SVERIGES GEOLOGISKA UNDERSÖKNING

SERIE C NR 764 AVHANDLINGAR OCH UPPSATSER ÅRSBOK 73 NR 5

UNO SVENSSON

GEOCHEMICAL INVESTIGATION OF MINOR ELEMENTS OF THE PRINCIPAL PRECAMBRIAN ROCKS OF VÄSTERBOTTEN COUNTY SWEDEN

UPPSALA 1980

SVERIGES GEOLOGISKA UNDERSÖKNING

SERIE C NR 764 AVHANDLINGAR OCH UPPSATSER ÅRSBOK 73 NR 5

UNO SVENSSON

GEOCHEMICAL INVESTIGATION OF MINOR ELEMENTS OF THE PRINCIPAL PRECAMBRIAN ROCKS OF VÄSTERBOTTEN COUNTY SWEDEN

UPPSALA 1980

ISBN 91-7158-172-3

Schmidts Boktryckeri AB
Helsingborg 1980

CONTENTS

ABSTRACT

This geochemical investigation concerns rocks belonging to the Volcanic Series, Phyllite Series, Gneisses and Revsund granite in the county of Västerbotten, north Sweden.

It has been established through earlier geological, stratigraphic, tectonic, and geochemical studies, that the Phyllite Series, Gneisses and Revsund granite belong to a single metamorphic series. In the investigation presented here, the occurrence and distribution of ore-forming elements and other minor elements in the various rock units have been examined.

The metamorphism of the rocks in the Phyllite Series and the formation of the Revsund granite caused sufficient redistribution of the ore-forming elements to account for the sulphide deposits of Västerbotten. The content of the same elements in the Volcanic Series, in which the ores are situated, is remarkably low.

Many other minor elements were also redistributed during the metamorphism and the formation of the Revsund granite. This shows that there was another rock-forming process taking place alongside granitisation, causing the formation of granodiorite, diorite or gabbro. An exchange of elements took place between the two centres of rock formation. The driving forces for the movement of elements were differences in temperature and pressure.

Elements are dependent on one another and therefore occur in associations that are influenced by the conditions under which rocks form. Associations originating under sedimentary conditions are destroyed through metamorphism, and new ones are built up. The differentiation of a rock unit which occurs when granite is formed in one location, while diorite or gabbro is formed in another, implies that the element associations are developed differently. Associations which dominate in the basic rocks are supressed in the acidic rocks, where other associations take the leading role.

The Volcanic Series in Västerbotten is composed of many different rock units whose

boundaries are difficult to distinguish. It is, however, easy to divide the series into two groups, one with acid and one with basic volcanics. The group of acid volcanics includes rocks of the differentiation series quartz porphyry — keratophyre — dacite. An unknown number of samples of sediments are included with the samples, but it was not possible to separate these. The basic group comprises andesites and basalts of various types. The subdivision has made possible to find out the minor elements concentrated in the basic rock units and the trace elements prevailing in the acid volcanics. The elements As, Cr, Mn, Ni, Sr, Ti, V, and to a certain extent Cu show close affinities to the basic volcanics. The elements Ba, Ga, Ge, Pb, and Zn appear to be less dependent upon rock composition. The elements As, Cu, Pb, S, and Zn show remarkably low concentrations in the whole Volcanic Series and this fact is particularly remarkable when it is considered that all the rich sulphide ores of the Skellefte district are localised in these rocks.

ACKNOWLEDGEMENTS

This work forms the second part of a geochemical study of the Precambrian of Västerbotten, the broad outlines of which were laid down by Professor S. Gavelin and by the former chief geologist of Boliden AB Dr E. Grip. The author would like to express his gratitude for their kind assistance during the progress of the study.

To a large extent this investigation would not have been possible were it not for the development of analytical techniques that has taken place at Boliden's analytical laboratory at Rönnskär. The author would like to thank the chief of the laboratory fil. lic. G. Sundkvist and his staff for their cooperation.

The author also wishes to thank his colleagues in the prospecting division of Boliden AB for their valuable comments and viewpoints.

The management of Boliden AB is thanked for permission to publish this account.

PURPOSE OF THE INVESTIGATION

The geological investigations of Gavelin and Grip (1946) and Gavelin (1955) have established that the Phyllite Series, the Gneiss Series and the Revsund granite in Västerbotten belong to a single metamorphic series. In many places it is possible to follow continuous transitions between the three rock types. This has been verified by geochemical investigations (Svensson 1970). It has also been claimed (Gavelin 1955) that the sulphide ores, found in the Volcanic Series of the Skellefteå district, have been formed metasomatically through the removal of ore material in solution from the rocks of the Phyllite Series during the metamorphism which resulted in the formation of the Västerbotten gneisses and the Revsund granite.

One of the original purposes of this investigation was therefore to study the realtionships between the ore forming elements and between the various other minor elements in the different rock units. By this means it should be possible to make clear the processes which have been in operation during the formation of the sulphide ores. A proper understanding of these processes is essential for the correct exploitation of geochemical prospecting methods in the search for mineral concentrations of industrial use.

In addition to this economic and practical motivation it was also considered desirable to gain an understanding of the behaviour of minor elements during the rock forming processes of sedimentation, diagenesis, metamorphism, and granitisation.

GEOLOGICAL SETTING

The geological relationships within the Precambrian of Västerbotten are well established thanks to the ore prospecting that has been carried out in the Skellefteå district in the northern part of the county. The first, preliminary work was reported by A. G. Högbom in 1899. This has been followed by a series of publications, including Kautsky (1957). Kautsky proposed a stratigraphic scheme for the Skellefteå district, the basis of which can still be used. The scheme presented below is a revision by Grip (1970) in which he introduces local modifications. The ages indicated are from Welin 1970.

Sorsele granite	1 625 ± 45 m.y.
Conglomerates and volcanics (eg. Duobblon)	1 725 ± 75 m.y.
Discordance	
Revsund granite. Folding and ore-formation	1 785 ± 40 m.y.
Phyllite Series = Phyllites and basic rocks	
Gallejaure granite	
Border zone between Volcanic and Phyllite series	
Discordance	
Jörn granite. Folding	
Volcanic series	

This is an investigation of the rocks of the Volcanic Series, the Phyllites and their alteration products – the Västerbotten gneisses and the Revsund granite.

The rocks of the Volcanic Series comprise quartz porphyries, keratophyres and dacites with intercalations of sediments together with intrusions of andesites and basalts in the form of dykes and sills. The acid volcanics will, to a large extent, have been ignimbrites. Lavas were less important in the acid compared to the basic volcanics (Grip and Frietsch 1973).

The rocks of the Phyllite Series comprise a variety of sediments and include layers of effusive greenstones. Among the sediments, fine-grained types are the most common. They are often graphitic and contain a bundant pyrite and magnetite. Sandstones and coarse greywackes in a more or less altered condition are also common. As both pure quartzites and extremely fine clays are lacking, the series can be said to have a greywacke-type composition.

The rocks of the Phyllite Series have been altered to gneisses by metamorphism. These are usually developed as veined gneisses and are sometimes rich in fragments of a less altered character. The process has progressed furthest along the contact with the Revsund granite, and the gneisses contain porphyroblasts of microcline of the same type as in the Revsund granite.

The end result of the metamorphism is the Revsund granite. This is usually coarsely porphyritic, containing microcline porphyroblasts up to 5 cm in diameter. A fine-grained variety is to be found north of the town of Skellefteå and is termed the Skellefteå granite. The same type of granite occurs throughout the gneiss area in the form of small diapirs.

ANALYTICAL TECHNIQUES

The rock samples used in this study are those already investigated in Svensson 1970.

The rocks sampled at Stenbrånet had been subjected to a metasomatic differentiation by means of which some of the minor elements had been leached out of some layers and enriched in others. These samples have therefore been treated separately from the rest of the Gneiss Series.

Analytical values are given in the appendix. The densities of the samples are also quoted. A discussion of the density values is given in Svensson 1970.

The analyses were performed at the Central analytical laboratory at Rönnskär following methods developed there. Two different procedures have been followed, sulphide isoformation and fusion isoformation.

With sulphide isoformation, a relatively large sample is treated successively with HNO_3, HF and H_2SO_4 and then dissolved in water. H_2S is passed through the solution and the precipitate is analysed by the tape method in a direct-reading spectrograph. The analytical values are obtained in comparison with standards which have been prepared from synthetic solutions and sulphide isoformation by the same method. The method has been designed for the analysis of Ag, As, Ba, Bi, Cu, Ga, Ge, In, Mo, Pb, Sb, Sn, Tl, and Zn. In this investigation, it was used for the analysis of Ag, As, Bi, Cu, Ga, Ge, Pb, and Zn.

With fusion isoformation a relatively large sample is melted together with a buffer which also functions as flux. When the sample has cooled, it is milled and then analysed by the tape method on a direct-reading spectrograph. The samples are compared with synthetic standards. The method can be used for the analysis of Ba, Be, Co, Cr, Cu, Li, Mn, Ni, Si, Ti, V, and Zn within most rocks. In this investigation it was used for the analysis of Ba, Be, Cr, Li, Mn, Ni, Sr, Ti, and V.

S (sulphur) has been analysed by roasting and titration.

Analyses of the major elements, locations of the samples and descriptions of the rocks are to be found in Svensson 1970.

TABLE 1. Sensitivity and precision in analysis of minor elements in rocks from Västerbotten County. The precision of sulfide isoformation is better than 5 % of the analytical value.

Element	Ag	As	Pa	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	Sr	Ti	V	Zn	S
Isoformation method	Sul	Sul	Fus	Fus	Sul	Fus	Sul	Sul	Sul	Fus	Fus	Fus	Sul	Fus	Fus	Fus	Sul	Roast
Sensitivity in ppm	0.3	2	10	0.5	0.3	20	2	-	-	10	-	20	2	100	50	20	2	0.1 %
Variation with normal conditions	-	-	15	0.5	-	30	-	-	-	10	10	25	-	175	50	30	-	0.1 %

Sul.: sulphide isoformation
Fus.: fusion isoformation
Roast.: roasting and titration

STATISTICAL METHODS

"A Computer Program for Factor Analysis of Geochemical and other Data" (Cameron 1967) has been used for the statistical treatment of the analytical data. The program calculates, among other things, average concentration, standard deviation, correlation coefficients, varimax matrix, factor scores and lists of factor scores.

As regards factor analysis, it is necessary that the regressions between the different elements are linear. The data may be transformed in various ways in order to achieve linear regression. A log-transformation is most usual.

The data have been plotted on diagrams with a variety of scales, both linear and logarithmic, in order to investigate the courses of the regression lines. For many pairs of elements, the scatter proved to be so large that no difference could be distinguished. One cause for this scatter may be that the groups treated were not internally homogeneous but were comprised of several populations.

A comparison has been made between transformed and non-transformed data in order to obtain as correct information as is possible under the circumstances The data have been transformed partly by taking the logarithms of all concentrations and partly through the log-transformation of the concentrations of those elements which have been shown to have a lognormal distribution. In the latter case, calculations for K (potassium) in the Revsund granite have been made using the function log(6-K) when it has a normal distribution. All calculations have been made using weight-percent values. It can be shown that the broadest information can be obtained through factor analysis of the untransformed material. The interpretations presented in this account are therefore based on calculations made using untransformed material.

The adaptions of the separate elements to differing distribution forms in the different rock groups have been investigated by plotting on a cumulative diagram. Diagrams for normal and log-normal cumulative distributions have been used. The diagram not only displays the distribution form but also allows a judgement to be made as to whether one or more populations are present.

AVERAGES, DISPERSIONS AND DISTRIBUTION FORMS

AVERAGES (MEANS)

Average concentrations of the trace elements in the different rock units are presented in Table 2. Values for major elements are reported in Svensson 1970. In many samples, the contents of the elements Ag, Be, and Bi are too low for the sensitivity of the analytical method and the calculated averages are, therefore, uncertain. Such values are set in brackets. Calculation of the dispersion could not be made in these cases.

TABLE 2. Average concentrations of minor elements in the Precambrian rocks of Västerbotten.

	Phyllites	Gneisses	Revsund granite	Volcanics	Acid volc.	Basic volc.
	ppm	ppm	ppm	ppm	ppm	ppm
Ag	0.56	(0.34)	(0.31)	(<0.5)	(<0.5)	(<0.5)
As	21.9	6.2	13.0	8.4	6.3	12.8
Ba	570	595	805	560	585	510
Be	1.9	2.2	2.7	(1.0)	(1.0)	1.0
Bi	0.45	0.44	0.58	(0.36)	(0.35)	(0.38)
Cr	163	99	-	165	40	436
Cu	95.5	38.8	13.6	36.2	26.7	56.8
Ga	19.8	21.1	22	15	15	16
Ge	1.4	1.3	1.2	0.8	0.8	0.8
Li	54	40	44	-	-	-
Mn	782	518	421	1030	750	1630
Ni	96	52	-	85	37	190
Pb	31.8	22.1	31.7	9.0	9.0	8.9
S	9300	2300	1100	800	800	800
Sr	296	300	264	380	260	640
Ti	4365	3920	2900	3050	2050	5250
V	185	119	34	140	73	286
Zn	225	116	95	110	108	115

The rocks of the Phyllite Series consist mainly of clay-bearing sediments and a large part of them have been formed in a reducing environment in the presence of organic material and hydrogen sulphide. It is therefore natural that the concentrations of those elements which are absorbed by clay minerals and those which are precipitated by hydrogen sulphide should be high.

Ag, As, Cu, Pb, and Zn are especially bound to the sulphide-rich environment. They are all metals which are easily precipitated by hydrogen sulphide in an acid solution. Most of the S is, however, bound to Fe in the form of pyrrhotite and pyrite.

The rocks of the Phyllite Series have high contents of Ba and Ga because they are clay-rich sediments. Ba, having a large ionic radius, has a low ionic potential and is therefore absorbed easily by clay minerals. Ga, on the other hand, has an ionic radius near to that of Al and therefore these two can substitute for one another. The concentrations of Ba and Ga are therefore high in these Al-rich rocks compared to the average value for the earth's crust.

The relatively high average concentrations of Cr, Ni, Ti, and V in the Phyllite Series are due, to a large extent, to the intercalations of basic rocks which have raised the values.

The Gneiss Series and the Revsund granite have been formed through metamorphism of the rocks of the Phyllite Series. This has affected the concentrations of minor elements in the rocks. The reduction in the content of S and those metals bound to S is particularly noticeable. The loss in As, Cu and Zn is so great that it is equivalent to a 5 m thick vertical ore zone every kilometre, this hypothetical ore having metal contents of 0.3 % As, 1.6 % Cu and 2.6 % Zn. The loss in sulphur is equivalent to a 16 m thick zone of compact pyrite every kilometre.

