106
Y	75	73	73	70	72	76	75	75	74	73	72	73	72	72	70
ZN	93	90	88	87	90	90	94	92	91	89	93	95	94	95	97
ZR	181	182	177	174	178	180	179	181	181	176	179	180	187	176	175

												NASM1	NASM2		
Var.\ID:	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon1	'Mon2	'Mon2	'Mon2
SIO2	52.36	52.46	52.17	52.27	52.18	52.38	52.27	52.54	52.92	52.41	52.26	52.48	52.35	52.33	52.29
AL2O3	13.46	13.45	13.39	13.40	13.39	13.43	13.40	13.43	13.42	13.43	13.38	13.49	13.42	13.31	13.36
TIO2	0.68	0.73	0.73	0.73	0.73	0.71	0.71	0.73	0.69	0.70	0.69	0.68	0.66	0.66	0.65
FE2O3	5.07	5.49	5.47	5.45	5.47	5.36	5.31	5.44	5.21	5.22	5.21	5.15	5.25	5.11	5.20
MGO	3.45	3.43	3.43	3.47	3.43	3.48	3.49	3.46	3.45	3.46	3.44	3.49	3.41	3.39	3.44
CAO	4.72	4.72	4.74	4.74	4.74	4.75	4.71	4.74	4.71	4.72	4.71	4.72	4.70	4.69	4.71
NA2O	3.26	3.26	3.25	3.27	3.26	3.19	3.21	3.13	3.33	3.23	3.17	3.26	3.29	3.21	3.27
K2O	2.00	2.00	2.01	2.03	2.00	2.00	2.01	2.02	2.03	2.01	2.01	2.00	2.00	2.00	2.00
MNO	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09
P2O5	0.22	0.22	0.22	0.23	0.22	0.22	0.23	0.22	0.23	0.22	0.23	0.23	0.23	0.23	0.23
BA	963	954	957	972	975	985	958	981	965	973	955	968	936	948	965
CO	48	47	47	43	44	49	50	46	44	45	46	42	45	44	43
CR	85	75	75	77	78	76	79	76	82	83	84	81	80	83	80
CU	64	64	65	64	67	67	67	67	65	66	63	65	65	60	63
GA	51	53	54	53	53	55	52	54	53	53	52	52	55	54	56
NI	64	63	63	60	61	65	63	65	66	64	63	65	61	65	63
PB	48	50	52	50	49	48	51	50	46	48	50	49	48	43	45
RB	86	91	92	89	91	91	89	90	87	88	86	89	86	86	86
SC	13	11	12	12	13	12	11	13	12	12	12	12	13	11	12
SR	787	822	828	824	823	830	816	830	798	794	798	806	805	786	806
V	103	95	95	95	101	97	95	96	101	104	108	109	99	100	104
Y	70	75	73	75	73	75	72	74	74	69	71	74	73	70	73
ZN	90	92	91	92	89	94	95	95	91	95	93	93	93	96	92
ZR	172	188	184	185	190	187	187	191	177	178	179	184	179	175	176

NASM2/cont.

Var.\ID:	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2
SIO2	52.21	52.51	52.44	52.51	52.37	52.40	52.84	52.75	52.64	52.69	52.73	52.81	52.70	52.71	52.70
AL2O3	13.36	13.53	13.52	13.53	13.58	13.51	13.56	13.51	13.55	13.55	13.49	13.58	13.54	13.53	13.55
TIO2	0.65	0.67	0.66	0.66	0.67	0.66	0.66	0.66	0.65	0.66	0.66	0.67	0.66	0.66	0.65
FE2O3	5.26	5.27	5.26	5.28	5.30	5.30	5.22	5.28	5.21	5.28	5.23	5.27	5.23	5.28	5.29
MGO	3.38	3.21	3.18	3.19	3.19	3.19	3.34	3.31	3.29	3.34	3.31	3.37	3.28	3.34	3.36
CAO	4.69	4.70	4.71	4.70	4.71	4.71	4.76	4.73	4.74	4.75	4.76	4.76	4.75	4.73	4.76
NA2O	3.24	3.32	3.27	3.25	3.23	3.36	3.27	3.24	3.25	3.31	3.22	3.30	3.26	3.21	3.31
K2O	2.01	2.01	1.98	1.99	1.99	2.01	2.02	2.02	2.01	2.02	2.01	2.04	2.02	2.01	2.03
MNO	0.09	0.09	0.10	0.09	0.09	0.10	0.09	0.09	0.10	0.09	0.09	0.09	0.10	0.09	0.09
P2O5	0.23	0.25	0.25	0.24	0.24	0.24	0.23	0.24	0.23	0.24	0.24	0.24	0.24	0.24	0.23
BA	962	954	966	971	970	951	982	974	980	964	975	983	960	970	977
CO	48	44	43	47	40	46	40	42	40	45	45	42	40	42	41
CR	79	83	84	76	86	86	82	78	78	78	78	81	77	76	79
CU	68	62	61	61	60	61	62	61	59	61	61	62	59	60	62
GA	54	51	52	52	53	53	52	53	53	53	54	53	53	53	53
NI	64	64	63	62	62	63	63	87	61	63	64	66	64	64	64
PB	46	45	44	47	44	43	46	51	43	49	53	46	46	45	51
RB	86	89	86	87	88	88	93	92	83	88	93	94	84	88	91
SC	12	14	13	11	14	13	12	11	11	10	11	9	8	6	11
SR	797	825	780	820	812	810	831	817	734	771	825	818	755	786	798
V	101	106	98	103	104	105	107	105	106	100	104	105	95	102	93
Y	72	75	72	74	74	75	75	77	71	74	75	75	71	75	75
ZN	92	96	88	92	95	91	93	95	85	87	89	92	87	84	92
ZR	179	186	173	179	185	180	183	181	169	177	186	186	174	178	182

NASM2/cont.

Var.\ID:	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2
SIO2	52.88	52.68	52.74	52.86	52.61	52.52	52.54	52.50	52.54	52.37	52.40	52.44	52.34	52.50	52.19
AL2O3	13.60	13.55	13.67	13.60	13.45	13.49	13.49	13.49	13.49	13.54	13.51	13.54	13.49	13.58	13.51
TIO2	0.67	0.66	0.67	0.67	0.64	0.66	0.67	0.66	0.66	0.66	0.67	0.66	0.66	0.67	0.66
FE2O3	5.25	5.21	5.29	5.24	5.10	5.28	5.27	5.27	5.25	5.26	5.26	5.29	5.29	5.28	5.27
MGO	3.36	3.30	3.32	3.38	3.19	3.25	3.22	3.23	3.25	3.18	3.25	3.26	3.30	3.22	3.31
CAO	4.75	4.74	4.75	4.77	4.75	4.76	4.77	4.75	4.74	4.73	4.74	4.74	4.75	4.74	4.70
NA2O	3.27	3.28	3.25	3.33	3.29	3.34	3.30	3.29	3.28	3.27	3.26	3.24	3.33	3.28	3.23
K2O	2.03	2.02	2.01	2.01	2.02	2.01	2.01	2.01	2.01	2.00	2.03	2.02	2.02	2.01	2.01
MNO	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10
P2O5	0.24	0.23	0.24	0.24	0.24	0.25	0.25	0.25	0.24	0.24	0.24	0.24	0.25	0.25	0.25
BA	950	949	972	988	942	980	986	963	991	964	977	977	979	988	971
CO	44	38	46	43	42	17	47	43	39	40	41	39	41	41	43
CR	83	76	77	80	79	83	85	82	80	77	89	81	85	80	83
CU	59	59	61	61	55	60	61	61	58	57	58	60	60	60	58
GA	52	52	53	52	52	55	53	55	53	54	53	55	54	53	54
NI	63	65	62	62	57	64	65	63	64	64	60	65	61	63	62
PB	45	42	46	43	43	54	58	51	51	50	51	53	55	50	52
RB	84	83	89	85	90	89	88	88	89	89	89	88	88	89	88
SC	13	13	12	12	9	8	11	13	14	12	13	11	10	11	10
SR	747	729	800	752	809	803	800	802	802	802	797	798	793	797	798
V	103	102	103	104	103	104	106	100	102	107	100	105	105	106	104
Y	73	71	75	72	65	75	76	72	73	73	71	74	75	74	73
ZN	86	84	91	86	86	94	99	95	92	94	94	94	97	95	88
ZR	175	173	185	174	164	182	186	184	180	183	181	192	184	186	179