As and Pb show a peculiar pattern inasmuch as the concentrations in the stage between phyllite and gneiss decrease sharply but increase again on further metamorphism so that there is twice as much As in the Revsund granite as in the Västerbotten gneisses, and as much Pb as in the rocks of the Phyllite Series. It is well known that Pb is easily substituted for K in potassium feldspar, and it should be easily enriched when a microcline-rich rock like the Revsund granite is formed. The enrichment mechanism for As is not so apparent. Possibly an As-rich apatite is formed.

Other elements which decrease in concentration with progressing metamorphism are Cr, Mn, Ni, Ti, and V. These elements have a close affinity to basic rocks. When the whole rock composition becomes more acid through metamorphism it is natural that their concentrations become lower.

Elements having affinities to acid rocks increase in concentration during the whole metamorphic process. Examples of these are Ba and Be, Ba substituting for K in potassium feldspar while Be is considered to substitute for Si in the Si-tetrahedron.

A schematic compilation of the distribution of the minor elements between the different rock units during metamorphism, granitisation and dioritisation of the rocks of the Phyllite Series is given in Fig. 1.

The rocks of the Volcanic Series have been divided into an acid and a basic group. As, Cr, Mn, Ni, Sr, Ti, V, and, to a certain extent, Cu, show affinities

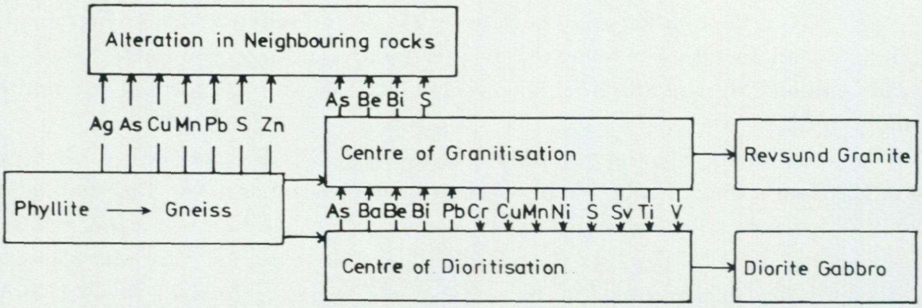


Fig. 1. Diagram showing the behaviour of the minor elements during metamorphism. The arrows indicate either the direction of increase in metamorphic grade or the direction of movement of the various elements.

to basic volcanics, while Ba, Ga, Ge, Pb and Zn are less dependant. The low concentrations of As, Cu, Pb, S, and Zn in the Volcanic Series are especially remarkable because it is this series which forms the country rock of all ore bodies of the Skellefte district. The concentrations of these metals in the Phyllite Series are conspicuously higher.

DISPERSIONS

The standard deviation (Table 3) and the relative standard deviation (Table 4) are measures of the dispersion of the elements within the rock groups.

TABLE 3. The standard deviations for minor elements in the Precambrian rocks of Västerbotten.

	Phyllites	Gneisses	Revsund granite	Volcanics	Acid volc.	Basic volc.
	ppm	ppm	ppm	ppm	ppm	ppm
As	30	7	11	10	7.7	14
Ba	355	260	383	750	843	502
Be	1.0	1.7	1.5			
Bi	0.2	0.3	0.6			
Cr	165	59		369	37	570
Cu	79	39	13	40	30	49
Ga	3.8	3.5	3.1	3.3	3.4	2.6
Ge	0.4	0.4	0.3	0.3	0.3	0.3
Li	77	28	26			
Mn	436	272	180	596	480	311
Ni	78	30		123	27	175
Pb	42	9	12	7.3	7.3	7.6
S	1700	4000	300	2000	3000	700
Sr	145	121	147	277	145	313
Ti	2140	1940	1670	2254	1216	2417
V	109	69	21	118	62	64
Zn	314	44	40	219	264	47

The standard deviation is rather considerable for many elements. Often this is because the element is asymmetrically distributed, instead of being symmetrically distributed. A high standard deviation may also be caused if the group under consideration consists of two populations with distinctly different means.

Within the metamorphic series Phyllite–Gneiss–Revsund granite, the processes of gneissification and granitisation usually cause a decrease in the standard deviation. This is especially applicable to those elements which decrease in concentration during the metamorphism, i.e. As, Cu, Cr, Mn, Ni, S, Ti, V, and Zn. Other elements, such as As, Ba, Be, Ga, Ge, Li, and Sr, remain constant or increase in concentration and their standard deviations remain constant or increase correspondingly.

Within the Volcanic Series there are several elements with remarkably high standard deviations, probably because the Volcanic Series comprises both an acid and a basic population. An element showing affinity to only one of these populations will show two peaks on the distribution curve and therefore a broad dispersion of content frequency. Element behaving like this include Cr, Mn, Ni, Sr, Ti, and V.

The relative standard deviation is used to compare the homogeneity between

TABLE 4. The relative standard deviation $\left(C = \frac{100S}{\times}\right)$ for minor elements in the Precambrian rocks of Västerbotten.

	Phyllites ppm	Gneisses ppm	Revsund granite ppm	Volcanics ppm	Acid volc. ppm	Basic volc. ppm
As	135	114	89	123	121	106
Ba	62	44	48	116	134	89
Be	52	78	55			
Bi	54	68	106			
Cr	101	60		223	94	131
Cu	83	101	92	110	114	87
Ga	19	17	14	21	23	17
Ge	30	29	28	37	38	35
Li	141	71	59			
Mn	56	52	43	58	64	19
Ni	81	57		144	72	93
Pb	133	42	36	82	81	85
S	180	180	32	277	295	119
Sr	49	40	56	73	56	48
Ti	49	49	58	74	59	46
V	59	58	60	84	85	22
Zn	140	38	42	199	240	41

the various rock groups independent of the variations in concentration, and also facilitates comparisons between different elements. The elements As, Cr, Li, Pb, S, and Zn show very high relative standard deviations in the phyllites, and with the exception of Cr and Li, it is these elements that are concentrated in the graphite- and sulphide-bearing phyllites. Cr belongs to the basic rocks in the Phyllite Series and Li occurs mostly in the coarse-grained sediments. It is a property of these elements that they tend to be concentrated into limited environments and this causes a large dispersion.

The relative standard deviation normally decreases during metamorphism as this is an homogeneising process. This is particularly marked for the elements As, Cr, Li, Ni, Pb, S, and Zn. In the Phyllite Series, these elements are differentiated between separate rock types. The metamorphism causes them to be incorporated into the silicate structure of the main rock-forming minerals, as they are all oxyophile. S is possibly incorporated into silicates as more or less well bound ions when the metamorphism has progressed as far as granitisation. By these means, the elements are homogeneously distributed throughout the whole rock mass and the relative standard deviation becomes lower. A reservation must be made for Cr and Ni as their concentrations in the Revsund granite are so low in relation to analytical sensitivity that calculations of averages and dispersions cannot be undertaken. The relative standard deviation in the Revsund granite should be expected to increase again as Cr and Ni have affinities to Fe-Mg-minerals which decrease markedly in proportion during granitisation. Cr and Ni are then less evenly distributed throughout the rock mass.

An element such as Bi has difficulty in being incorporated into the lattices of the silicate minerals and must therefore form an independent mineral. This explains why the relative standard deviation increases during metamorphism. Be, Ga, Ge, and Sr, on the other hand, are easily incorporated at all stages into the various rockforming silicates and therefore the grade of metamorphism has relatively little influence on the relative standard deviation.

The element Ba is readily absorbed by clay minerals during sedimentation and is therefore evenly dispersed throughout large parts of the Phyllite Series. Upon metamorphism and especially granitisation, Ba is included into the lattice of potassium feldspar causing yet further homogeneisation.

Mn, Ti and V have affinities to the Fe-Mg-minerals which are found in the basic rocks. The contents of these elements which remain in the acid products of metamorphism – gneiss and Revsund granite – are concentrated in the Fe-Mg-minerals which are present in varying proportions. For these elements, the relative standard deviation therefore tends to increase.

The elements As, Ba, Cu, Zn, and S have remarkably high relative standard deviations in the group of acid volcanics. An interpretation which may explain this is that volcanism causes these elements to be differentiated between separate parts of the rock unit. The chalcophile elements are easily mobilised during volcanism and may become fractionated. Mobilisation is facilitated when the elements are only slightly involved in the silicate phases. The distribution of the metals As, Ba, Cu, and Zn between the silicate phase, the sulphide phase and the carbonate phase is dependent on the content of sulphide- and carbonateions in the rocks. The proportion of silicates in the rocks is near to 100 % and therefore relatively constant. Under the conditions of volcanic eruption, a higher proportion of the metals is removed from the melt when the contents of sulphide- and carbonate-ions are high.

The elements As, Cr, and S have the highest relative standard deviations within the basic volcanic rock group. This should be the result of similar processes to those described above for the acid volcanics.

The remaining minor elements are more homogeneously distributed in the rocks of the Volcanic Series.

DISTRIBUTION FORMS

Normal-distribution is the natural distribution form in rocks. Skew-distributions usually occur in connection with boundaries. 0-boundaries are the most common cause of skew-distributions. Skew-distributions may often be fitted to a log-normal curve.

TABLE 5. Dispersion forms for minor elements in the Precambrian of Västerbotten. Log = Lognormal.

	Phyllite	Gneiss	Revsund granite	Volcanics
Ag	Log	–	–	–
As	Log	Log	Normal	Log
Ba	Log	Normal	Normal	Log
Be	Log	Normal	Normal	–
Bi	Log	Log	Log	–
Cr	Log	Log	–	Log
Cu	Log	Log	Log	Log
Ga	Normal	Normal	Normal	Log
Ge	Log	Log	Log	Log
Li	Log	Log	Log	–
Mn	Log	Log	Log	Log
Ni	Log	Log	–	Log
Pb	Log	Normal	Normal	Log
S	Log	Log	Log	Log
Sr	Log	Log	Log	Log
Ti	Log	Log	Log	Log
V	Log	Log	Log	Log
Zn	Log	Log	Log	Log

The effects of metamorphism on the distribution curves can be followed in the series Phyllite – Gneiss – Revsund granite. The curves for those elements which decrease in concentration during metamorphism are pressed nearer and nearer to the 0-boundaries and the distributions become progressively skewed. On the other hand, the metamorphic process as such tends to homogeneise the distribution of elements through the rock mass and, for some elements, this may compensate for the increased skewness that is caused by the decrease in concentration. An example is Cu which has a no more skew distribution in the Revsund granite than in the Phyllite Series. Zn has a more symmetrical distribution form in the granite stage than earlier.

Those elements which increase in concentration during the metamorphism achieve a more symmetrical distribution curve. The curves are often so well-smoothed that they can be regarded as normally-distributed. Ba and Be increase in concentration progressively during metamorphism and have even at the stage of gneissification a distribution form which can be fitted to the normal-distribution curve. The element Ga also increases in concentration continually but has, even in the phyllite stage, a normal-distribution. The element As decreases in concentration during gneissification only to increase again during the formation of the Revsund granite. Its behaviour is quite predictable inasmuch as it only becomes normally-distributed at the granite stage. Pb behaves differently as it is normally distributed in the gneiss stage despite a decrease in concentration. By the granite stage, the concentration has risen again and the distribution is normal again.

In the rocks of the Volcanic Series, all investigated elements have a skew-distribution approximating to log-normal curves. This applies even to Ga, an element which usually has the most constant concentrations and follows the normal-distribution curve independent of the inhomogeneity of the rock group.

CORRELATION

The correlation coefficient is a measure of the fit to a straight line in a coordinate system of a statistical material comprising pairs of values. It is calculated using the equation

$$r = \frac{\sum (x-\bar{x}) \cdot (y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \cdot (y-\bar{y})^2}}$$

where r is the correlation coefficient, x and y represent the analysis values and $\bar{x}$ and $\bar{y}$ the arithmetic means for the respective elements.

Where several elements have been analysed, correlation coefficients can be calculated for every combination of two elements and the material summarised by compilation into a correlation matrix. The major elements have been included in this study in order to obtain as complete a picture as possible of the interdependence of the elements. In the correlation matrix one can not only decipher the connections between pairs of elements but also collect them into correlation-groups. These groups are the keys to geochemical family relationships.

TABLE 6. Correlation matrix of 122 samples of phyllites.