Var.\ID:	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2	'Mon2
SIO2	52.13	52.21	52.44	52.36	52.43	52.41	52.42	52.48	52.48	52.31	52.51	52.40	52.48	52.42	52.55
AL2O3	13.45	13.52	13.45	13.48	13.48	13.52	13.52	13.44	13.52	13.52	13.47	13.43	13.49	13.47	13.46
TIO2	0.65	0.65	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.66	0.66	0.67	0.64
FE2O3	5.16	5.29	5.31	5.32	5.28	5.30	5.30	5.30	5.29	5.28	5.28	5.17	5.19	5.26	5.05
MGO	3.27	3.33	3.25	3.28	3.27	3.25	3.24	3.24	3.29	3.24	3.27	3.23	3.27	3.25	3.24
CAO	4.69	4.73	4.70	4.71	4.71	4.70	4.71	4.71	4.69	4.71	4.73	4.70	4.70	4.71	4.72
NA2O	3.33	3.34	3.33	3.34	3.28	3.29	3.31	3.32	3.37	3.24	3.32	3.29	3.29	3.33	3.30
K2O	2.00	1.99	2.01	2.01	2.01	1.99	2.01	2.01	2.01	1.99	2.01	1.98	2.00	2.00	2.02
MNO	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.09	0.10	0.10	0.09
P2O5	0.24	0.24	0.25	0.24	0.25	0.24	0.25	0.25	0.24	0.24	0.25	0.25	0.24	0.25	0.25
BA	944	954	975	999	988	967	982	990	961	985	964	953	957	972	949
CO	40	42	42	41	45	42	45	45	42	38	43	44	43	42	44
CR	83	83	80	81	78	78	81	79	80	74	79	80	81	79	74
CU	54	61	60	61	61	62	63	61	61	61	63	60	62	63	62
GA	51	55	51	52	53	51	52	52	51	55	51	53	53	52	52
NI	59	65	61	64	61	64	64	58	65	62	62	64	65	64	68
PB	46	53	47	46	47	47	48	46	45	48	48	45	46	42	47
RB	89	86	87	88	85	87	87	87	88	87	87	88	89	89	87
SC	10	11	9	13	15	11	12	13	10	10	10	11	8	7	11
SR	793	792	805	809	812	806	816	808	809	812	808	808	811	807	810
V	103	106	105	98	111	100	101	102	101	105	106	101	106	109	100
Y	67	73	76	74	75	73	75	74	73	70	71	67	67	72	63
ZN	88	92	95	92	93	91	92	93	90	93	92	91	91	90	93
ZR	167	182	177	176	177	179	182	176	180	181	177	175	180	183	178

Var.\ID:	NASM2/cont. 'Mon2	'Mon2	NASM2 'Mon2	NASM3 'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3
SIO2	52.43	52.46	52.50	53.18	52.94	53.00	52.89	52.30	52.03	52.64	51.52	52.29	52.81	52.34	53.29
AL2O3	13.50	13.47	13.51	13.38	13.33	13.32	13.29	13.28	13.27	13.40	13.17	13.41	13.37	13.30	13.48
TIO2	0.65	0.67	0.67	0.62	0.64	0.64	0.64	0.64	0.65	0.65	0.63	0.65	0.62	0.61	0.63
FE2O3	5.04	5.31	5.30	5.12	5.24	5.26	5.24	5.36	5.39	5.33	5.19	5.24	5.10	4.97	5.25
MGO	3.21	3.27	3.31	3.18	3.17	3.14	3.16	3.12	3.12	3.13	3.12	3.13	3.16	3.13	3.19
CAO	4.71	4.71	4.70	4.70	4.73	4.71	4.68	4.68	4.69	4.73	4.65	4.74	4.69	4.70	4.72
NA2O	3.31	3.31	3.41	3.28	3.30	3.31	3.33	3.27	3.28	3.26	3.23	3.29	3.24	3.29	3.34
K2O	2.00	2.02	2.00	2.06	2.06	2.05	2.05	1.97	1.97	2.00	1.94	1.96	2.03	1.97	2.06
MNO	0.10	0.09	0.10	0.09	0.10	0.09	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09
P2O5	0.24	0.25	0.25	0.25	0.26	0.26	0.25	0.25	0.25	0.26	0.25	0.25	0.26	0.25	0.25
BA	928	965	978	957	978	954	990	1000	982	1012	976	965	990	943	965
CO	43	41	42	38	44	46	42	39	42	43	45	39	43	43	48
CR	79	79	79	80	80	80	79	85	79	87	82	82	79	75	76
CU	61	62	61	59	63	58	60	63	62	61	60	58	58	56	60
GA	52	53	52	51	54	52	51	52	52	53	53	53	53	51	53
NI	62	64	61	64	63	63	65	67	66	67	63	66	63	63	65
PB	44	45	49	49	48	49	48	48	48	51	49	48	46	47	54
RB	89	89	86	88	88	89	89	90	90	90	89	88	86	89	89
SC	14	10	10	10	10	13	14	9	11	13	12	11	12	14	9
SR	805	806	808	788	811	803	802	812	824	809	791	793	782	769	810
V	109	102	104	114	103	110	112	108	103	105	107	107	109	109	104
Y	63	74	75	71	74	72	74	73	75	74	72	73	71	71	74
ZN	90	92	91	95	93	91	95	95	94	93	92	93	90	92	95
ZR	177	184	179	170	178	174	177	180	181	185	169	178	168	163	173

Var.\ID:	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3
SIO2	52.47	52.75	52.32	52.39	52.42	52.36	52.39	52.11	52.03	52.06	52.45	52.21	52.46	52.48	52.53
AL2O3	13.43	13.48	13.36	13.38	13.29	13.43	13.37	13.36	13.30	13.28	13.37	13.32	13.36	13.40	13.32
TIO2	0.64	0.65	0.65	0.64	0.64	0.65	0.65	0.64	0.64	0.65	0.64	0.64	0.65	0.64	0.64
FE2O3	5.29	5.25	5.27	5.25	5.27	5.26	5.25	5.28	5.27	5.24	5.24	5.22	5.25	5.27	5.28
MGO	3.28	3.25	3.19	3.14	3.22	3.24	3.15	3.19	3.20	3.21	3.24	3.15	3.20	3.22	3.23
CAO	4.69	4.69	4.68	4.66	4.68	4.68	4.68	4.66	4.67	4.69	4.68	4.66	4.69	4.67	4.68
NA2O	3.26	3.20	3.29	3.28	3.27	3.28	3.27	3.27	3.26	3.27	3.17	3.29	3.26	3.28	3.21
K2O	2.01	2.00	1.99	1.97	1.99	1.98	2.01	1.97	1.97	1.96	1.99	2.00	2.02	2.00	2.00
MNO	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.10	0.09	0.09	0.09	0.10	0.09	0.10	0.10
P2O5	0.24	0.25	0.24	0.24	0.25	0.24	0.25	0.25	0.24	0.24	0.24	0.25	0.25	0.25	0.25
BA	969	994	980	961	987	974	962	972	998	985	972	985	945	976	983
CO	45	40	41	40	46	39	46	41	43	47	42	43	38	43	42
CR	85	82	75	82	83	85	85	86	83	80	85	84	81	81	81
CU	60	58	61	60	60	59	59	62	60	59	57	61	60	60	60
GA	55	56	53	55	54	51	53	51	52	56	54	56	51	52	52
NI	62	60	64	60	64	61	64	64	60	62	62	62	61	61	61
PB	54	52	52	49	52	49	51	51	53	52	41	51	51	51	48
RB	91	96	85	91	89	85	92	90	86	93	85	93	89	83	86
SC	8	13	11	11	14	14	14	14	10	12	11	13	14	11	11
SR	818	825	789	812	811	788	809	805	797	811	785	819	803	793	787
V	102	103	104	102	103	105	105	107	104	102	102	108	107	105	102
Y	72	76	68	74	73	69	73	71	69	73	68	73	71	72	69
ZN	94	96	93	92	93	89	93	95	90	95	92	95	97	94	89
ZR	186	188	184	185	181	178	186	184	180	187	176	189	182	185	182

Var.\ID:	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3
SIO2	52.42	52.58	52.48	52.38	52.35	52.33	51.96	52.32	52.14	52.19	52.48	52.26	52.58	52.55	52.15
AL2O3	13.36	13.36	13.37	13.36	13.34	13.39	13.31	13.32	13.34	13.34	13.37	13.35	13.35	13.41	13.32
TIO2	0.65	0.65	0.65	0.65	0.66	0.65	0.65	0.66	0.65	0.65	0.65	0.65	0.65	0.63	0.64
FE2O3	5.28	5.27	5.26	5.29	5.30	5.31	5.30	5.29	5.30	5.29	5.26	5.28	5.29	5.19	5.18
MGO	3.17	3.22	3.13	3.18	3.21	3.21	3.16	3.16	3.15	3.13	3.24	3.16	3.20	3.17	3.18
CAO	4.68	4.70	4.69	4.68	4.68	4.69	4.67	4.66	4.68	4.67	4.68	4.67	4.69	4.68	4.67
NA2O	3.24	3.18	3.20	3.27	3.24	3.29	3.33	3.29	3.23	3.26	3.27	3.30	3.32	3.28	3.18
K2O	2.00	2.00	1.99	2.00	1.99	1.98	1.96	1.99	1.98	1.99	2.01	1.98	2.02	2.00	1.99
MNO	0.10	0.10	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.09	0.09
P2O5	0.25	0.25	0.24	0.24	0.25	0.25	0.24	0.24	0.24	0.25	0.24	0.25	0.25	0.25	0.25
BA	969	985	956	968	981	950	984	965	979	970	942	961	952	940	942
CO	45	43	45	44	45	44	44	41	44	39	41	43	43	40	41
CR	82	88	81	78	83	86	81	85	76	82	80	80	85	86	86
CU	62	59	59	60	62	60	60	61	61	63	59	60	59	60	58
GA	54	54	55	55	54	53	52	50	53	53	49	51	50	49	46
NI	62	63	62	60	66	64	65	66	64	64	65	64	62	63	64
PB	57	57	55	52	52	51	54	55	53	54	49	54	52	48	45
RB	95	96	98	94	91	91	93	79	88	87	78	82	84	74	71
SC	10	12	12	11	7	14	12	7	13	10	13	13	14	11	13
SR	856	846	852	849	853	843	832	790	830	818	769	801	809	739	728
V	105	101	106	107	107	98	102	101	108	108	103	101	104	104	105
Y	76	77	77	76	77	77	74	68	74	71	66	71	72	63	61
ZN	95	96	100	95	95	98	95	94	96	94	87	95	90	86	83
ZR	189	189	193	193	188	187	182	180	186	179	172	181	182	161	167

NASM3/cont.