	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S
As	1.00	-0.03	-0.21	0.18	-0.05	0.30	-0.12	-0.10	-0.08	0.16	0.21	0.46	0.49
Ba	-0.03	1.00	-0.01	-0.05	-0.06	-0.02	0.07	-0.14	0.02	-0.06	-0.10	0.05	0.03
Be	-0.21	-0.01	1.00	0.04	-0.15	-0.10	0.34	0.31	0.53	-0.45	-0.16	0.00	-0.06
Bi	0.18	-0.05	0.04	1.00	-0.08	0.38	0.28	0.14	-0.00	0.11	0.11	0.29	0.30
Cr	-0.05	-0.06	-0.15	-0.08	1.00	0.11	-0.04	0.03	0.02	0.19	0.77	-0.15	-0.10
Cu	0.30	-0.02	-0.10	0.38	0.11	1.00	0.26	0.06	-0.10	0.30	0.58	0.56	0.82
Ga	-0.12	0.07	0.34	0.28	-0.04	0.26	1.00	0.44	0.14	-0.10	0.15	0.07	0.03
Ge	-0.10	-0.14	0.31	0.14	0.03	0.06	0.44	1.00	0.31	-0.11	0.01	-0.07	-0.14
Li	-0.08	0.02	0.53	-0.00	0.02	-0.10	0.14	0.31	1.00	-0.21	-0.03	-0.11	-0.13
Mn	0.16	-0.06	-0.45	0.11	0.19	0.30	-0.10	-0.11	-0.21	1.00	0.28	0.10	0.18
Ni	0.21	-0.10	-0.16	0.11	0.77	0.58	0.15	0.01	-0.03	0.28	1.00	0.24	0.38
Pb	0.46	0.05	0.00	0.29	-0.15	0.56	0.07	-0.07	-0.11	0.10	0.24	1.00	0.72
S	0.49	0.03	-0.06	0.30	-0.10	0.82	0.03	-0.14	-0.13	0.18	0.38	0.72	1.00
Sr	-0.04	0.06	-0.11	0.21	0.29	0.09	0.24	0.11	0.01	0.35	0.32	0.00	-0.02
Ti	-0.11	-0.19	-0.33	0.08	0.40	0.20	0.24	0.11	-0.03	0.50	0.41	-0.14	-0.17
V	-0.10	-0.20	-0.23	0.18	0.37	0.46	0.35	0.20	-0.02	0.49	0.54	0.00	0.07
Zn	0.54	-0.00	-0.08	0.30	-0.11	0.73	0.08	-0.12	-0.08	0.20	0.39	0.74	0.87
$Si0_2$	-0.05	0.14	0.24	-0.19	-0.19	-0.39	-0.13	0.10	0.07	-0.31	-0.37	-0.08	-0.23
Al_20_3	-0.18	0.18	0.17	0.23	-0.05	0.09	0.71	0.28	0.19	-0.13	0.02	-0.05	-0.13
Fe_20_3	0.01	0.05	-0.10	0.19	0.09	0.24	0.09	-0.03	-0.08	0.16	0.16	0.08	0.19
Fe0	0.17	-0.09	-0.15	0.23	0.06	0.47	0.05	0.04	-0.04	0.27	0.23	0.20	0.45
Mg0	0.20	-0.20	-0.35	0.08	0.60	0.27	0.12	0.06	-0.06	0.44	0.62	0.06	0.01
Ca0	0.11	-0.20	-0.37	0.13	0.20	0.17	-0.09	-0.09	-0.20	0.67	0.22	0.03	0.07
Na_20	-0.12	0.05	-0.08	-0.00	-0.18	-0.23	0.06	-0.13	0.05	-0.02	-0.23	-0.16	-0.25
K_20	0.03	0.38	0.41	0.01	-0.27	-0.02	0.36	0.09	0.13	-0.50	-0.22	0.18	0.11

	Sr	Ti	V	Zn	$Si0_2$	Al_20_3	Fe_20_3	Fe0	Mg0	Ca0	Na_20	K_20
As	-0.04	-0.11	-0.10	0.54	-0.05	-0.18	0.01	0.17	0.20	0.11	-0.12	0.03
Ba	0.06	-0.19	-0.20	-0.00	0.14	0.18	0.05	-0.09	-0.20	-0.20	0.05	0.38
Be	-0.11	-0.33	-0.23	-0.08	0.24	0.17	-0.10	-0.15	-0.35	-0.37	-0.08	0.41
Bi	0.21	0.08	0.18	0.30	-0.19	0.23	0.19	0.23	0.08	0.13	-0.00	0.01
Cr	0.29	0.40	0.37	-0.11	-0.19	-0.05	0.09	0.06	0.60	0.20	-0.18	-0.27
Cu	0.09	0.20	0.46	0.73	-0.39	0.09	0.24	0.47	0.27	0.17	-0.23	-0.02
Ga	0.24	0.24	0.35	0.08	-0.13	0.71	0.09	0.05	0.12	-0.09	0.06	0.36
Ge	0.11	0.11	0.20	-0.12	0.10	0.28	-0.03	0.04	0.06	-0.09	-0.13	0.09
Li	0.01	-0.03	-0.02	-0.08	0.07	0.19	-0.08	-0.04	-0.06	-0.20	0.05	0.13
Mn	0.35	0.50	0.49	0.20	-0.31	-0.13	0.16	0.27	0.44	0.67	-0.02	-0.50
Ni	0.32	0.41	0.54	0.39	-0.37	0.02	0.16	0.23	0.62	0.22	-0.23	-0.22
Pb	0.00	-0.14	0.00	0.74	-0.08	-0.05	0.08	0.20	0.06	0.03	-0.16	0.18
S	-0.02	-0.17	0.07	0.87	-0.23	-0.13	0.19	0.45	0.01	0.07	-0.25	0.11
Sr	1.00	0.29	0.36	0.02	-0.18	0.22	-0.03	0.05	0.23	0.34	0.02	-0.24
Ti	0.29	1.00	0.82	-0.11	-0.37	0.18	0.08	0.19	0.55	0.37	0.16	-0.49
V	0.36	0.82	1.00	0.06	-0.50	0.27	0.15	0.30	0.57	0.33	0.00	-0.41
Zn	0.02	-0.11	0.06	1.00	-0.22	-0.08	0.14	0.29	0.22	0.16	-0.21	0.09
$Si0_2$	-0.18	-0.37	-0.50	-0.22	1.00	-0.05	-0.13	-0.27	-0.37	-0.33	0.05	0.23
Al_20_3	0.22	0.18	0.27	-0.08	-0.05	1.00	0.14	-0.04	0.10	-0.20	0.26	0.23
Fe_20_3	-0.03	0.08	0.15	0.14	-0.13	0.14	1.00	-0.14	0.06	0.18	0.13	-0.17
Fe0	0.05	0.19	0.30	0.29	-0.27	-0.04	-0.14	1.00	0.16	0.08	-0.23	0.01
Mg0	0.23	0.55	0.57	0.22	-0.37	0.10	0.06	0.16	1.00	0.51	-0.06	-0.35
Ca0	0.34	0.37	0.33	0.16	-0.33	-0.20	0.18	0.08	0.51	1.00	-0.07	-0.41
Na_20	0.02	0.16	0.00	-0.21	0.05	0.26	0.13	-0.23	-0.06	-0.07	1.00	-0.21
K_20	-0.24	-0.49	-0.41	0.09	0.23	0.23	-0.17	0.01	-0.35	-0.41	-0.21	1.00

In the Phyllite Series for example (Table 6), it is possible to discern a group with the elements Cr, Ni, Ti, V, and Mg all of which show a good correlation to each other. Cu seems to lie just outside this group, having a good correlation with Ni and V but a poor correlation with Cr, Ti and Mg. The elements that are in the group are typical of basic rocks. They are present in high concentrations in the amphibolites and greenstones which occur as layers in the Phyllite Series. However, a high internal coefficient in these rocks is not sufficient to explain the high correlation coefficient. The elements must have such common properties allowing them to be associated together in the sedimentary parts of the Phyllite Series. One common property is the ionic-radius. This lies in the narrow interval 0.64 – 0.78 Å. for those valencies common under the oxidation conditions prevalent during the sedimentation of the Phyllite Group.

It should be possible to distinguish several such correlation-groups, but it is difficult to determine the boundaries as a number of elements occur in several groups. A clearer picture of the grouping can be gained from Factor Analysis.

FACTOR ANALYSIS

Factor analysis is a statistical method which is used to study the internal relationships between a large number of variables, such as the different elements in a number of analyses from a series of rocks. Factor analysis forms a part of multivariate-analysis.

It must be emphasised at this stage that the statistical procedure which is termed "factor analysis" in this and other geochemical literature is, according to current usage in statistics, in fact "principal component"-analysis. Strictly speaking, factor analysis is a rather different statistical and mathematical procedure.

In factor analysis, a linear combination of normalised concentrations in a sample, made under certain statistical conditions, is termed a factor belonging to the sample. Different types of matrixes, displaying relationships between element and factor, can be set up. The varimax matrix is one type. The varimax matrix can reduce a large number of correlation coefficients to a few secondary numbers, and this makes it easier to reveiw the relationship between different phenomena. The varimax matrix uses factor loading to calculate how strongly each element is related to the factor. The closest equivalent to each factor is the correlation group which could or should have been obtained from the correlation matrix.

A list of factor scores can be calculated from the varimax matrix. This indicates which factors are influencing each separate sample. This is of great help in the interpretation of the significance of the factors.

Factor analysis has been performed on each rock group separately. For the sake of clarity, the computer-printed matrixes have been rearranged in the tables by sorting the elements according to loading and sign. Elements with low loadings (loading < 0.100) have been excluded except where it was necessary to emphasise the dominance of one element in a factor. In such cases a second element has been included without regard to the size of the loading. The element with the largest loading of the opposite sign to the one dominating in the factor has always been taken, without regard to the size of the loading. Loadings greater than 0.600 are termed high, those between 0.200 and 0.600 termed medium, and those below 0.200 termed low. The significance of the sign of the loading is discussed later.

THE PHYLLITE SERIES

The Phyllite Series is dominated by sediments, deposited under a variety of conditions. Some of the most typical sedimentary facies will now be described.

Sediments deposited near the shore-line are often sandy and have been laid down in O (oxygen)-rich water, i.e. an oxidising environment. Fe and Mn particularly are oxidised. This zone can also give rise to carbonate-rich sediments. The formation of carbonate rocks is dependent on gas-exchange with the air and on sun-light for the participating organisms and is thus favoured near to the shore. Within the Phyllite Series neither real carbonate rocks nor the type of pure quartz-sandstone developed near to the shore occur. The sandstones developed are fine-grained and have a notable content of clay minerals.

Sedimentation of rocks rich in clay minerals takes place further from the shore. This is also an oxidising environment as the water contains oxygen. It has been termed the hydrolysate zone. Elements are concentrated here either through absorption into clay minerals or incorporated into the structure of the clay minerals.

Further out to sea or in isolated basins, where the water is static, the O content decreases and a reducing environment can result. S with valency +6 for the sulphate ion is reduced to valency –2 for the sulphide ion. This process is probably assisted by bacteria and is thus dependent on the presence of organic material. The organic substances do not disintegrate completely as in the oxidising environment but form a sapropel mud which forms layers in the sediment and is later altered to amorphous C (carbon) or graphite. This sedimentation zone has been termed the reduzate zone and is distinguished by its high content of sulphides and graphite, and it may have high contents of clay minerals.

A reducing environment can also occur within sediments below water which is O-bearing. This occurs when the circulation of water in the sediment is so restricted that a bacteria culture is able to develop and reduce the sulphate ions to sulphides.

The Phyllite Series also contains interlayers of volcanic rocks in the form of greenstones and amphibolites.

The relationship between the type of sedimentation and the varimax factor can be interpreted by studying the list of factor scores. A high standard deviation in the factor score for a particular sample is related to the sedimentation type expressed by the factor.

In the list of factor scores it is possible to pick out deviations from the initially assumed pattern of sedimentation. Thus many samples from the black phyllites of the reduzate zone have high factor scores in factors which are associated with clay sedimentation despite this being characteristic of the hydrolysate zone. The explanation is that clay sedimentation has continued in the reduzate zone alongside the development of sapropel muds and sulphide precipitation. An example of this is factor 3 with Al, Ga, K, etc, which is the most typical clay factor. Of the 35 samples with high factor scores 17 are phyllites, 11 graphitic phyllites and 7 are from other rocks. Factor 2, which is a sulphide factor, is more strongly bound to the reduzate zone. 14 of the 17 samples with high factor scores are graphitic phyllites.

TABLE 7. Varimax factors controlled by near-shore sedimentation.
Analysis of 25 elements in 122 samples from the rocks of the Phyllite Series.

Factor	7	8	9	11	16
	K 0.125	Na 0.950	Li 0.957	Si 0.922	Be 0.863
		Al 0.130	Be 0.309	Be 0.087	Ga 0.239
			Ge 0.145		Li 0.210
					K 0.167
	V -0.153			Ca -0.127	Ca -0.115
	Ca -0.168			Mg -0.128	Ti -0.131
	Mn -0.170		Mn -0.086	Cu -0.144	Mg -0.157
	Sr -0.932	K -0.146	Ca -0.086	V -0.222	Mn -0.165
Sum of squares	1.043	1.013	1.068	1.037	0.996

In the Phyllite Series, it is the factors 7, 8, 9, 11, and 16 which point to near-shore sedimentation (Table 7). It should be noted that factor 7 has a negative sign for Sr, Mn etc. but, in spite of this, points to near-shore sedimentation. Even in the list of factor scores, the factor 7 has a negative sign for those types of sediment that are considered to be near-shore. The elements which are most closely bound to this sedimentation zone are Sr, Na, Li, Si, and Be. Si is enriched in sandstones because quartz is, of course, the most common residual mineral. Na is also concentrated in residual sediments as it is found in the feldspar which is a constituent of the greywacke-sandstones but which is lacking in the clay-rich sediments of the hydrolysate zone.

Li and Be occur both in factors 9 and 16 with high varimax loadings and, in general, the factors agree together so well that they can be considered to be twins. This phenomenon recurs several times in this investigation. The similarity suggests that both factors have the same cause. It is known that Be is enriched together with Al during kaolin weathering and it is evident that Be remains among the residual products of the incomplete weathering processes that have affected some of the rocks of the Phyllite Series. Little is known about the enrichment of Li in the near-shore sediments, possibly because Li rarely forms its own minerals. It may be that Li is incorporated in the micas which are concentrated in the near-shore sediments.

It might be expected that Sr would be concentrated in the carbonate precipitates of the near-shore sedimentary zone but this seems less probable when it is considered that Mn and Ca are positioned next to Sr in the same factor even though their loadings are low.

TABLE 8. Varimax factors directed by sedimentation in the hydrolyzate zone.
Analysis of 25 elements in 122 samples from the rocks of the Phyllite Series.

Factor	3	5	12	15	18	21	22
	Al 0.944	Ba 0.971	Bi 0.940	Na 0.084	Mg 0.189	Mg 0.594	Ca 0.508
	Ga 0.660	K 0.236	Cu 0.139			Zn 0.198	K 0,057
	K 0.218	Al 0.098	Ga 0.118			V 0.121	
			Pb 0.102				
			Al 0.102				
				Li -0.137	Ba -0.127		
				Bi -0.144	Be -0.136		
				Ga -0.272	Ga -0.259		
	Ca -0.122	Mg -0.114	Si -0.065	Ge -0.949	K -0.803	S -0.110	Al -0,051
Sum of squares	1.603	1.067	0.992	1.086	0.870	0.443	0.508

Sedimentation in the hydrolysate zone can be recognised by the factors 3, 5, 12, 15, 18, 21, and 22 (Table 8). Those elements which are strongly associated with this type of sedimentation are Al, Ba, Bi, Ga, Ge, K, and, to a lesser extent, Mg. Of these Al, Ga ande Ge are bound to oxygen in the tetrahedra of the clay minerals in the same way that Si is placed in the Si tetrahedra. This may because the ionic radii and ionic potentials do not differ significantly from those of Si.

The elements Ba and K are bound to the clay minerals through absorbtion or, more precisely, through base exchange, by which means the large ions with low ionic potential fit between the lattice planes of the clay minerals.

Mg ougt to be found in the Mg-rich clay minerals which occur in the hydrolyzate zone.

As far as is known, Bi is not incorporated in clay minerals but forms bismutite

$BiO(OH)_2CO_3$ by preference in the hydrolyzate zone (Rankama and Sahama 1949).

TABLE 9. Varimax factors directed by sedimentation in the reduzate zone. Analysis of 25 elements in 122 samples from the rocks of the Phyllite Series.