Var.\ID:	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3	'Mon3
SIO2	52.52	52.69	52.65	52.65	52.54	52.24	52.21	52.35	52.40	51.67	52.11	51.98	52.23	52.38	52.49
AL2O3	13.44	13.36	13.42	13.40	13.37	13.36	13.36	13.45	13.40	13.39	13.51	13.42	13.38	13.47	13.37
TIO2	0.65	0.66	0.65	0.66	0.65	0.65	0.66	0.65	0.65	0.63	0.62	0.62	0.63	0.63	0.64
FE2O3	5.26	5.30	5.22	5.24	5.28	5.22	5.30	5.27	5.22	5.23	5.20	5.27	5.29	5.25	5.28
MGO	3.21	3.16	3.19	3.17	3.18	3.17	3.15	3.19	3.16	3.10	3.18	3.16	3.18	3.16	3.17
CAO	4.69	4.68	4.67	4.68	4.69	4.67	4.67	4.69	4.68	4.63	4.65	4.64	4.68	4.68	4.68
NA2O	3.26	3.25	3.33	3.28	3.33	3.35	3.34	3.25	3.29	3.24	3.31	3.17	3.29	3.23	3.24
K2O	2.00	2.00	2.00	2.00	2.01	1.98	1.99	1.99	1.99	1.91	1.95	1.96	1.96	1.99	2.00
MNO	0.10	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.09	0.10	0.10	0.10	0.10
P2O5	0.25	0.25	0.24	0.25	0.25	0.24	0.25	0.24	0.25	0.24	0.25	0.24	0.24	0.25	0.25
BA	977	972	963	975	963	980	980	992	931	987	980	990	1000	982	992
CO	44	45	45	41	40	41	42	40	43	40	45	43	41	45	42
CR	82	79	84	83	81	85	86	82	85	80	84	81	84	84	82
CU	56	59	56	58	60	57	57	58	57	57	56	59	57	56	57
GA	53	49	46	47	50	52	50	51	48	59	62	57	58	55	54
NI	63	60	64	63	65	62	64	64	62	60	59	63	58	62	58
PB	45	45	41	40	45	42	44	44	43	49	50	49	49	49	47
RB	89	83	75	80	83	89	84	89	76	104	107	99	95	91	93
SC	14	8	10	10	14	14	15	15	10	10	10	9	9	8	9
SR	831	801	759	776	791	828	801	820	757	873	887	868	849	824	827
V	111	101	107	102	102	109	106	107	103	106	105	105	102	108	106
Y	76	71	65	63	71	77	68	75	65	85	83	80	81	74	75
ZN	99	92	88	91	89	95	95	98	91	74	101	97	95	93	92
ZR	184	176	167	169	176	181	178	184	168	186	194	191	187	187	183

			NASM3	NASM4											
Var.\ID:	'Mon3	'Mon3	'Mon3	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4
SIO2	52.70	52.58	52.72	52.98	52.91	52.97	52.99	53.13	53.16	53.26	53.14	53.19	53.16	53.15	53.15
AL2O3	13.51	13.41	13.43	13.79	13.72	13.78	13.85	13.83	13.89	13.88	13.74	13.77	13.78	13.84	13.75
TIO2	0.64	0.63	0.64	0.63	0.63	0.64	0.64	0.65	0.65	0.63	0.63	0.64	0.65	0.63	0.63
FE2O3	5.27	5.25	5.24	5.21	5.22	5.21	5.18	5.22	5.22	5.24	5.24	5.24	5.24	5.24	5.25
MGO	3.21	3.22	3.22	3.46	3.47	3.42	3.47	3.47	3.50	3.48	3.47	3.48	3.49	3.51	3.49
CAO	4.70	4.70	4.69	4.78	4.78	4.75	4.76	4.75	4.78	4.79	4.77	4.77	4.79	4.78	4.79
NA2O	3.29	3.34	3.29	3.38	3.41	3.35	3.27	3.26	3.37	3.37	3.38	3.40	3.31	3.29	3.36
K2O	2.01	2.02	2.01	2.02	2.01	2.03	2.03	2.03	2.03	2.04	2.04	2.03	2.03	2.02	2.01
MNO	0.09	0.10	0.09	0.09	0.09	0.10	0.09	0.10	0.10	0.09	0.10	0.10	0.10	0.09	0.10
P2O5	0.24	0.25	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.23
BA	968	963	976	1012	978	955	961	966	969	974	981	987	949	973	1033
CO	45	42	37	39	40	42	44	40	46	41	40	42	42	37	38
CR	85	85	86	86	82	84	78	76	83	86	82	88	84	79	83
CU	56	54	57	60	65	65	67	64	64	65	64	64	62	62	60
GA	56	56	53	54	54	55	55	56	55	57	55	56	55	54	60
NI	61	63	62	61	65	65	64	63	64	63	61	61	62	61	61
PB	47	50	46	46	48	46	47	46	48	51	48	45	48	49	50
RB	95	90	87	84	87	90	88	87	87	88	88	87	88	89	89
SC	10	9	9	9	12	5	12	10	11	10	12	7	12	8	9
SR	847	821	809	760	804	809	809	805	805	804	788	803	802	785	779
V	104	104	105	99	103	105	100	107	100	101	102	104	102	109	108
Y	79	75	72	70	75	74	74	74	74	74	74	74	74	72	71
ZN	95	92	92	89	89	92	92	94	90	93	95	94	92	92	90
ZR	184	178	175	165	182	176	181	179	177	182	175	180	178	173	167

Var.\ID:	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4
SIO2	53.17	53.22	53.25	53.20	53.31	53.20	53.21	53.10	53.26	53.21	53.12	53.32	53.20	53.13	53.16
AL2O3	13.78	13.71	13.82	13.82	13.83	13.83	13.85	13.85	13.79	13.84	13.78	13.84	13.84	13.82	13.82
TIO2	0.64	0.63	0.64	0.64	0.64	0.65	0.65	0.64	0.64	0.64	0.63	0.63	0.64	0.64	0.65
FE2O3	5.23	5.25	5.26	5.23	5.24	5.21	5.22	5.22	5.23	5.23	5.22	5.22	5.24	5.23	5.23
MGO	3.45	3.48	3.45	3.46	3.47	3.48	3.50	3.48	3.44	3.47	3.46	3.49	3.53	3.44	3.47
CAO	4.78	4.78	4.80	4.79	4.78	4.77	4.78	4.78	4.79	4.78	4.77	4.78	4.78	4.76	4.78
NA2O	3.31	3.37	3.29	3.24	3.36	3.34	3.26	3.26	3.23	3.42	3.42	3.32	3.30	3.31	3.32
K2O	2.02	2.02	2.05	2.02	2.04	2.04	2.04	2.02	2.03	2.01	2.03	2.04	2.04	2.02	2.01
MNO	0.09	0.09	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.10
P2O5	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.23	0.24	0.24	0.23	0.23	0.24	0.24	0.24
BA	1028	1024	1010	1016	999	998	995	978	1021	1021	983	977	992	992	977
CO	41	44	44	43	42	43	42	41	42	43	43	42	46	39	37
CR	86	85	87	83	80	88	84	80	84	89	77	82	79	80	80
CU	58	61	62	66	63	63	66	66	63	64	66	65	64	64	63
GA	58	59	61	61	61	61	61	62	60	61	55	55	55	56	56
NI	59	63	63	65	63	59	63	63	64	61	60	62	61	61	61
PB	49	50	50	49	50	48	50	51	53	50	50	51	47	52	50
RB	85	88	89	89	88	89	88	87	90	89	89	87	89	88	90
SC	10	13	10	10	11	9	12	9	8	15	11	11	18	12	10
SR	764	790	791	802	801	807	806	799	805	807	798	797	795	789	804
V	109	108	111	112	100	104	110	107	103	103	100	101	103	102	103
Y	72	74	75	73	74	73	76	75	73	73	74	75	71	73	73
ZN	88	94	92	92	92	94	92	89	96	94	94	93	96	92	94
ZR	172	173	179	171	177	182	178	180	180	179	180	178	176	179	178

NASM4/cont.