Factor	2	6	13	17	20
	Zn 0.925	Fe^{2+} 0.108	As 0.907	Pb 0.655	V 0.259
	S 0.920		Zn 0.185	As 0.062	Cu 0.196
	Cu 0.848		Pb 0.138		S 0.041
	Pb 0.720		S 0.138		
	Ni 0.408				
	As 0.369				
	Fe^{2+} 0.284				
	Bi 0.233				
		S -0.094			
	Si -0.174	Fe^{3+} -0.966	Be -0.115	Cu -0.072	Zn -0.177
Sum of squares	3.553	1.027	0.968	0.448	0.169

The factors 2, 6, 13, 17, and 20 may be considered as part of the group which is associated with the graphitic phyllites of the reduzate zone (Table 9). The most important factor is 2 where the sum of the squares of the loadings is 3.553. The other factors which steer elements in the reduzate zone are of less importance; they direct fewer elements and have a smaller share in the variance. It is the elements As, Cu, Pb, S, Zn and Fe^{3+} which are most strongly bound while Ni, V and Fe^{2+} are more weakly related to sedimentation in the reduzate zone. The most prominent characteristic of the reduzate zone is the precipitation of sulphides. Precipitation of the chalcophile elements within the reduzate is zoned, a feature expressed in factors 2, 13, 17 and 20. Factors 2 and 20 belong to the best developed graphitic phyllites, while factors 13 and 17 with As and Pb have high factor scores in rocks with a low graphite content or in graphite-free rocks in layers adjacent to graphitic phyllites. Factor 13 includes many sandstones with high factor scores and factor 17 phyllitic schists. Some of the zoning which is apparent from the factor analysis may result from a local metasomatic differentiation of the sulphides in close connection with the precipitation occurring in strongly reducing environments. The factor scores show that factor 6 with Fe^{3+} is connected to graphitic phyllites instead of a factor with Fe^{2+} as might have been expected. Fe^{2+} ought to be the oxidation state in which Fe is precipitated within the reduzate zone. This may have been caused by oxidation processes, affecting the sediments of the reduzate zone at a later stage. It is, however, remarkable that the factors which have high loadings for Fe^{2+} are not bound to the graphitic phyllites, many of which have high concentrations of pyrite and magnetite, but are bound to the volcanic rocks intercalated within the rock series.

TABLE 10. Varimax factors directed by eruptive rocks within the Phyllite Series.
Analysis of 25 elements in 122 samples from the rocks of the Phyllite Series.

Factor	1		4		10		14		19	
	Ti	0.869	K	0.145	K	0.146	Fe^{2+}	0.921	K	0.161
	V	0.789	Si	0.136	Be	0.142	S	0.204	Be	0.115
	Mn	0.315			Si	0.123	Cu	0.170		
			Cu	-0.183						
	Mg	0.309					Mn	0.123		
			Sr	-0.185						
	Ni	0.246					V	0.122		
			V	-0.253	Sr	-0.154			Mg	-0.106
	Cu	0.235								
			Ti	-0.260	Ti	-0.162			Ti	-0.119
			Mg	-0.561	Mg	-0.333			V	-0.129
	Si	-0.218	Ni	-0.823	Mn	-0.382			Ca	-0.197
	K	-0.287	Cr	-0.955	Ca	-0.894	Si	-0.094	Mn	-0.762
Sum of squares		2.032		2.198		1.211		0.999		0.734

The factors 1, 4, 10, 14, and 19 (Table 10) are linked to the eruptive rocks of the Phyllite Series. Of these, factors 1 and 4 are the most influential and determine a large part of the total variance. Those elements which are particularly strongly bound to the eruptive environment are Ca, Cr, Mn, Ti, V, and Fe^{2+} while Cu, S and Mg are only slightly influenced. In the following discussion this group of elements is referred to as magmatic.

Factor 1 with high loadings for the elements Ti, V, Mn, and Mg is termed the ilmenite factor. The loading of Fe^{2+}, which is contained in ilmenite, is, however, low. The loading is low because the formation of ilmenite uses little Fe when the content of Ti is low in relation to Fe^{2+}. It may even be that minor elements at this level of concentration mostly go into silicates instead of forming ilmenite. As the ionic radii of Ti and V are closer to that of Mg than that of

Fe^{2+} it is easier for these elements to go into the Mg-silicates. This is expressed in the low loadings for Fe^{2+} and the high loadings for Mg in factor 1. With higher Ti concentrations, when considerable quantities of ilmenite are to be found in the rock, the Fe content is usually high. Under these conditions the loading of Fe^{2+} in the varimax factor should be high. The negative loadings for K and Si in factor 1 indicate also that the ilmenite association is bound to basic rocks poor in K.

Another group of elements, here termed the chromite association, gives rise to factor 4. It includes Cr and Ni with high loadings and Mg, Ti, V, Sr, and Cu with relatively high loadings in the varimax factor. Fe^{2+}, which is a constituent of chromite, has a low loading, as was the situation in factor 1. The loading for Mg is, however, even higher which suggests that the chromite association is much more strongly bound to rocks rich in Mg-silicates than the ilmenite association. In this case, too, the influence of the ionic radii has been the deciding factor, as well as at the low level of concentration found in the basic volcanics of the Phyllite Series owing to the fact that the elements of the chromite association have mostly been taken up in silicates. It also seems that the close relationship between the Mg-silicates and the elements of the chromite association is found even when the concentrations are so high that considerable quantities of chromite are to be found in the rocks. The significance of the factor it not reduced by the fact that Cr, Ni etc. have negative signs on their loadings in the varimax factor and K and Si have positive signs. The rocks in question also have negative signs in the factor scores.

Factors 10 and 19 form a twin pair and obviously imply the development of more or less Mn-rich Ca-silicates. This element group can be termed the rhodonite association although in fact the Mn in the Phyllite Series is to be found in various amphiboles, not in rhodonite. Factors 10 and 19 have high factor scores for amphibolitic rocks. Many graphitic phyllites have high values in factor 19. The factor plays a small part in the total variance. The sum of the squares of the charges is only 0.734.

Factor 14 seems to be an expression for sulphide mineralisation in the basic eruptives of the Phyllite Series.

The different element associations in the Phyllite Series are summarised in Fig. 2.

GNEISS SERIES

A large proportion of the gneisses of Västerbotten have formed by metamorphism of the rocks of the Phyllite Series. This process has weakened or obliterated many of the element associations which formed during sedimentation. New associations have developed during recrystallisation. Sometimes associations have survived, but are bound to new minerals or mineral groups.

Sediments	Factors - sum of squares 4 3 2 1 0	Element associations
Near shore	7)Sr Mn Ca V	Carbonate precipitation
	8)Na Al	Greywackes
	9)Li Be Ge	Mica residuals
	11)Si	Quartz residuals
	16)Be Ga Li K	Kaolin residuals
Hydrolyzates	3)Al Ga K	Clay
	5)Ba K	Adsorptions in clay
	12)Bi Cu Ga	Bismutite
	15)Ge Ga Bi Li	Clay
	18)K Ga Be	Adsorptions in clay
	21)Mg	Mg-clay
	22)Ga	Clay
Reduzates	2)Zn S Cu Pb Ni As Fe^{2+} Bi	Sulfide precipitation
	6)Fe^{3+}	Oxidation of reduzates
	13)As Zn Pb S	Metasomatically introduced in phyllites
	17)Pb	Metasomatically introduced in sandstones
	20)V	
Eruptive rocks	1)Ti V Mn Mg Ni Cu	Ilmenite
	4)Cr Ni Mg Ti V Sr Cu	Chromite
	10)Ca Mn Mg Ti	Rhodonite
	14)Fe^{2+} S Cu	Sulfide
	19)Mn Ca	Rhodonite

Fig. 2. Element associations in the Phyllite Series.

Micas are easily formed from the clay minerals of the Phyllite Series during metamorphism, and sometimes also cordierite, sillimanite and garnet are formed. The factors which, in general, are dependent on phyllosilicate crystallisation are summarised in Table 11. The elements Al, Ga, Li, and Fe^{3+} are particularly strongly bound to these factors, but some variations for Mn and Zn also belong to the group. According to the factor scores, Factor 4 covers most of the biotite gneisses, whereas Factors 12 and 16 are caused by special types of biotite gneisses where the concentrations of Li and Ga respectively are high. Both Li and Ga

TABLE 11. Varimax factors directed by phyllo-silicate crystallisation.
Analysis of 25 elements in 150 samples from the Gneiss Series in Västerbotten.

Factor	4	8	12	16
	Al 0.941	Fe^{3+} 0.924	Ca 0.125	Si 0.117
	Ga 0.267	Mn 0.297		
	Li 0.136	Ge 0.237		
				Al -0.213
			Ga -0.159	Zn -0.231
	Si -0.177	Si -0.148	Li -0.916	Ga -0.882
Sum of squares	1.078	1.168	1.020	1.056

are known to be included in mica minerals. Factor 8 is intimately bound to the biotite garnet gneisses. The garnets which occur in the gneisses are not particularly rich in Fe^{3+} or Mn, but the environment with Fe and Mn is thought to

TABLE 12. Varimax factors directed by feldspar crystallisation.
Analysis of 25 elements in 150 samples from the Gneiss Series in Västerbotten.

Factor	2	3	11	14	22
	K 0.213	Na 0.099	Pb 0.926	Fe^{2+} 0.200	K 0.687
			K 0.474		Pb 0.121
			Ba 0.133		Ba 0.106
		Pb -0.122			
	Mn -0.216	Ti -0.240			
	Ca -0.406	K -0.333		Ca -0.171	
	Sr -0.930	Ba -0.956	Ca -0.233	Na -0.897	Ca -0.149
Sum of squares	1.257	1.160	1.292	1.005	0.553

favour garnet formation. The garnet gneisses have a clearly restricted areal extent in the central part of the coast of Västerbotten.

The elements Ba, Pb, K, Na, and Sr (Table 12) are associated with the crystallisation of feldspars. The loadings for Ca are low in the feldspar factors. Factors 3, 11 and 22 refer mainly to rocks which are classified as granite gneisses, that is, microcline-bearing gneisses with low concentrations of biotite. These gneisses lie in the border zone to the Revsund granite, and form transition rocks to the granite. From the list of factor scores for the factors 11 and 22, it is seen that some of the variations of Pb and K may be attributed to biotite gneisses. Much of the K and Pb which is adsorbed by the clay minerals in the original sediments is incorporated into the means during the first stage of gneissification. Pb in particular has suffered a large reduction in concentration in the step from phyllite to gneiss, but this has affected the Pb bound to sulphides, which is seen from the following. With further increases in the grade of metamorphism, resulting in the formation of microcline, Ba, Pb and K are redistributed to the feldspars. The differentiation processes in connection with recrystallisation cause the concentrations of these elements to increase in the acid parts of the rock mass during the metamorphism. At the same time in the basic parts of the rock mass, an association is formed which expresses itself in factor 2, with high loadings for Sr and Ca, which relate to the formation of anorthite-rich plagioclase. Factor 14, with a high loading for Na, is a result of the crystallisation of albite-rich plagioclase, which belongs to the acid or granitic part of the differentiation process.

TABLE 13. Varimax factors directed by sulfide mineral crystallisation.
Analysis of 25 elements in 150 samples from the Gneiss Series in Västerbotten.

Factor	5		7		15		18	
	K	0.085	As	0.964	Si	0.137	Mn	0.051
			Ca	0.174				
	Ni	-0.191						
	Fe^{2+}	-0.235						
	Zn	-0.247						
	V	-0.271						
	Cu	-0.441			Fe^{2+}	-0.181	S	-0.203
	S	-0.950	Be	-0.043	Zn	-0.786	Cu	-0.797
Sum of squares	1.353		1.073		0.811		0.789	

Gneissification of the rocks of the Phyllite Series has resulted in the redistribution of the chalcophile elements. In the Phyllite Series, the elements As, Cu, Pb, S, and Zn are strongly bound to sedimentation in the reduzate zone where they are precipitated as sulphides. In the Gneiss Series, As, Cu and S still have high loadings in the factors which relate to the sulphide minerals. Zn, however, has receded and Pb has almost completely disappeared from the group. The factors 5, 15 and 18, where S, Cu and Zn have high loadings (Table 13) are strongly bound to the biotite gneisses, which can be seen from the list of factor scores. Factor 7 with As is favoured by the granite gneisses and the biotite gneisses with moderate biotite contents. This is a result of the re-layering which occurred in the phyllite stage where As was associated with the sandstones immediately adjacent to the graphite phyllites, and not to the extreme reduzate sediments together with the other chalcophile elements.

TABLE 14. Varimax factors directed by magmatic element associations.
Analysis of 25 elements in 150 samples from the Gneiss Series in Västerbotten.

Factor	1		17		19	
	Cr	0.950	Ti	0.785	Ca	0.750
	Mg	0.835	Fe^{2+}	0.418	Mn	0.665
	Ni	0.833	Mn	0.207	Ti	0.257
	V	0.694			Mg	0.254
	Fe^{2+}	0.652			Sr	0.238
	Mn	0.387				
	Zn	0.374				
	Cu	0.347				
	Ti	0.308				
	Si	-0.415	Si	-0.135	K	-0.259
Sum of squares	4.211		1.050		1.420	

The minerals in the basic rocks of the Gneiss Series strongly determine the factors 1, 17 and 19 (Table 14). Factor 1 with Cr, Mg, and Ni etc. is the same as that which appeared in the Phyllite Series and was called the chromite association. The high loadings for Mg indicate that the association is favoured by the Mg-silicates. This factor is the most important of those for the Gneiss Series, and accounts for 1/6 of the total element variations. Factor 17 with Ti and Fe^{2+} is the ilmenite association and is recognised from the eruptive rocks of the Phyllite Series. In comparison with the relationship in the Phyllite Series, such elements as V, Ni, and Cu have receded in importance, but Fe^{2+} has taken over the position it should have in this association which builds on the Fe^{2+} mineral ilmenite. The higher loading for Fe^{2+} in the ilmenite factor of the Gneiss Series results from the marked reduction in the total concentration of Fe within the rock group which has affected other associations including Fe^{2+}. Factor 19 is determined by the rhodonite association which is treated more fully among the magmatic element associations in the rocks of the Volcanic Series.

The elements Cr, Mg, Ni, Ti, Ca, Mn, Fe^{2+}, and V are those which, through different magmatic associations, are bound to the basic rocks of the Gneiss Series. In the acid and K-rich rocks, these associations are less apparent, which is illustrated by the negative loadings for Si and K in the factors.