Var.\ID:	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4	'Mon4
SIO2	53.16	53.26	53.16	53.17	53.17	53.21	53.15	53.11	53.29	53.18	53.18	53.12	53.16	53.04	52.90
AL2O3	13.75	13.81	13.85	13.79	13.85	13.84	13.92	13.90	13.91	13.90	13.84	13.95	13.90	13.86	13.84
TIO2	0.64	0.63	0.63	0.64	0.63	0.64	0.65	0.64	0.66	0.64	0.66	0.65	0.65	0.65	0.65
FE2O3	5.24	5.23	5.22	5.24	5.23	5.24	5.24	5.24	5.26	5.26	5.23	5.23	5.25	5.25	5.25
MGO	3.45	3.44	3.45	3.49	3.48	3.46	3.47	3.51	3.51	3.49	3.48	3.40	3.48	3.42	3.46
CAO	4.76	4.78	4.76	4.79	4.78	4.78	4.76	4.77	4.78	4.78	4.76	4.78	4.78	4.76	4.74
NA2O	3.37	3.31	3.32	3.31	3.32	3.35	3.28	3.29	3.29	3.32	3.26	3.21	3.30	3.26	3.24
K2O	2.03	2.03	2.02	2.02	2.01	2.03	2.04	2.03	2.04	2.04	2.02	2.01	2.02	2.03	2.02
MNO	0.09	0.10	0.09	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
P2O5	0.23	0.24	0.24	0.24	0.24	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
BA	1003	995	1023	1004	983	995	982	984	973	995	950	953	1003	975	970
CO	44	41	45	42	42	39	47	43	46	43	43	44	40	46	43
CR	82	80	83	82	80	84	83	78	78	82	81	81	82	82	85
CU	64	63	63	62	64	67	68	71	70	69	73	68	69	73	70
GA	55	55	54	54	55	55	56	57	57	57	58	56	55	59	58
NI	61	61	58	60	62	61	60	65	65	61	64	63	61	61	65
PB	45	47	51	47	49	49	53	50	52	49	49	51	53	49	51
RB	87	86	84	88	86	84	91	91	89	91	92	90	89	93	90
SC	5	11	11	13	13	12	11	12	12	9	9	11	12	9	9
SR	783	786	777	783	780	778	824	827	832	828	836	814	810	838	825
V	100	104	101	106	99	104	104	107	104	100.	100	99	107	105	103
Y	72	71	74	71	72	73	78	78	78	76	78	76	76	79	76
ZN	95	89	92	91	91	88	91	90	89	92	90	87	92	90	89
ZR	175	176	178	177	173	175	184	189	189	186	186	183	186	188	186

Var.\ID:	'Mon4	'Mon4	NASM4 'Mon4
SIO2	53.10	53.00	53.09
AL2O3	13.81	13.80	13.94
TIO2	0.66	0.65	0.66
FE2O3	5.26	5.24	5.25
MGO	3.51	3.42	3.45
CAO	4.75	4.76	4.76
NA2O	3.27	3.24	3.24
K2O	2.02	2.01	2.04
MNO	0.09	0.10	0.09
P2O5	0.24	0.24	0.23
BA	955	972	945
CO	43	44	47
CR	80	80	80
CU	73	69	75
GA	58	59	59
NI	63	62	63
PB	52	54	50
RB	92	91	94
SC	13	9	12
SR	841	850	850
V	97	96	106
Y	77	79	77
ZN	91	93	93
ZR	194	187	193

	NAS50												
Var.\ID:	S-1226A	S-1226B	S-1226C	S-1226D	S-1227	S-1228	S-1229	S-1230A	S-1230B	S-1230C	S-1230D	S-1231	S-1232
SI02	55.88	54.54	55.02	55.19	55.46	55.01	55.99	53.37	53.29	53.86	54.29	55.83	56.62
AL203	18.91	17.92	18.19	18.44	17.21	16.29	17.37	18.48	18.46	18.80	19.10	19.58	18.13
TI02	1.88	1.87	1.86	1.88	1.97	1.76	1.98	2.22	2.24	2.24	2.27	2.61	1.91
FE203	11.62	11.36	11.41	11.62	11.01	10.12	11.09	12.65	12.40	12.47	12.65	12.57	11.08
MGO	3.31	3.69	3.52	3.41	4.01	4.27	4.18	4.25	4.20	4.01	3.85	3.21	3.30
CAO	5.68	5.44	5.48	5.54	5.75	5.25	6.16	5.10	5.10	5.20	5.27	4.42	5.17
NA20	0.25	0.27	0.35	0.32	0.38	0.36	0.46	0.53	0.54	0.51	0.48	0.51	0.39
K20	1.57	1.60	1.59	1.58	1.59	1.78	1.66	2.88	2.88	2.86	2.84	4.15	2.34
MNO	0.20	0.20	0.20	0.20	0.21	0.21	0.22	0.19	0.19	0.19	0.19	0.17	0.18
P205	0.45	0.46	0.45	0.45	0.47	0.49	0.47	0.47	0.48	0.47	0.47	0.46	0.40
BA	204	208	201	216	187	220	180	164	174	136	172	152	199
CO	39	33	34	35	37	35	38	40	45	44	41	45	35
CR	172	164	176	168	185	187	198	243	243	256	249	196	181
CU	52	46	48	46	49	41	41	38	39	37	38	42	40
GA	23	22	24	22	21	20	21	22	21	21	23	25	22
NI	76	75	76	79	86	81	87	87	89	87	91	75	70
PB	17	21	23	22	21	23	22	18	15	15	18	20	20
RB	45	47	47	47	45	55	49	58	59	60	62	62	56
SC	33	35	39	39	36	32	35	37	47	40	41	45	36
SR	96	93	95	93	88	93	103	90	88	89	87	66	101
V	169	161	167	164	173	153	164	196	193	206	194	220	167
Y	28	25	27	27	28	25	27	23	23	21	22	22	22
ZN	181	181	183	186	174	155	173	274	276	276	273	299	191
ZR	178	175	183	176	177	188	185	138	140	140	144	155	186

Var.\ID:	S-1233	S-1234A	S-1234B	S-1234C	S-1234D	S-1235	S-1236	S-1237	S-1238A	S-1238B	S-1238C	S-1238D	S-1239
SI02	56.23	54.73	54.50	54.50	53.98	55.67	52.98	51.89	53.37	53.13	54.23	53.00	52.47
AL203	18.12	19.23	19.13	19.14	18.78	18.13	15.77	16.65	16.08	16.02	16.73	16.14	16.95
TI02	1.98	2.27	2.29	2.30	2.26	1.94	2.08	2.23	2.13	2.15	2.15	2.15	2.13
FE203	11.28	12.90	12.82	12.85	12.78	11.64	11.47	12.51	11.29	11.27	11.52	11.17	12.34
MGO	3.76	3.34	3.42	3.43	3.54	3.95	5.59	5.11	4.68	4.71	4.38	4.58	4.99
CAO	4.89	5.64	5.66	5.65	5.55	4.97	6.55	6.24	5.67	5.67	5.84	5.64	6.43
NA20	0.53	0.37	0.33	0.35	0.40	0.37	0.65	0.37	0.51	0.50	0.44	0.46	0.48
K20	2.75	2.38	2.35	2.37	2.38	2.66	1.73	2.07	1.93	1.92	1.89	1.92	1.97
MNO	0.19	0.17	0.18	0.18	0.18	0.19	0.23	0.21	0.22	0.22	0.22	0.22	0.22
P205	0.43	0.43	0.43	0.44	0.44	0.44	0.46	0.48	0.53	0.54	0.54	0.54	0.48
BA	166	181	212	192	199	219	190	155	182	187	196	185	165
CO	36	36	47	47	40	37	41	42	34	38	35	34	46
CR	199	239	229	228	228	217	235	272	211	205	211	227	234
CU	39	38	40	41	38	35	32	27	38	37	39	36	36
GA	23	24	23	20	22	21	20	23	22	20	19	19	22
NI	72	89	90	93	89	80	96	92	88	90	88	88	91
PB	22	20	21	23	24	21	15	18	19	19	19	21	21
RB	60	56	56	56	55	54	46	56	51	50	51	49	50
SC	36	41	36	45	41	35	38	43	37	34	34	34	38
SR	88	100	97	96	96	81	111	119	95	95	97	98	109
V	174	203	194	197	196	174	188	221	182	181	177	183	203
Y	26	21	20	22	21	22	22	22	22	23	23	25	24
ZN	235	253	245	249	248	212	205	251	193	198	193	196	220
ZR	177	169	160	162	160	158	159	137	172	183	174	175	152