TABLE 15. Varimax factors directed by pegmatite-forming processes.
Analysis of 25 elements in 150 samples from the Gneiss Series in Västerbotten.

Factor	6		9		10		13	
	Cr	0.088	Si	0.117	Ge	0.866	Mn	0.232
					Ti	0.204		
	Li	-0.163	Li	-0.115			Na	-0.021
	Bi	-0.949	Be	-0.969	Si	-0.108	Si	-0.797
Sum of squares	1.054		1.047		0.991		0.877	

Factors 6, 9, 10, and 13 (Table 15) are governed by single elements and not by element associations. These factors relate, according to the factor scores in general, to granite gneisses, particularly those with pegmatitic schlieren and veins, and therefore are grouped under the term hydrothermal processes. The value of factor analysis is clearly less when the factors contain only single elements and no associations are apparent. The single element variations can be read directly from the analytical protocol.

The different element associations of the Gneiss Series are summarised in Fig. 3.

REVSUND GRANITE

The Revsund granite seems to have been formed by granitisation of the rocks of the Phyllite Series of Västerbotten. The granitisation process should be inter-

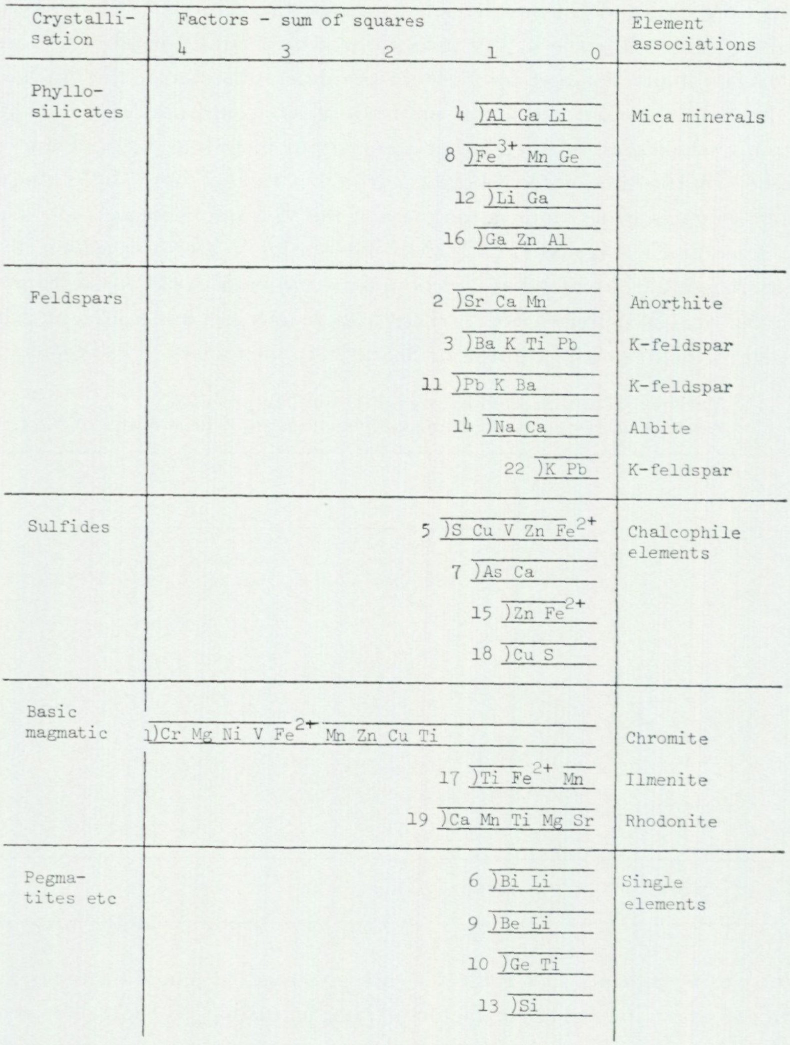


Fig. 3. Element associations in the Gneiss Series.

preted as a continuation of the metamorphism which resulted in the gneisses. This process should have further accentuated many of the element associations which began to develop during the gneiss stage. The element associations which were due to sedimentation of the original rock mass have almost completely disappeared in the granite stage.

The association which most intimately belongs to the sediment stage is that of the clay minerals. The elements most closely connected to the clay minerals are Al, Ba, Ge, Bi, Ga, K, and Mg. In the Revsund granite, the elements Fe^{3+}, Al, Li, Ga, and Ca are associated with the phyllosilicate crystallisation. The ele-

TABLE 16. Varimax factors directed by phyllosilicate crystallisation.
Analysis of 23 elements in 151 samples from the Revsund granite of Västerbotten.

Factor	3		9		13		17	
	Ba	0.148	Fe^{3+}	0.958	K	0.190	Ga	0.815
	Ca	0.122	Mn	0.200	Pb	0.111	Zn	0.215
			Ti	0.138			Ge	0.170
							Be	0.152
	Bi	-0.153						
	Ga	-0.153			V	-0.198		
	Ge	-0.171			Sr	-0.359		
	Be	-0.297			Ca	-0.520		
	Li	-0.874	Pb	-0.099	Al	-0.893	Na	-0.040
Sum of squares	1.004		1.060		1.417		0.827	

ments which were bound to the clay minerals by adsorption have, in particular, transferred to other mineral groups, as those which were built into the tetrahedra are most easily retained by the phyllosilicates which formed from the clay mineral substance. Table 16 represents the factors which relate to the phyllosilicate crystallisation. From the factor scores, one sees that these factors refer to the more mica-rich types of Revsund granite. The variations in mica concentrations within the rock group are however small. As seen in Table 16, the feldspar-forming elements have opposite loadings to the elements governed by phyllosilicate crystallisation. Many of these elements were bound to the clay minerals by adsorption in the phyllites. These feldspar-forming elements have, however, low loadings, and in the group of factors relating to feldspar crystallisation there are no corresponding opposite relationships to the elements governed by phyllosilicate crystallisation. Competition between the two groups is therefore not extensive in the Revsund granite.

Table 17 includes the factors which relate to feldspar crystallisation. The elements whose variations are most strongly affected are, in order, Pb, Na, K, and Ca.

The increasing grade of metamorphism from gneiss to Revsund granite has caused K and Pb to be more strongly bound to the feldspar group. These elements were mobilised during the differentiation processes which affected the rock mass during the highest stage of metamorphism. One would expect that Ba should also have followed with increased loadings, but this has not occurred.

TABLE 17. Varimax factors directed by feldspar crystallisation.
Analysis of 23 elements in 151 samples from the Revsund granite of Västerbotten.

Factor	2		11		15		18		19	
	K	0.183	Na	0.191	K	0.912	K	0.119	Ba	0.667
	Pb	0.176	Ca	0.181	Pb	0.170	Ge	0.105	Mn	0.074
			Sr	0.136	Ga	0.090	Pb	0.077		
					Al	-0.164	Al	-0.163		
	Al	-0.138			Na	-0.180	V	-0.172		
	Sr	-0.227	K	-0.186	Sr	-0.198	Ca	-0.254		
	Na	-0.915	Pb	-0.941	Ca	-0.218	Sr	-0.763	Bi	-0.070
Sum of squares	1.020		1.080		1.070		0.794		0.489	

Ba forms instead a single factor (factor 19) and thus no connection with the feldspars can be seen. The concentrations of Ba have, however, not increased as much as those for K and Pb, which indicates that Ba is affected much less by the differentiation processes which divide the rock mass into basic and acid types.

In the Revsund granite, the loadings for Na have increased in the factors which relate to plagioclase formation, and those for Ca have decreased compared with the gneiss stage, just as expected. The plagioclase has become more albite rich in the granite, and as a result the anorthite concentration has increased in the feldspars of the basic type by differentiation. In the varimax factor, the loadings for Sr have decreased to some degree as for Ca.

From Table 17, it is seen that not only the plagioclases undergo differentiation during granitisation, but there is also a clear differentiation between the albite-rich plagioclases and the potassium feldspars. Both factors expressing the variations in the albite and anorthite and members of the plagioclase series have opposite loadings to the microcline-forming elements, and vice versa. The only exception is met with in factor 19 with Ba, relating to microcline crystallisation, but this factor contains only a small part of the variance.

These variations in the feldspar-forming elements reflect some of the element mobilisation which occurred during the differentiation processes that resulted in the formation of granite and diorite–gabbro. In the centres where the basic rocks were formed, An-rich plagioclases crystallised by the enrichment of, for example, Ca and Sr, and in the centres where the acid or granitic rocks were formed, feldspars, rich in Na, K, Pb, (Ba), and to some extent Sr, crystallised. Within

TABLE 18. Varimax factors directed by formation of magmatic element associations. Analysis of 23 elements in 151 samples from the Revsund granite of Västerbotten.

Factor	1		4		8		10	
	Na	0.203	Ge	0.052	Li	0.090	K	0.104
	Si	0.160					Pb	0.071
	Ga	-0.406						
	Ca	-0.563						
	Ba	-0.632						
	Mn	-0.685					Ti	-0.228
	Ti	-0.866			V	-0.110	Ca	-0.231
	Zn	-0.902	Ca	-0.078	Ti	-0.124	Sr	-0.294
	Fe^{2+}	-0.925	Mg	-0.988	Cu	-0.956	V	-0.895
Sum of squares	4.093		1.017		1.024		1.096	

the granitic mass there is also a division into both Na and K feldspar types. The driving force in these differentiation processes must be the differences in pressure and temperature between the different parts of the rock mass.

Table 18 contains the factors which relate to the crystallisation of the basic minerals. As this group of minerals in the Revsund granite is quantitatively subordinate the factor analysis gives a more diffuse picture of the element associations which can occur. Interpretation becomes even more difficult with the lack of analyses of such important elements as Cr and Ni.

Factor 1 is the most important. The sum of the squares of the loadings reaches 4.093. This covers more than 1/6 of the whole element variation in the rock group. The important position which Fe^{2+} and Ti have is a parallel feature to that of factor 17 for the Gneiss Series, which there is an expression of the ilmenite association. Other elements such as Zn, Ba, Ca, and Ga have also entered the factor. Mn occurred in the same factor in the gneiss stage, but its loading has increased as a result of granitisation. According to the factor scores, this association is the most common in granites which are described as dark-grey or reddish with abundant dark minerals. Ilmenite grains are abundant in the samples which have high factor scores. The values of the factor scores have also a positive correlation with the anorthite concentrations, and negative with the albite concentrations. The latter can also be seen from varimax factor 1. The elements Zn, Mn, Ba, and Ga, which also are included with high loadings, ought in part to belong in the amphiboles which sometimes can be seen in the basic types of the Revsund granite.

In factor 4, Mg alone has a high loading. In the Phyllite and Gneiss Series, Mg occurs together with Cr and Ni in the factor governed by the chromite association. Cr and Ni were not analysed in the Revsund granite as the analytical method was not sufficiently accurate for the low concentrations which occurred. One may presume, however, that in the Revsund granite Mg belongs to the chromite association.

Cu dominates in factor 8. Because Ti and V are also present, this factor is attributed to the group relating to magmatic element associations. The same is applicable to factor 10, where V alone has a high loading, and Sr, Ca, Ti, and Al have moderately high loadings. It is difficult to correlate these two factors with any for the Phyllite or Gneiss Series. The variations of V there are divided among many of the factors which are governed by the crystallisation of basic minerals. Only a small part of the loading for Cu belongs to the group of factors governed by the crystallisation of basic rocks in the Phyllite and Gneiss Series. Factor 8 possibly describes the silicate-bound Cu of the Revsund granite, and factor 10 the occurrence of V-bearing amphiboles.

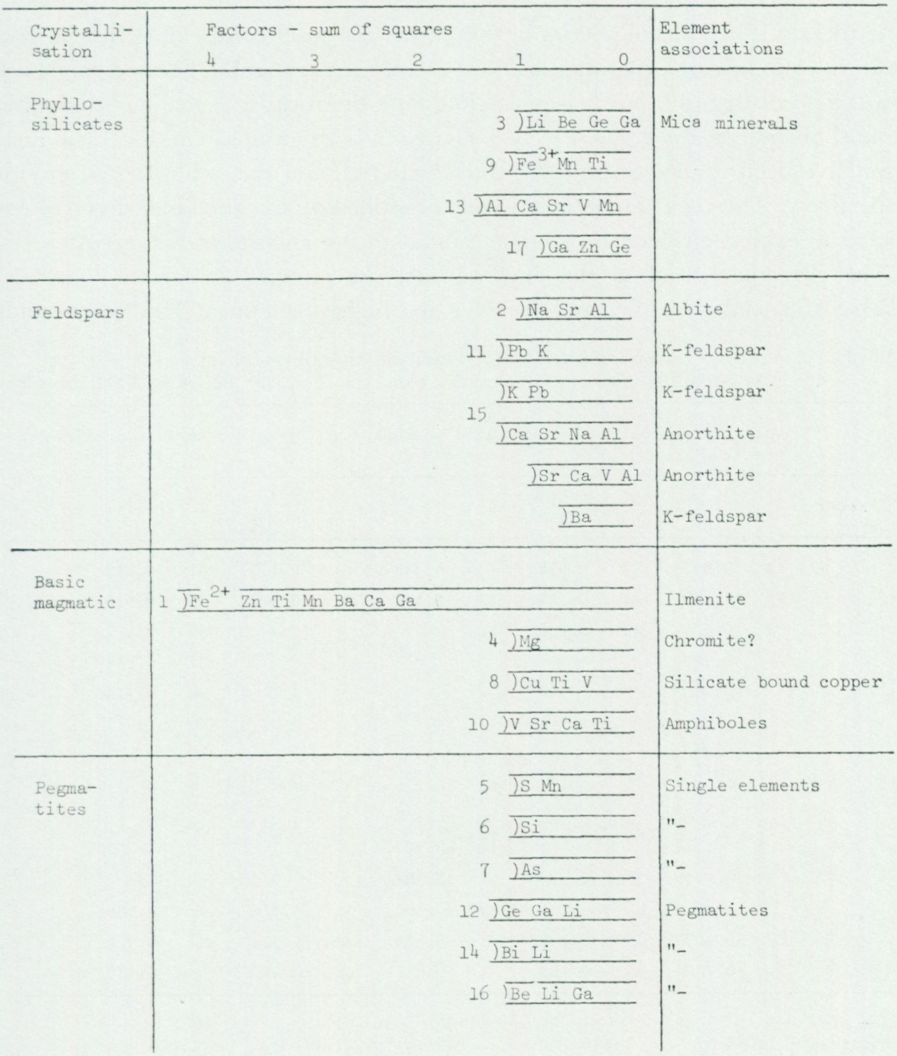
TABLE 19. Varimax factors directed by single elements.
Analysis of 23 elements in 151 samples from the Revsund granite of Västerbotten.

Factor	5		6		7		12		14		16	
	S	0.986	Si	0.977	As	0.975	Ge	0.908	Ba	0.195	Ca	0.114
	Mn	0.136	Ge	0.054	Ge	0.125	Ga	0.242	Cu	0.150		
							Li	0.189				
							Be	0.185				
							Bi	0.159				
											Bi	-0.143
									Be	-0.171	Ge	-0.173
									Ge	-0.180	Ga	-0.198
									Li	-0.191	Li	-0.309
	Si	-0.047	Ba	-0.133	Al	-0.133	Sr	-0.173	Bi	-0.944	Be	-0.882
Sum of squares	1.024		1.018		1.040		1.071		1.090		1.021	

Table 19 contains 6 different factors each dominated by single elements. These factors are therefore difficult to interpret. Some are thought to relate to pegmatitic pneumatolytic reactions, for example factor 4, where Si dominates with a high loading, and factor 16 with a high loading for Be. Factor 12 appears as a twin factor to no. 16. The other factors can relate to the crystallisation of sulphide minerals.

Factor 5 describes the main part of the variations in S concentrations. The mineral in which one expects to find S is pyrite, but as the concentration of Fe is large compared with that of S, the formation of pyrite is not affected by variations in the Fe concentrations. There is always sufficient Fe present for pyrite to be formed. Fe therefore has a low loading in the pyrite factor for the Revsund granite.

The factor analysis, however, does not reveal whether such chalcophile elements as As and Bi crystallise as sulphides or not. The S concentrations in the Revsund granite dominate to such an extent over the concentrations of these



Crystallisation	Factors - sum of squares 4 3 2 1 0	Element associations
Phyllosilicates	3 Li Be Ge Ga	Mica minerals
	9 Fe^{3+} Mn Ti	
	13 Al Ca Sr V Mn	
	17 Ga Zn Ge	
Feldspars	2 Na Sr Al	Albite
	11 Pb K	K-feldspar
	15 K Pb	K-feldspar
	Ca Sr Na Al	Anorthite
	Sr Ca V Al	Anorthite
	Ba	K-feldspar
Basic magmatic	1 Fe^{2+} Zn Ti Mn Ba Ca Ga	Ilmenite
	4 Mg	Chromite?
	8 Cu Ti V	Silicate bound copper
	10 V Sr Ca Ti	Amphiboles
Pegmatites	5 S Mn	Single elements
	6 Si	"-
	7 As	"-
	12 Ge Ga Li	Pegmatites
	14 Bi Li	"-
	16 Be Li Ga	"-

Fig. 4. Element associations in the Revsund granite.

elements that only a small part need be responsible for sulphide formation. The loadings for S are therefore low in factors 7 and 14 which refer to the main variations of As and Bi respectively. It is also possible that As is included in some phosphate mineral. It is thought to be easy for some $(PO_4)^{3-}$ to be substituted by $(AsO_4)^{3-}$ in, for example, apatite. In apatite it should also be possible for Bi to substitute for Ca on the basis of similar ion radii.

The different element associations in the Revsund granite are summarised in Fig. 4.

VOLCANIC SERIES

The rocks of the Volcanic Series in the Skellefte district consist of both acid and basic volcanics, with some intercalations of sedimentary rocks. The sediments are difficult to distinguish, but it is easier to divide the rocks into the acid and basic groups. Sediments are thought to be included in both groups. The statistical analyses have been carried out on the entire material, and the two different groups respectively. The rocks are generally metamorphosed, and therefore they are expected to exhibit element associations similar to the gneisses of Västerbotten.

The elements bound to the phyllosilicates are grouped in factors 1 and 13 (Table 20), and there Ga and Al have the highest loadings. This corresponds

TABLE 20. Varimax factors directed by phyllosilicate crystallisation.
Analysis of 22 elements in samples from the Volcanic Series of Västerbotten.

	Volcanic series, n = 120		Acid volcanics, n = 82		Basic volcanics, n = 38
Factor	1	13	1	3	1
	Al 0.825	Ga 0.939	Si 0.388	Si 0.175	Al 0.918
	V 0.288	Al 0.364	S 0.114	S 0.077	Ga 0.811
	Ga 0.224	Ti 0.236			Si 0.374
	Fe^{3+} 0.205				Ti 0.268
					Na 0.226
			Ga -0.236		
			Mg -0.249		
			Fe^{2+} -0.301		
			Sr -0.368		
			Ti -0.607	Sr -0.176	Ni -0.889
	Cr -0.103	Cr -0.096	V -0.652	Al -0.336	Mg -0.914
	Si -0.250	Si -0.180	Al -0.851	Ga -0.932	Cr -0.936
Sum of squares	1.046	1.214	2.133	1.111	4.603

with the pattern seen in other rock groups where Ga accompanies Al because it can substitute for Al. V, Ti and Fe^{3+} are also included in the groups but with lower loadings. On the basis of the similarity of ion radii between Al^{3+} on the one hand and Ti^{4+}, V^{5+} and Fe^{3+} on the other, these elements can be internally exchanged in the crystal lattice. They therefore occur together in the element association bound to the phyllosilicates. Si and Cr have opposite loadings in both these factors which means that they have negative correlations with the phyllosilicate associations, which in turn means that higher concentrations of Al, Ga, V, Ti and Fe^{3+} correspond to low concentrations of Si and Cr.

It is possible to study more closely the behaviour of these factors by dividing the analytical material into acid and basic groups, and even then Al and Ga re-

TABLE 21. Varimax factors directed by feldspar crystallisation.
Analysis of 22 elements in samples from the Volcanic Series of Västerbotten.

	Volcanic series, n = 120				Acid volcanics, n = 82			
Factor	3	9	14	17	2	7	11	16
	Ca 0.218	K 0.205	Fe^{2+} 0.113	Si 0.468	Sr 0.236	Ca 0.937	Fe^{2+} 0.125	K 0.253
	Sr 0.182	Ca 0.137		K 0.192	Na 0.214	Sr 0.443		Zn 0.129
				Na 0.099	Ca 0.156	Ni 0.378		
						V 0.204		
				Fe^{3+} -0.213				
				Mn -0.239				
	Si -0.110			Sr -0.282				
	Ba -0.172	Si -0.113	K -0.248	V -0.294	Ba -0.182	K -0.188	K -0.228	Sr -0.131
	K -0.864	Na -0.937	Ba -0.963	Ca -0.808	K -0.892	Si -0.732	Ba -0.957	Na -0.938
Sum of squares	0.990	1.020	1.042	1.288	1.013	1.957	1.045	1.049

	Basic volcanics, n = 38			
Factor	4	6	14	15
	Cu 0.187	Ni 0.182	Al 0.202	Si 0.777
	Na 0.130	Ca 0.174	Ga 0.108	Na 0.182
		K 0.147		
	Ba -0.333	Si -0.322	K -0.277	Mn -0.248
	K -0.887	Na -0.931	Ba -0.841	Ca -0.398
Sum of squares	1.012	1.140	0.912	1.021

main the dominant elements (Table 20, factors 1 and 3 in acid volcanics and factor 1 in basic volcanics). In the basic group of the Volcanic Series, Si has transferred to the Al–Ga association because Cr together with Mg and Ni have strong opposite loadings. In the acid group, Si has developed into an even more strong opposite loading. This means that the phyllosilicates are restricted to the intermediate rocks, and in the list of factor scores, one finds that it is the fine-grained andesites, dacites and occasional keratophyres which have the highest values.

The factors affected by variations in feldspar crystallisation are 3, 9, 14, and 17 (Table 21), and it is the elements Ba, Na, K, and Ca which are most affected. Pb usually belongs to the group of elements included in feldspars, but clearly does not in the Volcanic Series. The variations in Pb are restricted to one factor not affected by K, which in the highly metamorphosed rocks is a faithful companion. The various factors illustrate the attempts of the feldspars to differentiate. In factor 3 where K has a high loading, Ca together with Ba form an opposite pole. In factor 9, Na has a negative loading and K a positive, thus they attempt to differentiate. Factor 17 is to some extent a mirror image of factor 3. In the group of basic volcanics, one finds the same pattern in factors 4, 6 and 15, but in factor 14, Al and Ga form opposites. Among the acid volcanics, the relationship is even clearer. The same relationships also appear clearly among the gneisses and Revsund granite of Västerbotten. Ca and Si also have opposite loadings in both the basic and acid groups of the Volcanic Series. It is apparent from the factor scores, that it is mainly the keratophyres which are divided into Na- and K-rich varieties. The Ca-rich types are to be found among the basic rocks such as andesites and dacites. The attempt to differentiate into rock types with different feldspars is seen to be an essential function of greater importance

TABLE 22. Varimax factors directed by sulfide mineral crystallisation.
Analysis of 22 elements in samples from the Volcanic Series of Västerbotten.

	Volcanic series, n = 120			Acid volcanics, n = 82			Basic volcanics, n = 38	
Factor	5	7	12	4	8	13	5	10
	S 0.947	Na 0.124	Si 0.146	S 0.945	Zn 0.959	As 0.947	Al 0.109	Ge 0.125
	As 0.143			As 0.243	Cu 0.175	S 0.246		
	Zn 0.092			Si 0.105				
			S -0.140					
		Cu -0.117	V -0.161				As -0.140	V -0.196
	Ga -0.071	Ba -0.125	Sr -0.195				Zn -0.893	Mn -0.229
	Al -0.123	Zn -0.974	As -0.969	Al -0.172	Na -0.134	Mg -0.091	Pb -0.947	S -0.931
Sum of squares	1.020	1.014	1.102	1.024	1.028	1.022	1.778	1.043

than the differentiation into sodium and potassium feldspar types on the one hand and types with Fe and Mg on the other.

The variations in the chalcophile elements are reflected in factors 5, 7 and 12 for the analyses of the whole Volcanic Series; in factors 4, 8 and 13 for the acid volcanics; and in factors 5 and 10 for the basic volcanics (Table 22). The elements within the group are S, As, and Zn. Cu is included in an association referred to the magmatic group. As appears as a single factor in the basic volcanics, and it is difficult to interpret. Pb also forms a single factor in both the acid volcanics and the Volcanic Series as a whole. In the group of basic volcanics, however, Pb is associated with Zn and As in a typical sulphide mineral factor. The chalcophile element associations are most strongly bound to andesites and keratophyres, but even some felsites have high loadings in the factor scores. One remarkable feature is that none of the samples with high sulphide mineral factor scores show any notable sericite alteration. The samples with sericite alteration have low scores. This illustrates the relationships found in the investigation of alteration zones around metasomatic sulphide ores in the Skellefte district. An alteration zone comprises a wide zone with leaching of heavy minerals and with sericite or chlorite alteration of the rocks. Within these zones, aureoles are sometimes found with considerably increased concentrations of the chalcophile elements. Such aureoles surround the ore bodies. An enriched aureole generally has a very limited extent, and therefore they are not sufficiently well represented in the sampling of the rocks of the Volcanic Series to form a separate factor. An even distribution of samples over the area was attempted. The sulphide mineral factors which have appeared are thus caused by variations which originated during the rock-forming processes, and not with ore formation.

Many different magmatic element associations appear within the Volcanic Series (Table 23). The most important is the chromite association. Cr, Ni and Mg are the main elements, as in the rocks of the Phyllite Series and in the Västerbotten gneisses. The elements Fe^{3+} or Fe^{2+}, V, and less regularly Sr, are also attached to the chromite association. Even Ti may be included.

Another element group among the magmatic associations appears in the ilmenite factor. Here, Fe^{2+}, Ti, and V are the most important elements, but in addition Mn may be included. The factors governed by the elements of the ilmenite association are factors 6, 18, and 8 for the Volcanic Series, acid volcanics and basic volcanics respectively. It is apparent from the factors that knowledge of the association is not made clearer with analysis of the basic rocks, rather the opposite. Among the basic volcanics, many other magmatic element associations develop so strongly that variations in V and Mn, for example, are drawn out of the ilmenite association.

Another prominent factor found in the Volcanic Series, as well as in the phyllites and gneisses of Västerbotten, is one reflecting the variations of Mn and

TABLE 23. Varimax factors directed by magmatic element associations.
Analysis of 22 elements in samples from the Volcanic Series of Västerbotten.

Volcanic series, n = 120

Factor	2	6	10	11	16
	Cr 0.969	Fe^{2+} 0.939	Si 0.238	Si 0.107	Si 0.203
	Ni 0.949	Ti 0.512			
	Mg 0.902	V 0.505			
	Fe^{3+} 0.534	Mn 0.293			
	V 0.391				
	Sr 0.381				
			V -0.233		Ca -0.207
			Ca -0.234	V -0.198	Ti -0.207
	Na -0.197	K -0.159	Fe^{3+} -0.316	Ti -0.213	Fe^{3+} -0.264
	Si -0.520	Si -0.439	Mn -0.831	Cu -0.933	Sr -0.761
Sum of squares	3.896	1.921	1.080	1.075	0.871

Acid volcanics, n = 82

Factor	6	10	12	14	15	18
	Cr 0.978	Fe^{3+} 0.950	Si 0.145	Si 0.088	Mg 0.870	Si 0.264
	Ni 0.862	Sr 0.325			Fe^{2+} 0.323	
	V 0.534	Ti 0.219			Ti 0.186	
	Ti 0.455					
	Cu 0.232					
	Mg 0.207					
	Fe^{2+} 0.202					
	Sr 0.196					
				Fe^{2+} -0.230		Mg -0.206
			Ca -0.121	Ti -0.239		V -0.210
			Fe^{2+} -0.206	V -0.288		Ti -0.281
	Si -0.213	Si -0.170	Mn -0.967	Cu -0.930	Si -0.255	Fe^{2+} -0.765
Sum of squares	2.477	1.198	1.060	1.133	1.094	0.885

Basic volcanics, n = 38

Factor	1	2	3	7	8
	Al 0.918	Fe^{2+} 0.918	V 0.926	Sr 0.129	Ti 0.899
			Mn 0.541	S 0.083	Ga 0.446
			Fe^{3+} 0.254		Fe^{2+} 0.166
			S 0.234		
	Fe^{3+} -0.232				
	Ba -0.325	Mn -0.245			
	Ni -0.889	Sr -0.320		Ni -0.150	
	Mg -0.914	Ca -0.830	Si -0.209	Ge -0.154	
	Cr -0.936	Fe^{3+} -0.864	Sr -0.222	Cu -0.961	Ge -0.130
Sum of squares	4.603	2.669	1.425	1.054	1.167

Ca in particular, but also of V, Fe^{3+} and sometimes Fe^{2+}. The association is found in factors 10, 12 and 2–3 for the Volcanic Series, acid volcanics and basic volcanics respectively. It has been called the rhodonite association and the factor the rhodonite factor, even though the Mn concentration in reality is not bound to the mineral rhodonite, but to other silicates, most particularly amphiboles. In the sediments, a similar association is thought to be possible resulting from precipitation in an oxidising environment. Often, similar associations owe their origins to different geochemical processes. In the basic rocks, the factor is thought to be influenced by magmatic element associations.