		NAS50	NAS50Z									NAS50Z	NAS51
Var.\ID:	S-1240	S-1241	S-1226Z	S-1226Z	S-1226Z	S-1226Z	S-1226Z	S-1226Z	S-1226Z	S-1226Z	S-1226Z	S-1226Z	S-1242A
SI02	55.30	54.85	55.91	56.10	56.11	56.22	56.22	56.33	56.33	56.32	56.26	56.35	55.28
AL203	16.36	16.96	18.84	18.88	18.85	18.91	18.94	18.96	18.89	18.91	18.92	18.98	15.97
TI02	1.95	1.84	1.82	1.81	1.82	1.82	1.82	1.82	1.81	1.81	1.80	1.80	1.94
FE203	10.97	12.18	11.62	11.59	11.55	11.58	11.70	11.69	11.62	11.55	11.57	11.66	7.91
MGO	5.05	6.33	3.45	3.45	3.54	3.48	3.34	3.31	3.39	3.42	3.46	3.35	4.56
CAO	6.03	6.48	5.66	5.68	5.71	5.68	5.70	5.68	5.66	5.74	5.70	5.71	6.81
NA20	0.32	0.10	0.26	0.22	0.23	0.27	0.22	0.27	0.27	0.18	0.22	0.19	0.92
K20	2.01	3.18	1.57	1.57	1.57	1.57	1.56	1.57	1.58	1.56	1.57	1.56	0.79
MNO	0.23	0.20	0.20	0.20	0.20	0.20	0.19	0.19	0.20	0.20	0.20	0.19	0.17
P205	0.56	0.45	0.45	0.45	0.45	0.44	0.45	0.44	0.44	0.44	0.44	0.44	0.31
BA	213	109	215	212	225	195	202	207	210	215	196	223	126
CO	45	41	35	39	33	40	40	43	36	31	36	42	34
CR	215	252	177	173	172	174	177	178	175	180	176	179	307
CU	41	30	47	46	48	48	49	47	49	48	46	49	41
GA	20	23	19	19	18	19	21	20	20	21	20	18	15
NI	92	91	73	75	75	75	76	77	75	76	77	77	104
PB	24	17	20	17	20	18	16	17	23	16	20	22	15
RB	51	94	46	45	48	45	46	45	46	44	47	47	29
SC	35	38	36	38	37	35	31	43	35	31	36	37	40
SR	99	140	96	96	95	98	94	96	94	94	95	93	136
V	177	213	164	162	163	167	161	169	162	169	165	161	141
Y	24	21	26	26	26	27	26	26	27	28	27	24	23
ZN	184	273	186	185	187	189	183	187	187	186	186	186	74
ZR	175	120	176	176	182	179	173	181	178	182	185	176	183

NAS51/cont.

Var.\ID:	S-1242B	S-1242C	S-1242D	S-1243	S-1244	S-1245	S-1246A	S-1246B	S-1246C	S-1246D	S-1247	S-1248	S-1249
SIO2	57.49	56.25	57.50	54.83	55.88	55.48	57.36	56.95	55.00	56.15	55.31	56.10	55.57
AL203	17.27	16.85	17.36	16.00	16.90	16.62	17.20	17.16	15.98	16.67	16.53	16.35	16.42
TIO2	1.77	1.95	1.79	2.03	1.90	2.27	1.77	1.82	1.94	1.82	2.15	2.18	2.48
FE203	8.40	8.34	8.49	8.14	8.77	9.22	8.61	8.52	8.12	8.32	8.52	8.79	8.74
MGO	4.34	4.30	4.36	4.77	5.10	4.94	4.51	4.50	4.72	4.67	4.20	4.52	3.98
CAO	7.07	7.04	7.11	6.98	7.45	7.36	7.19	7.21	6.98	7.05	7.16	7.43	7.37
NA20	0.71	0.78	0.80	1.04	1.00	1.19	0.88	0.84	0.95	0.94	1.05	0.98	1.04
K20	0.75	0.75	0.73	0.85	0.74	0.77	0.74	0.75	0.80	0.76	0.75	0.73	0.75
MNO	0.16	0.17	0.16	0.17	0.17	0.18	0.16	0.16	0.17	0.17	0.16	0.18	0.17
P205	0.28	0.31	0.28	0.31	0.29	0.30	0.27	0.28	0.30	0.28	0.33	0.33	0.32
BA	140	114	144	98	95	91	106	125	110	119	103	113	108
CO	34	38	35	40	38	36	39	39	42	38	49	40	41
CR	321	315	322	312	332	331	336	336	329	323	321	331	350
CU	42	40	44	42	44	46	44	44	41	43	36	40	40
GA	15	14	15	15	15	15	16	16	16	16	17	16	15
NI	109	105	107	107	115	115	109	113	111	107	103	102	104
PB	15	25	17	17	14	20	15	15	19	13	18	21	19
RB	31	30	30	31	29	29	32	30	30	28	31	31	30
SC	44	41	41	38	44	40	41	42	45	43	44	38	43
SR	136	136	139	145	137	136	138	139	136	136	127	124	128
V	147	149	150	155	158	166	156	147	150	154	147	162	161
Y	24	22	24	22	21	25	22	23	21	22	23	22	22
ZN	79	73	77	73	78	83	74	74	69	70	73	72	68
ZR	186	190	183	180	170	183	184	182	174	180	188	190	195

Var.\ID:	S-1250A	S-1250B	S-1250C	S-1250D	S-1251	S-1252	S-1253	S-1254A	S-1254B	S-1254C	S-1254D	S-1255	S-1256
SIO2	57.18	56.86	56.85	57.09	55.37	55.25	56.02	55.74	53.45	53.84	55.83	55.51	56.10
AL203	16.80	16.76	16.67	16.76	15.63	15.73	16.25	16.95	15.87	15.85	17.02	16.18	17.14
TIO2	1.98	2.00	2.02	2.00	2.05	2.10	2.05	1.98	2.09	2.03	1.99	2.12	2.20
FE203	8.45	8.39	8.41	8.40	8.11	8.20	8.32	9.11	8.72	8.73	9.09	8.33	8.55
MGO	4.13	4.21	4.10	4.06	4.50	4.50	4.63	4.94	5.05	5.11	4.89	4.35	4.66
CAO	7.14	7.14	7.11	7.10	7.01	7.06	7.27	6.84	6.57	6.54	6.87	7.13	7.55
NA20	0.91	0.96	0.96	1.01	1.00	1.01	1.03	1.00	1.04	1.08	0.98	1.02	0.96
K20	0.77	0.79	0.78	0.78	0.78	0.78	0.75	0.81	0.86	0.86	0.83	0.78	0.71
MNO	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.18	0.18	0.17	0.17	0.19
P205	0.30	0.30	0.30	0.30	0.31	0.32	0.31	0.28	0.31	0.31	0.29	0.31	0.30
BA	105	111	114	102	109	112	118	103	91	95	98	106	96
CO	35	40	37	32	45	40	42	39	44	43	43	34	40
CR	314	310	313	306	318	313	322	328	318	314	321	304	324
CU	38	39	38	42	38	39	38	56	52	53	56	38	43
GA	15	14	15	15	17	14	15	16	17	17	18	14	16
NI	103	101	102	107	102	104	107	112	107	112	113	105	107
PB	19	19	19	17	21	23	18	28	27	28	26	16	16
RB	30	30	32	31	28	31	29	30	32	33	33	30	29
SC	38	41	41	41	35	35	44	40	38	46	42	44	42
SR	127	127	129	130	126	128	132	149	148	149	149	125	135
V	149	149	146	141	140	147	153	159	153	153	157	150	161
Y	23	25	24	25	25	23	22	23	23	23	22	24	22
ZN	71	72	70	69	72	73	72	98	93	95	101	72	71
ZR	197	196	194	204	192	194	187	190	188	194	195	193	178

	NAS51	NAS51Z									NAS51Z	NAS52	
Var.\ID:	S-1257	S-1242Z	S-1242Z	S-1242Z	S-1242Z	S-1242Z	S-1242Z	S-1242Z	S-1242Z	S-1242Z	S-1242Z	S-1258A	S-1258B
SIO2	56.14	55.32	55.52	55.54	55.45	55.53	55.47	55.63	55.60	55.68	55.65	60.81	59.89
AL203	16.68	15.97	16.05	16.05	16.05	16.05	16.04	16.03	16.05	16.01	16.07	8.02	7.88
TIO2	2.28	1.85	1.85	1.85	1.83	1.84	1.85	1.86	1.84	1.84	1.85	0.71	0.70
FE203	8.70	7.93	7.91	7.90	7.88	7.94	7.85	7.90	7.87	7.92	7.91	10.57	10.43
MGO	4.55	4.65	4.64	4.72	4.69	4.65	4.73	4.69	4.71	4.70	4.63	14.76	14.90
CAO	7.64	6.81	6.85	6.84	6.78	6.84	6.84	6.83	6.84	6.83	6.84	3.08	3.05
NA20	1.08	0.82	0.79	0.85	0.93	0.81	0.88	0.88	0.87	0.85	0.81	0.11	0.13
K20	0.70	0.78	0.78	0.79	0.79	0.80	0.80	0.79	0.79	0.79	0.79	1.12	1.12
MNO	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.31	0.32
P205	0.29	0.31	0.30	0.31	0.31	0.30	0.31	0.30	0.30	0.30	0.30	0.10	0.11
BA	94	125	113	133	118	133	110	123	122	108	136	269	285
CO	36	36	36	31	37	31	33	38	38	34	35	104	108
CR	339	314	309	312	311	310	308	312	315	311	312	1967	2003
CU	40	41	40	42	39	42	41	43	45	42	40	25	21
GA	17	14	14	15	15	15	14	14	15	14	14	10	12
NI	113	106	103	104	103	101	104	104	104	103	103	1777	1807
PB	14	14	13	17	17	15	17	17	14	13	15	14	13
RB	27	29	29	30	31	29	28	30	27	28	30	30	30
SC	39	36	40	45	37	40	34	42	43	41	41	23	27
SR	138	136	136	139	133	133	138	136	139	137	138	64	61
V	167	155	148	151	151	154	150	153	147	153	154	95	97
Y	23	23	20	22	21	22	22	21	22	22	22	18	17
ZN	70	73	73	70	73	74	73	77	73	71	70	72	68
ZR	186	186	183	187	185	186	184	186	185	188	183	179	170

Var.\ID:	NAS52/cont. S-1258C	S-1258D	S-1259	S-1260	S-1261	S-1262A	S-1262B	S-1262C	S-1262D	S-1263	S-1264	S-1265	S-1266A
SIO2	59.88	61.51	59.33	60.18	60.28	58.39	60.12	59.38	60.56	63.71	61.70	64.46	58.95
AL203	7.91	8.11	9.37	9.77	8.96	9.81	9.89	9.93	10.03	11.15	11.97	11.79	9.61
TIO2	0.69	0.72	0.71	0.78	0.77	0.64	0.65	0.65	0.65	0.92	0.85	0.96	0.65
FE203	10.72	10.70	10.56	11.40	9.40	13.28	13.64	13.44	13.50	9.13	11.00	8.07	12.96
MGO	14.87	14.80	12.16	9.69	12.08	10.22	10.37	10.28	10.51	7.04	6.55	6.43	9.90
CAO	3.02	3.12	2.89	2.68	3.08	2.30	2.43	2.40	2.48	3.28	3.17	3.34	2.46
NA2O	0.16	0.12	0.23	0.33	0.37	0.26	0.23	0.19	0.20	0.40	0.42	0.40	0.32
K2O	1.11	1.11	1.20	1.18	1.24	1.00	0.98	1.00	0.99	1.50	1.41	1.42	1.06
MNO	0.31	0.30	0.24	0.19	0.23	0.17	0.17	0.17	0.17	0.21	0.18	0.18	0.16
P205	0.10	0.08	0.11	0.09	0.10	0.07	0.05	0.06	0.04	0.10	0.09	0.09	0.06
BA	288	281	304	255	284	248	250	253	228	342	325	321	248
CO	107	107	81	65	68	73	78	80	77	59	58	48	83
CR	2001	1961	1657	1816	1678	2064	2095	2057	2084	1191	1233	1105	2112
CU	21	24	20	14	13	19	21	21	23	19	18	19	24
GA	9	10	9	10	9	10	11	12	11	13	13	12	11
NI	1798	1788	1315	1045	999	1753	1782	1767	1788	733	725	624	1621
PB	17	14	13	11	13	13	11	10	12	15	20	18	14
RB	30	30	38	37	36	35	33	35	34	47	45	44	32
SC	24	24	26	27	17	29	28	28	29	23	23	20	25
SR	61	63	70	65	78	58	57	58	58	84	82	79	61
V	92	92	87	89	87	86	84	85	88	110	105	88	89
Y	19	17	18	18	18	18	19	18	18	25	25	25	17
ZN	69	66	67	68	71	65	63	65	62	68	69	64	65
ZR	168	174	172	198	216	161	147	157	155	253	240	248	162

Var.\ID:	S-1266B	S-1266C	S-1266D	S-1267	S-1268	S-1269	S-1270A	S-1270B	S-1270C	S-1270D	S-1271	S-1272	NAS52 S-1273
SIO2	59.14	59.52	57.23	62.27	58.16	62.15	60.55	60.61	60.22	61.57	62.83	59.55	60.46
AL203	9.60	9.65	9.20	11.31	11.81	11.95	12.42	12.36	12.23	12.46	12.32	13.29	12.53
TIO2	0.66	0.63	0.65	0.92	0.96	0.90	0.82	0.85	0.85	0.86	0.86	0.89	0.93
FE203	12.86	13.12	12.55	8.90	10.78	10.08	12.40	12.34	12.07	12.52	10.45	10.17	9.68
MGO	9.97	9.88	9.95	6.71	8.30	7.21	6.04	6.06	6.06	6.02	5.66	6.34	7.45
CAO	2.50	2.52	2.30	3.30	3.88	3.41	3.06	3.08	3.02	3.14	3.20	3.58	3.94
NA2O	0.28	0.24	0.35	0.51	0.43	0.42	0.42	0.44	0.45	0.44	0.42	0.47	0.32
K2O	1.04	1.03	1.07	1.50	1.22	1.44	1.26	1.26	1.27	1.26	1.31	1.13	1.29
MNO	0.17	0.16	0.17	0.18	0.22	0.18	0.11	0.12	0.12	0.11	0.12	0.12	0.21
P205	0.06	0.05	0.09	0.10	0.14	0.09	0.06	0.07	0.07	0.05	0.07	0.10	0.13
BA	235	234	229	310	284	333	277	282	285	290	305	302	344
CO	83	78	80	58	77	59	45	47	44	42	41	42	59
CR	2128	2220	2098	1326	1652	1279	1577	1520	1515	1561	1135	1312	1101
CU	25	21	20	19	28	20	18	20	20	21	15	23	33
GA	10	12	10	13	13	13	12	13	14	13	11	14	15
NI	1639	1604	1576	606	834	721	842	845	838	853	537	646	671
PB	16	13	9	12	16	14	14	12	12	15	15	13	12
RB	34	32	32	44	37	45	42	39	41	42	43	39	38
SC	22	24	21	20	31	23	21	23	27	21	21	28	29
SR	61	57	57	84	94	77	76	74	74	75	74	73	65
V	85	87	87	104	133	107	112	111	111	109	104	106	126
Y	19	19	19	25	24	22	21	22	20	21	23	25	27
ZN	68	65	65	58	74	67	73	71	71	73	61	66	71
ZR	165	158	153	282	227	212	192	198	196	200	213	213	192

Var.\ID:	NAS52Z S-1258Z	S-1258Z	S-1258Z	S-1258Z	S-1258Z	S-1258Z	S-1258Z	S-1258Z	S-1258Z	NAS52Z S-1258Z	NAS53 S-1284A	S-1284B	S-1284C
SIO2	60.59	60.60	60.74	60.71	60.78	60.76	60.65	60.82	60.72	60.62	57.18	56.97	57.17
AL203	8.01	7.97	7.95	8.05	8.07	7.95	8.09	8.01	8.01	8.01	10.90	10.95	10.88
TIO2	0.68	0.68	0.69	0.69	0.69	0.69	0.68	0.68	0.69	0.69	0.87	0.86	0.84
FE203	10.49	10.47	10.53	10.59	10.60	10.51	10.61	10.60	10.58	10.61	9.39	9.52	9.47
MGO	14.60	14.71	14.69	14.62	14.63	14.74	14.60	14.73	14.73	14.72	9.28	9.26	9.14
CAO	3.06	3.05	3.06	3.06	3.07	3.08	3.07	3.06	3.09	3.05	3.68	3.64	3.61
NA2O	0.10	0.15	0.12	0.11	0.13	0.10	0.12	0.11	0.08	0.14	0.26	0.26	0.25
K2O	1.12	1.13	1.12	1.12	1.11	1.12	1.12	1.12	1.11	1.11	1.08	1.08	1.08
MNO	0.30	0.31	0.30	0.30	0.30	0.31	0.30	0.30	0.30	0.30	0.20	0.20	0.19
P205	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.10	0.10	0.24	0.24	0.23
BA	283	288	288	291	276	297	288	280	284	282	266	246	254
CO	111	104	106	107	102	112	103	106	105	110	73	70	69
CR	1974	1991	1999	2001	2003	2012	1986	1997	2010	2027	1634	1628	1606
CU	23	20	21	21	23	21	24	22	22	23	31	30	30
GA	10	10	9	9	9	8	10	9	10	9	10	9	7
NI	1771	1779	1794	1794	1803	1804	1791	1801	1815	1825	1189	1182	1179
PB	15	12	12	15	12	16	13	10	11	15	26	28	26
RB	31	31	32	31	31	31	33	32	32	34	35	36	36
SC	21	22	24	23	21	25	27	22	28	26	26	26	21
SR	64	63	64	65	65	66	65	65	65	66	87	89	87
V	92	101	98	93	99	99	101	99	95	96	72	73	70
Y	17	17	17	18	18	17	18	19	18	17	19	18	18
ZN	69	68	69	72	69	72	68	73	71	73	107	109	110
ZR	176	179	181	177	180	177	181	183	186	188	193	195	195

NAS53/cont.