An association with Cu, Ti, and V is found in the Volcanic Series in factor 11, and in the acid volcanics in factor 14, while Cu alone dominates in factor 7 for the basic volcanics. The same factor was found in the analysis of the Revsund granite, and was then attributed to the group of magmatic element associations. The element groups have high factor scores in the silica-rich varieties of andesites and in the basic varieties of keratophyres. In most of the samples with high factor scores, the concentrations of S are low, which is also reflected in the factors where S has a low or opposite loading to Cu. The factor is therefore seen to give emphasis to the silicate-bound part of the Cu concentrations. Cu, Ti, and V may be included in amphiboles or pyroxenes instead of Fe^{2+} or Mg. It is natural for Cu to be distributed between the sulphide and silicate phases in the rocks, and that equilibrium is transferred to the silicate phase when the concentration of S decreases. The association is best described as that with silica-bound Cu.

Factors with Sr, Fe^{3+} and Ti have appeared in the analysis of the acid volcanics (factor 10), and of the whole Volcanic Series (factor 16). These are thought to reflect the crystallisation of amphiboles, with extensive interchange between Ca/Mg and Sr/Ti.

TABLE 24. Varimax factors with single elements.
Analysis of 22 elements in samples from the Volcanic Series of Västerbotten.

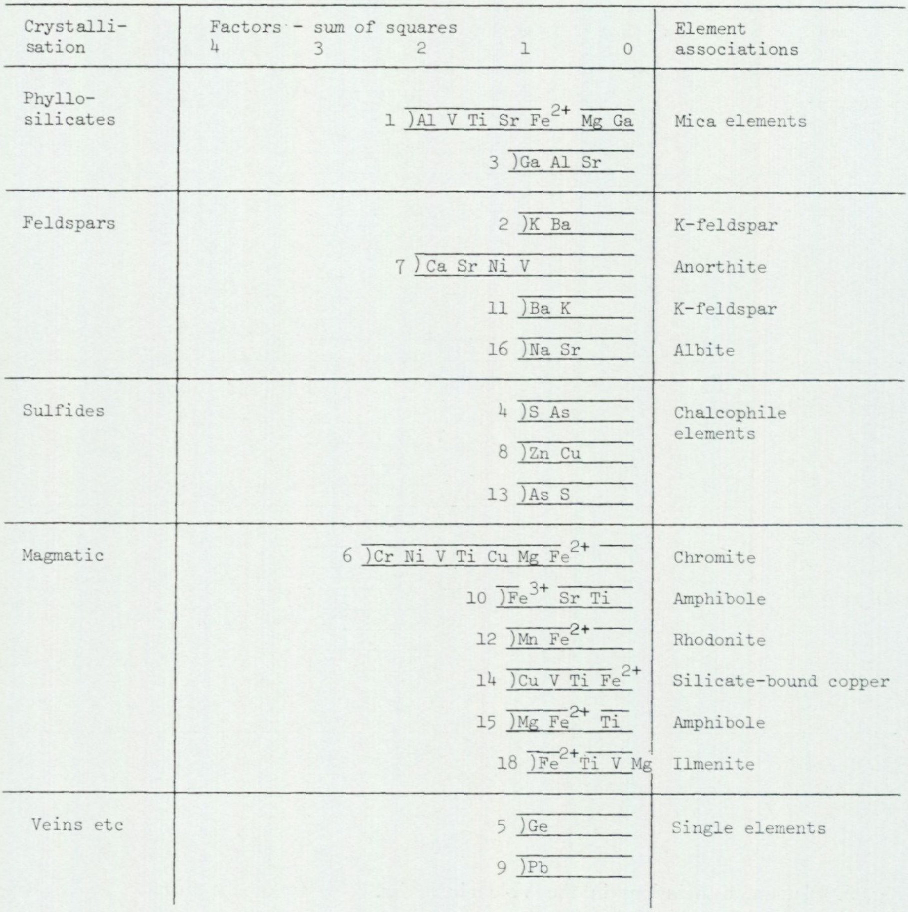
	Volcanic series, n = 120		Acid volcanics, n = 82		Basic volcanics, n = 38		
Factor	4	8	5	9	9	11	13
	Pb 0.989	Ge 0.983	Ge 0.972	Pb 0.981	Zn 0.179	Fe^{3+} 0.173	V 0.164
	Ge 0.079	Pb 0.077	Ga 0.129	Ge 0.107			
		Ca -0.078	Ti -0.087		Cu -0.139	K -0.227	Ga -0.158
	Ba -0.042	Ti -0.141	Mg -0.111	Mn -0.064	Ge -0.931	As -0.945	Sr -0.868
Sum of squares	1.010	1.037	1.027	1.021	1.023	1.106	0.955

Table 24 includes many factors which are dominated by single elements, and whose meaning is difficult to interpret. In the acid volcanics, Ge and Pb form single element factors, and in the basic volcanics, Ge, As and Sr. This can be compared with the relationship in the Revsund granite, where As and Ge, among others, appear in the same manner. Even in the Västerbotten gneisses, Ge appears alone with a high loading in one factor.

The different element associations of the Volcanic Series are summarised in Figs 5, 6 and 7.

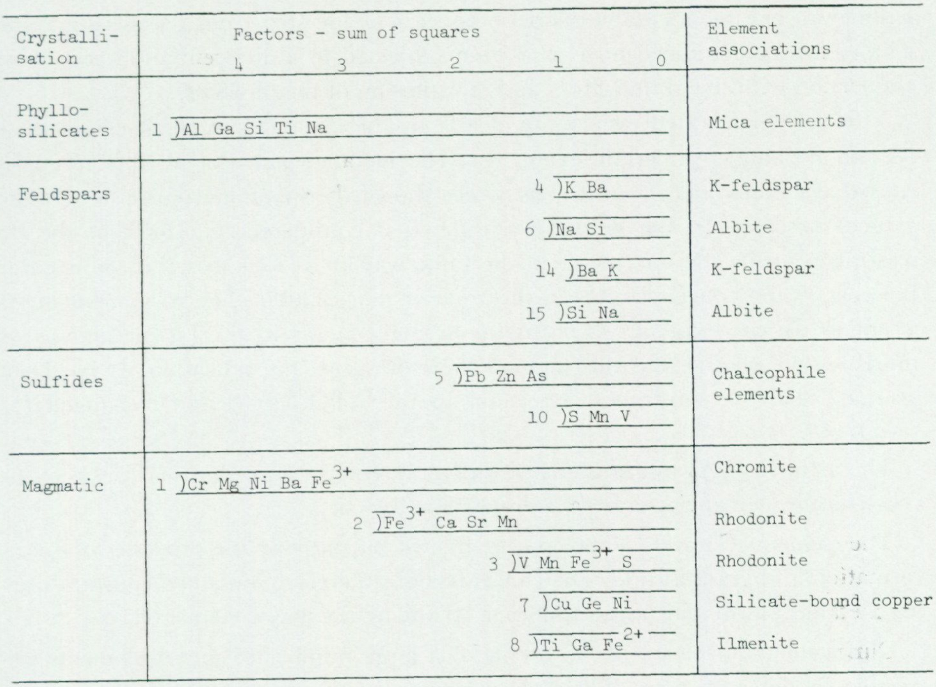
Crystallisation	Factors - sum of squares 4 3 2 1 0	Element associations
Phyllosilicates	1)Al V Ga Fe^{3+} 13)Ga Al Ti	Mica minerals
Feldspars	3)K Ba	K-feldspar
	9)Na Si	Albite
	14)Ba K	K-feldspar
	17)Ca V Sr Mn Fe^{3+}	Anorthite
Sulfides	5)S As Zn 7)Zn Ba Cu -12)As Sr V S	Chalcophile elements
Magmatic	2)Cr Ni Mg Fe^{3+} V Sr	Chromite
	6)Fe^{2+} Ti V Mn	Ilmenite
	10)Mn Fe^{3+} Ca V	Rhodonite
	11)Cu Ti V	Silicate-bound copper
	16)Sr Fe^{3+} TiCa	Sr-amphiboles
Veins etc	4)Pb 8)Ge	Single elements

Fig. 5. Element associations in the Volcanic Series.



Crystallisation	Factors - sum of squares (4 3 2 1 0)	Element associations
Phyllosilicates	1)Al V Ti Sr Fe^{2+} Mg Ga 3)Ga Al Sr	Mica elements
Feldspars	2)K Ba	K-feldspar
	7)Ca Sr Ni V	Anorthite
	11)Ba K	K-feldspar
	16)Na Sr	Albite
Sulfides	4)S As 8)Zn Cu 13)As S	Chalcophile elements
Magmatic	6)Cr Ni V Ti Cu Mg Fe^{2+}	Chromite
	10)Fe^{3+} Sr Ti	Amphibole
	12)Mn Fe^{2+}	Rhodonite
	14)Cu V Ti Fe^{2+}	Silicate-bound copper
	15)Mg Fe^{2+} Ti	Amphibole
	18)Fe^{2+} Ti V Mg	Ilmenite
Veins etc	5)Ge 9)Pb	Single elements

Fig. 6. Element associations in acid volcanics.



Crystallisation	Factors - sum of squares 4 3 2 1 0	Element associations
Phyllosilicates	1)Al Ga Si Ti Na	Mica elements
Feldspars	4)K Ba	K-feldspar
	6)Na Si	Albite
	14)Ba K	K-feldspar
	15)Si Na	Albite
Sulfides	5)Pb Zn As	Chalcophile elements
	10)S Mn V	
Magmatic	1)Cr Mg Ni Ba Fe^{3+}	Chromite
	2)Fe^{3+} Ca Sr Mn	Rhodonite
	3)V Mn Fe^{3+} S	Rhodonite
	7)Cu Ge Ni	Silicate-bound copper
	8)Ti Ga Fe^{2+}	Ilmenite

Fig. 7. Element associations in basic volcanics.

SUMMARY

The sedimentary relationships within the Norrland Geosyncline, where the Phyllite Series was deposited have affected to a high degree the concentrations and distributions of many of the minor elements. Because the Phyllite Series is dominated by sediments deposited in the hydrolyzate and reduzate zones, it contains high concentrations of Ba, Ga, Ag, As, Cu, Pb, Zn, and S. The first two elements belong to the clay mineral environment and the rest have been enriched by precipitation with hydrogen sulphide in the reduzate zone. Basic rocks are interlayered in the Series, and these have increased the average contents of Cr, Ni, Ti, and V in the whole series.

It has been stated as probable that the Västerbotten Gneisses and the Revsund granite have been developed by a metamorphism implying the removal of large quantities of minor elements. In the discussion of the major elements (Svensson 1970), it was suggested that the granitisation of the rock mass was accompanied by a process of dioritisation. K_2O, Na_2O, and SiO_2 were enriched in the centres where granitisation took place and Fe_2O_3, FeO, MgO, and CaO where dioritisation occurred. The distribution of most of the minor elements is considered to have occurred in the same manner. Ba, Be and Bi show high concentrations in the gneisses and the Revsund granite as compared to the original sediments. The most notable increase appears in the step from gneiss to granite. The elements mentioned have thus been subjected to a differentiation process in connection with the granitisation and dioritisation of the phyllites.

This is demonstrated even more clearly by the behaviour of such elements as As and Pb and, to a certain extent, Li. The metamorphism of phyllite to gneiss caused decreases in concentrations while the further metamorphism to granite caused increases. In the Revsund granite, it is considered that most of the Pb was taken up by the microcline in the same way as K, and that this occurred at the cost of the concentrations in the zone of dioritisation. The movement of As is not as easy to explain. As occurs as a single factor in the factor analysis of the Revsund granite and this method therefore gives no indication. It has been assumed that As substitutes for P in apatite, $(PO_4)^{3-}$ being exchanged for $(AsO_4)^{3-}$.

The affinity of As to granite is considerably greater than that of Li, whose increase in the step gneiss–granite is proportionally less.

The elements Ga and Ge have been affected but little by the processes of gneiss formation and granitisation. The concentrations therefore remained constant during metamorphism. The same applies to Al among the major elements.

During metamorphism, the contents of a large number of minor elements decreased in the rock mass. These elements can be divided into two groups. One group consists of the chalcophile elements Ag, Cu, S, and Zn. The other consists of Cr, Mn, Sr, Ti, and V, which all have affinities with the basic rocks. The elements of the first group decreased in concentration most in the step from phyllite to gneiss while those of the second group decreased most in the step from gneiss to granite. The reason for the elements of the first group migrating at the relatively low grade of metamorphism is thought to be that metals bound to sulphides are removed with the sulphides while those which are bound to the silicates remain. Even Pb and As were found mainly in sulphide-bound forms in the Phyllite Series and the factor analysis demonstrates that it is particularly the sulphide-bound part which migrated. The elements of the second group were subjected to redistribution on a large scale when dioritisation started simultaneously with granitisation.

The investigation of the rock series Phyllite–Gneiss–Revsund granite has provided the basis for a model of the metamorphic process. It is suggested that the metamorphism of the sediments began with a moderate increase in temperature because they contained water and other solutions which facilitated recrystallisation. Outgassing caused a decrease in mass. Superheated water and steam together with other solutions escaped through zones of weakness in the cover. In general, the first part of the metamorphism caused homogeneisation. Only when the pressure and temperature had increased sufficiently to initiate granitisation did differentiation occur. Granitisation is thought to have occurred alongside granodioritisation and dioritisation. The grade of differentiation was dependent on the temperature and pressure attained. If the pressure and temperature had reached a sufficiently high level, it is thought that gabbro would have occurred. The composition of the granite, however, was less dependent on the further increases in P and T. It was probably not necessary for the entire rock mass to have been melted for these processes to have occurred. As both the granite and the coeval basic rocks are massive, it is thought that a situation was reached where the viscosity was so low that directional pressure ceased. Some form of partial melting was necessary for this to occur.

Further statistical treatment of the analytical data indicated the tendencies of the elements to occur in associations and showed how these tendencies were controlled by the sedimentary environment and the metamorphic grade.