Var.\ID:	S-1284D	S-1285	S-1286	S-1287	S-1288A	S-1288B	S-1288C	S-1288D	S-1289	S-1290	S-1291	S-1292A	S-1292B
SIO2	59.19	63.81	62.80	61.56	57.94	57.66	58.24	57.78	62.81	59.32	64.11	60.73	60.16
AL2O3	11.49	7.91	7.73	8.86	10.56	10.43	10.73	10.54	8.90	8.75	8.82	8.23	8.17
TIO2	0.87	0.88	0.88	0.82	1.16	1.25	1.21	1.23	0.94	0.93	0.90	0.85	0.86
FE2O3	9.76	5.74	7.08	8.07	10.40	10.32	10.43	10.38	7.16	10.15	7.51	10.55	10.27
MGO	9.23	11.05	10.47	8.97	10.66	10.79	10.56	10.64	10.02	11.46	9.70	11.45	11.38
CAO	3.90	3.78	3.67	3.53	3.87	3.90	3.89	3.89	3.81	3.94	3.70	3.65	3.58
NA2O	0.17	0.22	0.26	0.24	0.17	0.17	0.16	0.17	0.19	0.18	0.22	0.07	0.13
K2O	1.04	1.65	1.37	1.38	0.97	0.97	0.98	0.96	1.49	1.22	1.46	1.21	1.21
MNO	0.19	0.35	0.28	0.22	0.20	0.21	0.20	0.20	0.29	0.28	0.27	0.26	0.26
P2O5	0.21	0.23	0.21	0.21	0.18	0.19	0.18	0.19	0.24	0.20	0.20	0.18	0.19
BA	262	355	280	270	232	232	243	238	279	245	294	250	251
CO	70	106	102	74	81	84	87	81	128	129	96	118	124
CR	1649	1585	1736	1728	1570	1550	1574	1621	1831	2472	1738	2301	2350
CU	31	23	27	30	34	31	36	35	30	33	31	32	36
GA	11	9	9	11	10	11	12	10	9	10	9	8	10
NI	1213	727	877	998	1577	1559	1592	1562	934	1369	946	1574	1582
PB	24	28	29	31	29	28	26	25	28	28	32	29	29
RB	35	48	40	44	36	34	35	35	47	39	48	37	40
SC	24	21	16	19	26	25	24	23	19	25	20	24	23
SR	90	89	88	93	90	91	91	91	89	92	89	85	84
V	75	65	63	64	76	69	74	77	70	78	70	75	75
Y	20	21	21	20	19	20	21	20	20	20	20	19	18
ZN	114	95	102	105	120	119	121	119	106	130	111	128	127
ZR	199	263	249	251	206	206	214	210	262	221	265	224	219

												NAS53	NAS53Z
Var.\ID:	S-1292C	S-1292D	S-1293	S-1294	S-1295	S-1296A	S-1296B	S-1296C	S-1296D	S-1297	S-1298	S-1299	S-1284Z
SIO2	61.08	60.39	62.81	62.93	64.93	61.72	60.82	60.15	60.35	60.82	63.65	63.62	57.44
AL2O3	8.06	6.28	10.23	8.36	9.72	9.04	8.82	8.83	8.86	8.81	9.05	9.08	10.95
TIO2	0.86	0.83	0.87	0.90	0.90	0.81	0.83	0.82	0.83	1.01	0.88	0.88	0.86
FE2O3	10.48	10.54	9.51	8.08	8.08	9.98	9.88	9.85	9.90	8.81	7.80	7.87	9.44
MGO	11.62	11.55	7.83	10.14	7.79	9.89	10.03	10.19	10.14	9.40	7.89	8.43	9.38
CAO	3.64	3.64	3.44	3.84	3.53	3.58	3.52	3.56	3.55	3.68	3.38	3.59	3.71
NA2O	0.14	0.09	0.30	0.19	0.38	0.20	0.24	0.19	0.18	0.25	0.35	0.34	0.24
K2O	1.21	1.20	1.35	1.34	1.39	1.21	1.20	1.19	1.20	1.19	1.36	1.32	1.09
MNO	0.27	0.26	0.17	0.26	0.19	0.21	0.21	0.22	0.22	0.21	0.18	0.21	0.20
P2O5	0.18	0.18	0.17	0.22	0.17	0.16	0.17	0.18	0.18	0.25	0.18	0.18	0.23
BA	246	255	274	263	285	255	244	254	252	270	276	271	252
CO	119	120	78	103	68	93	95	95	91	88	66	88	74
CR	2352	2326	1782	1742	1676	2149	2170	2215	2148	1788	1678	1719	1633
CU	35	35	32	33	26	35	32	30	31	34	27	30	38
GA	10	9	11	11	9	11	9	9	8	9	9	9	9
NI	1578	1577	942	918	767	1337	1336	1309	1311	1038	749	841	1222
PB	29	25	29	30	29	32	29	28	26	32	34	25	26
RB	38	38	47	40	45	39	38	39	39	41	43	43	38
SC	24	25	20	20	21	20	22	20	19	20	14	17	23
SR	85	86	92	91	96	90	87	88	89	91	86	90	93
V	79	74	65	67	69	72	73	72	74	70	62	65	72
Y	18	19	22	21	20	22	22	19	20	21	20	21	19
ZN	129	123	109	113	104	118	114	114	114	116	98	99	114
ZR	221	223	259	261	276	237	236	228	230	249	275	268	213

									NAS53Z
Var.\ID:	S-1284Z	S-1284Z	S-1284Z	S-1284Z	S-1284Z	S-1284Z	S-1284Z	S-1284Z	S-1284Z
SIO2	57.56	57.53	57.68	57.63	57.61	57.65	57.65	57.70	57.70
AL2O3	11.01	11.01	10.98	11.03	11.01	10.96	11.05	11.05	11.05
TIO2	0.86	0.84	0.86	0.87	0.87	0.87	0.86	0.86	0.87
FE2O3	9.47	9.50	9.49	9.52	9.54	9.53	9.59	9.51	9.60
MGO	9.33	9.34	9.36	9.32	9.28	9.41	9.23	9.31	9.18
CAO	3.72	3.70	3.71	3.72	3.70	3.72	3.71	3.72	3.69
NA2O	0.21	0.21	0.22	0.25	0.25	0.23	0.24	0.25	0.28
K2O	1.07	1.08	1.09	1.08	1.08	1.08	1.09	1.09	1.08
MNO	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
P2O5	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.22	0.22
BA	250	256	241	238	255	242	238	232	256
CO	67	72	69	73	74	70	75	71	74
CR	1625	1621	1638	1631	1631	1639	1649	1622	1645
CU	37	36	36	37	36	36	39	36	41
GA	9	11	10	10	10	10	9	10	9
NI	1220	1228	1251	1233	1243	1247	1244	1251	1248
PB	24	26	27	26	24	26	26	22	23
RB	35	37	37	38	38	39	39	38	40
SC	27	24	24	27	26	24	23	29	23
SR	93	93	94	96	97	97	99	98	96
V	71	73	75	76	69	73	75	71	73
Y	20	20	19	19	19	19	20	21	19
ZN	112	116	112	113	116	115	115	118	116
ZR	211	214	221	215	219	224	219	224	223

Electron microprobe data

The data described in this Appendix are subdivided into two parts (opaque and silicate minerals) and were obtained at the Geology Department of Manchester University. The machine details were provided earlier in Appendix B. All the analyses show both Fe^{2+} and Fe^{3+} concentrations where necessary. These were recalculated by the program MPC (Appendix A).

The reference codes for the individual samples on which the analyses were made are listed immediately above the Identity code (ID). The latter code refers to the order in which analyses were carried out on the microprobe.

Major and trace element data from the Crousa gabbro

This shows the data from the group of samples which were originally collected for age determination.

ISO-1 ..... North of Coverack.
ISO-2 ..... Porthoustock.
ISO-3 ..... Dean Quarry towards Lowland Point.
ISO-4 ..... Dean Quarry.
ISO-5 ..... Dean Quarry.
ISO-6 ..... Dean Quarry.
ISO-7 ..... North of Coverack.
ISO-8 ..... North of Coverack.

Ilmenites

Var.\ID:	M81	M83	M84	M85	M90	M96	M16	M17	M19	M29	M39	M43	M44	M45	M48	M49	M64
*********	<---- ISO-2	---->		<---- ISO-5	---->		<------ BXA3040			------>	<-------------------			BXA3043			------------->
FEO	45.51	45.82	45.40	46.26	45.14	46.56	46.57	46.65	46.34	46.04	45.56	46.41	46.29	44.87	45.87	45.14	45.58
FE2O3	0.00	0.00	0.00	1.43	1.79	1.24	0.73	0.33	1.35	2.01	0.00	0.05	1.35	0.00	1.73	2.49	1.25
SIO2	0.34	0.47	0.50	0.36	0.37	0.37	0.28	0.24	0.32	0.42	0.29	0.29	0.39	0.51	0.00	0.24	0.23
AL2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MGO	0.41	0.41	0.00	0.00	0.30	0.00	0.00	0.00	0.33	0.67	0.60	0.37	0.00	0.00	0.31	0.37	0.68
V2O5	0.09	0.20	0.04	0.46	0.37	0.45	0.20	0.16	0.31	0.00	0.46	0.23	0.24	0.27	0.34	0.33	0.20
TIO2	53.15	52.59	54.61	51.83	50.82	51.97	52.32	52.44	52.33	52.87	51.85	52.57	51.68	51.85	52.42	51.35	52.56
NIO	0.08	0.01	0.01	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.06	0.00	0.05	0.00	0.03	0.02	0.00
COO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	0.04	0.06	0.07	0.02	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.00	0.02	0.00	0.00	0.00	0.00
MNO	1.57	1.42	1.78	1.48	1.03	1.29	1.12	1.04	0.99	0.79	1.01	0.89	0.97	1.46	1.20	1.16	1.05
CAO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	BXA3043	<--- BXA4055		--->
Var.\ID:	M65	M10	M12	M15
FE2	45.94	45.55	45.14	44.89
FE3	1.57	2.32	2.29	1.45
SIO2	0.31	0.33	0.33	0.32
AL2O3	0.00	0.00	0.00	0.00
MGO	0.74	0.85	1.06	1.23
V2O5	0.14	0.52	0.51	0.46
TIO2	52.92	51.61	51.92	51.82
NIO	0.04	0.03	0.07	0.01
COO	0.00	0.00	0.00	0.00
CR2O3	0.00	0.02	0.02	0.01
MNO	0.87	0.54	0.78	0.61
CAO	0.00	0.00	0.00	0.00

Magnetites

Var.\ID:	M94	M95	M97	M98	M100	M79	M20	M21	M24	M25	M26	M33	M34	M36	M37	M38	M40
**********	<----------	ISO-4		---------->		ISO-8	<----------		BXA3040		--------->	<------------		BXA3043			------------->
FEO	39.01	41.35	38.11	38.33	41.89	39.66	35.93	35.70	38.38	36.02	34.92	36.64	37.29	36.14	37.95	39.99	37.08
FE2O3	44.61	45.97	53.91	49.62	47.08	43.80	61.01	57.17	45.17	58.03	57.65	55.85	58.92	59.36	55.00	48.48	57.35
SIO2	0.35	0.39	0.44	0.42	0.32	0.55	0.29	0.79	4.05	0.35	0.70	0.47	0.47	0.24	0.54	0.91	0.36
AL2O3	3.80	2.21	0.38	0.74	0.00	1.31	0.77	0.68	3.73	0.79	0.64	4.54	0.87	0.81	3.84	2.94	1.14
MGO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.16	0.00	0.35	0.66	0.00	0.39	0.00	0.00	0.00
V2O5	2.01	2.12	2.04	1.80	1.72	1.28	2.26	2.33	1.91	2.51	2.44	2.39	2.44	2.45	2.47	2.19	2.42
TIO2	5.47	6.87	4.51	5.29	8.64	8.01	0.55	0.64	1.54	0.88	0.39	0.98	1.28	1.23	1.32	4.37	1.61
NIO	0.00	0.05	1.27	0.03	0.00	0.11	0.02	0.02	0.07	0.04	0.00	0.00	0.00	0.00	0.04	0.01	0.01
COO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	0.03	0.01	0.02	0.00	0.00	2.12	0.06	0.05	0.09	0.06	0.06	0.01	0.03	0.01	0.04	0.03	0.05
MNO	0.00	0.00	0.00	0.00	0.35	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	<------------------						BXA3043										------------------>
Var.\ID:	M41	M42	M46	M50	M51	M52	M58	M59	M60	M61	M62	M63	M67	M68	M69	M70	M71
FEO	36.92	37.61	36.32	36.00	35.74	35.76	36.71	35.63	36.91	36.06	36.66	36.33	36.63	36.52	36.45	35.56	36.06
FE2O3	57.47	53.43	59.52	60.13	59.90	60.00	56.44	55.78	55.68	59.06	57.50	59.42	58.76	59.04	59.67	60.51	59.78
SIO2	0.29	0.61	0.29	0.34	0.30	0.47	2.24	0.36	2.03	0.40	0.47	0.42	0.26	0.40	0.36	0.30	0.33
AL2O3	2.00	4.18	1.19	0.86	0.90	0.96	1.45	3.91	1.29	1.28	1.63	1.10	1.06	1.14	1.56	0.97	1.10
MGO	0.31	0.39	0.00	0.00	0.00	0.37	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00
V2O5	2.48	2.42	1.98	1.99	1.97	1.99	1.77	1.86	1.88	2.06	2.05	1.95	1.92	1.99	2.04	2.09	2.03
TIO2	1.46	1.76	1.39	1.11	1.12	1.20	0.48	1.02	0.51	1.05	1.60	1.34	1.97	1.49	1.11	0.95	1.09
NIO	0.03	0.02	0.00	0.00	0.04	0.05	0.00	0.05	0.05	0.00	0.02	0.02	0.05	0.00	0.00	0.00	0.00
COO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	0.09	0.03	0.04	0.03	0.04	0.03	0.04	0.00	0.08	0.03	0.05	0.09	0.08	0.01	0.03	0.09	0.06
MNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	<--- BXA3043		--->	<------ BXA4055			------>
Var.\ID:	M72	M76	M77	M9	M11	M13	M14
FEO	36.02	38.19	36.36	37.78	39.01	35.96	35.92
FE2O3	60.01	55.98	59.95	57.31	54.71	59.31	60.41
SIO2	0.30	0.28	0.34	0.34	0.40	0.40	0.45
AL2O3	0.69	1.34	0.66	0.33	0.51	0.87	0.54
MGO	0.00	0.00	0.00	0.00	0.00	0.00	0.30
V2O5	1.93	1.88	2.21	2.18	3.59	2.45	2.45
TIO2	1.39	3.44	1.13	2.70	1.68	0.47	0.49
NIO	0.06	0.00	0.06	0.04	0.07	0.04	0.00
COO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	0.04	0.05	0.07	0.22	0.46	0.26	0.31
MNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Plagioclase

	ISO-2	ISO-3	<- ISO-4 ->		<----- ISO-8 ---->			<------------ BXA3079 ------------>						<------- BXA4055 ------->			
Var.\ID:	M160	M159	M184	M194	M165	M173	M180	M101	M106	M110	M111	M114	M115	M117	M123	M124	M130
SIO2	54.77	55.19	60.42	60.80	54.21	55.19	56.40	58.73	60.43	60.27	60.12	61.10	57.08	58.47	57.79	57.20	59.87
TIO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
AL2O3	27.77	28.07	25.20	24.83	27.83	28.23	27.57	25.78	25.90	26.46	26.67	26.54	25.11	25.64	27.21	26.05	26.83
FEO	0.28	0.00	0.00	0.00	0.51	0.38	0.26	0.40	0.00	0.62	0.29	0.00	0.89	0.27	0.38	0.00	0.00
MNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MGO	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CAO	10.80	10.83	6.98	6.89	11.38	11.15	10.35	8.07	7.67	8.29	8.54	8.05	9.87	8.21	9.63	8.58	8.68
NA2O	5.52	5.39	7.57	8.01	4.88	4.96	5.68	7.01	7.64	7.23	6.86	7.35	6.95	6.87	6.30	6.50	6.99
K2O	0.00	0.00	0.00	0.00	0.00	0.12	0.21	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.12	0.00	0.00
NIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	<------- BXA4055 ------->			
Var.\ID:	M131	M137	M141	M148
SIO2	60.05	59.96	59.77	59.48
TIO2	0.00	0.00	0.00	0.00
AL2O3	26.92	26.97	27.27	26.46
FEO	0.00	0.00	0.42	0.42
MNO	0.00	0.00	0.00	0.00
MGO	0.00	0.00	0.00	0.00
CAO	8.63	8.02	9.20	8.58
NA2O	6.97	6.74	6.95	6.70
K2O	0.00	0.56	0.12	0.00
NIO	0.00	0.00	0.00	0.00
COO	0.00	0.00	0.00	0.00
CR2O3	0.00	0.00	0.00	0.00

Major and trace element data from Crousa gabbro

Var.\ID:	ISO-1	ISO-2	ISO-3	ISO-4	ISO-5	ISO-6	ISO-7	ISO-8
SIO2	50.60	50.64	49.29	41.67	45.94	43.99	50.65	50.11
AL2O3	17.66	15.75	12.06	11.90	12.41	11.80	15.88	14.73
TIO2	0.51	0.85	0.41	4.60	5.64	5.02	0.49	0.55
FE2O3	5.73	6.58	7.83	17.36	16.10	18.50	6.28	7.30
MGO	7.89	8.70	14.29	5.80	6.14	5.57	9.29	10.54
CAO	11.86	11.93	12.42	11.03	9.51	9.97	12.32	12.43
NA2O	3.69	3.28	2.20	3.35	3.63	3.52	2.60	2.85
K2O	0.15	0.11	0.09	0.11	0.15	0.12	0.09	0.08
MNO	0.11	0.13	0.14	0.25	0.24	0.23	0.11	0.13
P2O5	0.03	0.06	0.03	3.08	0.17	0.77	0.02	0.03
LOI	0.69	1.12	1.84	0.53	0.37	0.15	1.29	0.21
Total	98.92	99.15	100.60	99.68	100.30	99.64	99.02	98.96
BA	34	62	33	49	68	74	36	37
CE	12	0	0	78	17	29	0	21
CO	29	34	55	44	48	57	37	41
CR	467	172	568	53	103	113	576	566
CU	70	11	45	38	55	98	59	66
GA	15	16	12	22	22	22	14	13
HF	2	2	2	4	3	2	0	4
LA	0	0	4	18	5	5	0	0
NI	154	134	201	0	40	54	178	169
NB	3	2	3	7	7	5	3	0
PB	11	4	7	8	6	8	3	7
RB	4	5	6	7	5	6	4	3
SC	37	45	47	42	58	55	42	45
SR	231	187	148	207	177	174	215	202
TA	0	0	0	3	0	0	0	0
TH	3	2	2	0	0	3	3	0
U	0	2	0	2	1	0	0	0
V	125	183	138	622	620	865	136	146
Y	13	18	11	120	37	54	11	12
YB	5	8	7	0	2	5	5	6
ZN	31	34	40	117	98	119	32	37
ZR	39	48	31	91	99	106	32	34

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