The element associations developed in the shore zone depended on the enrichment of residual minerals and on those minerals precipitated in oxygenic water. Such precipitation is often dependent on photo-synthetic plants and related fauna.

Quartz is the most common residual mineral. It dominates to such an extent that Si is the only element in the association related to the sandy sediments of the Phyllite Series. Si is thus a single factor. The feldspar-rich arkoses common in the Phyllite Series, show enrichment in Na, the Na being associated with Al. A third element association of the same type builds upon the Li and Be minerals' resistance to chemical weathering. The weathering broke down the feldspars and formed clay minerals, which in their turn were washed away from the shore zone. The association which then occurred includes Li, Be and to some extent Ga and Ge. The chemical or biochemical sediment which occurred in the near-shore zone forms an association with the elements Sr, Mn, Ca, and V. The Phyllite Series is an unusually Ca-poor rock group reflected in the factor which describes the association.

The hydrolyzate zone is noted for clay mineral deposition and the metals in the clays were either bound to the lattice or to the spaces between the sheets, depending on the size of the metals. Al, Ga, and Ge were included in the lattice tetrahedra and form a restricted association favoured by clay sediments. Ba and K were absorbed on the clay minerals lattice plane and form an association group in which even Pb could be expected. Pb, however, had a marked ability to form sulphide minerals and therefore it is included in a chalcophile association. It is possible for Mg to be included in the clay minerals but not Bi, which tended to form basic bismutite which was then deposited in the hydrolyzate zone.

In the reduzate zone, an association of chalcophile elements was formed, including S, Zn, Cu, Pb, Ni, As, Fe^{2+}, and Bi. The environment in which these elements were precipitated is that of the extreme black shales. The variation in mobility of the chalcophile elements causes the association to be divided into various sub-groups even though the metamorphic grade is not particularly high in the Phyllite Series. As and Pb move to the edges of the black shale zones. The association including V also belongs to the graphitic phyllites.

Basic eruptive rocks are found interlayed in the Phyllite Series. The element association which are connected with this environment are largely the same as in the other basic rocks and are therefore treated in the section on basic volcanics.

A considerable redistribution of elements has occurred through the gneissification and later granitisation of the rocks of the Phyllite Series. The clay minerals altered to mica and, sometimes, garnet, cordierite, sillimanite, and, at higher grades of metamorphism, feldspar. New elements in the phyllosilicate association in the gneisses are Fe^{3+}, Mn and Zn, and in the granite stage Ca appears. It is thought that Li was already bound to mica in the residual sediments of the Phyllite Series. To a large extent Zn was absorbed by micas. Fe^{3+} and Mn indicate the environment where mica formation was followed by garnet formation. In summary, the following elements are included in the association connected with the crystallisation of phyllosilicates in the Gneisses and the Revsund granite: Al, Ga, Fe^{3+}, Mn, Li, Zn, and Ca. The association can, however, be divided into two because of the variations of Fe^{3+}, Li, Ca, and Ga.

Much of the Al, Ba, and K which were bound to the clay minerals in the Phyllite Series, was consumed in the gneiss and granite stages through the crystallisation of feldspars. Na, Ca, Sr, and Pb, which belong in other element groups, have also entered into the feldspar associations. In the true gneisses, plagioclase is the main feldspar, but in the contact areas near the Revsund granite, microcline is a constituent in a gneiss type which is very similar to the Revsund granite itself. Three different associations were thus formed on the basis of the feldspar crystallisation. There is an anorthite association with Sr, Ca, and Mn, an albite association with Na as the dominant element, and a microcline association with K, Pb, and Ba. The microcline association is somewhat split because of variations in Pb and Ba.

The main redistribution of the chalcophile elements occurred at the gneiss stage and only a small proportion of these elements are to be found in the sulphide phase of the Revsund granite. In the gneiss stage, Pb and As have almost disappeared from the central sulphide mineral association. The element As appears as a single element in a factor favoured in the granitic gneiss which lies near to the Revsund granite. The sulphide-bound Pb has almost completely left the rock mass, leaving only the silicate-bound Pb. In the Revsund granite, Pb is mainly incorporated in the microcline. Cu, Zn, and Ni have also decreased in the association which relates to the sulphide minerals in the gneiss stage. In the Revsund granite, these elements are found in the group of associations that are termed magmatic and are favoured by basic rock types. The magmatic element associations are treated under the section on basic volcanics.

In both the Gneisses and the Revsund granite many factors occur which are dominated by single elements and therefore, nothing definite can be said about the grouping of these elements in the element associations. In the gneisses it is considered that the elements Bi, Be, Ge, and Si were distributed by pegmatite-forming processes, but the variations in the pegmatites are so great that no associations between the elements have appeared in the factor analysis. In the Revsund granite, the same elements are found in single factors, which may also depend on pegmatite-forming processes in the same way as in the gneisses. S and As also appear as single factors in the granite. The S factor may represent the final remains of the chalcophile element association which was so prevalent in the black shales of the Phyllite Series.

The Volcanic Series of the Skellefte district has been divided into acid and basic groups for statistical reasons. Intermediate volcanics have been included in the acid group and it is thougt that different types of sediments are also included. The contents of most of the analysed minor elements are strikingly low for the series. The trace element contents of the rocks belonging to the Phyllite Series are considerably higher, and the contents become comparable only when the metamorphism progresses to the Gneiss or Revsund granite stage. This appears strange when it is considered that the ores of the Skellefte district are situated within the Volcanic Series, ores which are rich in As, Cu, S, Zn, and even Bi and Pb.

The contents of minor elements in the Volcanic Series are also low in comparison with contents in the earth's crust as a whole. There are, however, differences between the acid and basic groups, the latter having higher contents of As, Cr, Mn, Ni, Sr, Ti, V, and Cu.

Variations in concentrations of such elements as As, Ba, Cu, S, and Zn are higher, particularly in the acid volcanic group. This was caused because the sulphides were easily removed from the rock mass during volcanism. These variations are thus concerned with rock formation and not with ore formation. The ore formation is a completely local phenomenon which cannot be demonstrated by sampling on such a wide basis as in the present study.

The Volcanic Series contains many of the element associations already demonstrated in the series Phyllite–Gneiss–Granite. The elements Al, Ga, V, Ti, and Fe^{3+} are dependent on the phyllosilicates in the same way as in the metamorphic series. In the factor analysis, the element associations are most apparent in the intermediate rock types. In the acid volcanics, Si is an opposing pole and in the basic, Cr.

The elements included in the associations which are dependent on feldspar crystallisation are Ba, Na, K, and Ca, as the case is in the Gneisses and the Revsund granite, but Pb is excluded. The factor analysis reveals a tendency to differentiate into rocks with different feldspars. This differentiation tendency is stronger than the tendency to divide into rocks rich in Na and K feldspars on the one hand and rocks rich in Fe and Mg on the other hand.

The chalcophile element association S, As, Zn, Cu, and Pb appears in the Volcanic Series in a different way. In the acid volcanics, associations with S, Zn and As are the most apparent, while in the basic rocks associations with S, Pb and even Zn occur. Cu shows a strong connection with the basic rocks occurring there together with Ti and V, and clearly belongs to the relatively low concentrations involved in the silicate lattices. The chalcophile associations demonstrated were caused by variations occurring during rock formation. The ore-forming processes were developed more locally than could possibly be demonstrated in this regional study.

In the Volcanic Series, as in the Phyllite Series, the Gneiss Series and the Revsund granite, several element associations occur which can be described as magmatic. Those which could be demonstrated in the rock groups studied are:

Chromite association	Cr Ni Mg
Ilmenite association	Fe^{2+} Ti V
Rhodonite association	Mn Ca V Fe^{2+} Fe^{3+}
Amphibole association	Mg Ca Sr Fe^{3+} Ti
Element association with silicate-bound Cu	Cu Ti V

The chromite association has appeared in all the rock groups. In the Revsund granite, however, the appropriate factor could not be studied because the analytical accuracy for Cr and Ni was not sufficient to allow inclusion of the data in the statistical treatment.

The ilmenite association is also found in all the rock groups analysed. In the Revsund granite, V has decreased, while such elements as Zn, Ba, Ca, and Ga have increased.

The rhodonite association is found in the Phyllite, Gneiss and Volcanic Series, but was not sufficiently strong to be apparent in the Revsund granite.

The opposite is true for the element association with sulphide-bound Cu which appears in the Volcanic Series and in the Revsund granite but not in the Phyllite or Gneiss Series.

Many of the magmatic element associations are most clearly expressed in the basic rocks but the same associations exist also in the acid rocks. If the contents are lower the associations are less obvious. Similar conditions exist even for the other element associations.

The condition which affects the associations is the grade of metamorphism. An association which originated through a specific sedimentary process was weakened progressively with increasing metamorphism. The elements have differing abilities to withdraw from the association and form others. Some associations can consist of the same elements, even though the rocks were formed under such very different conditions as precipitation during sedimentation and mineral formation during granitisation. This depends on similarities in ionic radii, valency, ionic potential or other physical and chemical properties.

The connection between the ore-formation in the Skellefte district and the different rock-forming processes which are thought to have occurred in the area are not fully investigated in this study. Some of the ores have the same compositions as the metal quantities which were redistributed through metamorphism of the Phyllite Series. Such ores are the compact pyrite ores with sphalerite, chalcopyrite and arsenopyrite which, for example, are found at Rakkejaur and Näsliden. Other ores in the Skellefte district are of the so-called hard-ore type, rich in chalcopyrite but poor in pyrite, arsenopyrite and sphalerite. The composition of these ores corresponds better with the material which should be released on metamorphism of the rocks of the Volcanic Series. Such ores are those found in the Adak region. Ores which are intermediate between these two types also occur.

A third possibility for the formation of the ores in the Skellefte district is that the ore material was released from the rock material which was the source of the volcanics, and was brought to the surface during the volcanism. This original rock material is unknown.

The first two alternatives for the origin of the Skellefte district ores are epigenetic, whereas the third alternative is syngenetic.

REFERENCES

SGU = Sveriges geologiska undersökning
GFF = Geologiska Föreningens i Stockholm Förhandlingar

AHRENS, L. H., 1954: The lognormal distribution of the elements. — Geochim. et Cosmochim. Acta 5.
— 1954: The lognormal distribution of the elements (II). — Geochim. et Cosmochim. Acta 6.
— 1957: Lognormal-type distribution (III). — Geochim. et Cosmochim. Acta 11.
— 1964: Element distribution in igneous rocks (VII). — Geochim. et Cosmochim. Acta 28.

BROTZEN, O., 1961: Berggrunden inom östra delen av Bolidenfältet. — GFF 83.

CAMERON, E. M., 1967: A computer program for factor analysis of geochemical and other data. — Geol. Survey Canada, Paper 67–34.

EDELMAN, N., 1962: Mathematics and Geology. — GFF 84.
— 1963: Structural studies in the western part of the Skellefte District, northern Sweden. — GFF 85.

EKLUND, J., 1923: Skelleftefältets geologi. Ref. of lecture. — GFF 45.

GAVELIN, S., 1942: Relation between ore deposition and structure in the Skellefte district. — SGU C 443.
— 1955: Sulphide mineralization in the Skellefte District and its relation to regional granitization. — Econ. Geol. 50, 814—831.
— 1955: Beskrivning till berggrundskarta över Västerbottens län. Urbergsområdet inom Västerbottens län. — SGU Ca 37.
— 1960: On the relation between Kinetometamorphism and Metasomatism in Granitization. — GFF 82.

GAVELIN, S., och GRIP, E., 1946: Skellefte- och Arvidsjaurfälten. — GFF 68.

GRIP, E., 1941: Die Tektonik und Stratigraphie des zentralen und östlichen Teile des Skelleftefeldes. — Bull. Geol. Inst., Uppsala, 30.
— 1945: Arvidsjaurfältet och dess förhållande till omgivande berggrund. — SGU C 474.

GRIP, E., och FRIETSCH, R., 1973: Malm i Sverige 2. — Almqvist & Wiksell, Uppsala.

HELFRICH, H. K., 1970: Der Schlingenbau im Grundgebirge des Renströmgebietes, Skelleftefeld, N Schweden, in montangeologischer und ingenieurgeologischer Sicht. Experimental and natural rock deformation. — Proc. Internat. Symposium, Darmstadt, Springer Verlag, Berlin.
— 1971: Stratigraphische, tektonische, petrochemische und montangeologische Züge am Nordrand der zentralen "Norrlandgeosynklinale". — SGU C 654.

HÖGBOM, A., 1931: Nya iakttagelser inom Norr- och Västerbottens urberg. — GFF 53.
— 1937: Skelleftefältet med angränsande delar av Västerbottens och Norrbottens län. — SGU C 389.

HÖGBOM, A. G., 1899: Skelleftefältets geologi och bergarter. Ref. av föredrag. — GFF 21.
— 1910: Precambrian geology of Sweden. — Bull. Geol. Inst., Uppsala, 10.

KAUTSKY, G., 1956: Skelleftefältets stratigrafi och geologiska historia. — GFF 78.
— 1957: Ein Beitrag zur Stratigraphie und dem Bau des Skelleftefeldes, Nordschweden. — SGU 543.
— 1959: Studien zur Paläogeographie des Archäikums im nördlichen Schweden. — GFF 81.
— 1959: Gesichtspunkte zur Stratigraphie des Archäikums im Grenzgebiet zwischen Västerbotten und Norrbotten, Nordschweden. — GFF 81.

MARMO, V., 1968: The origin of granite, a hydrothermal model. — Litos 1.
— 1971: Granite petrology and the granite problem. — Elsevier, Amsterdam.

MEHNERT, K. R., 1971: Migmatites and the origin of granitic rocks. — Elsevier, Amsterdam.

NAIRIS, B., 1971: Endogene dispersion aureoles around the Rudtjebäcken sulphide ore in the Adak area. — Can. Inst. Min. Bull. Spec. Vol. Nr 11.

NILSSON, C. A., 1968: Wall rock alteration at the Boliden deposit, Sweden. — Econ. Geol. 63.

OFFERBERG, J., 1959: Rocks and Stratigraphy of the Ledfat area, Västerbotten County, Northern Sweden. — SGU C 564.

RANKAMA, K., and SAHAMA, TH. G., 1949: Geochemistry. — The University of Chicago Press.

SAAGER, R., and ESSELAAR, P. A., 1969: Factor Analysis of Geochemical Data from the Basal Reef, Orange Free State Goldfield, South Africa. — Econ. Geol. 64.

SVENSSON, U., 1970: Geochemical investigation of the principal Precambrian rocks of Västerbotten, Sweden. — SGU C 652.

WELIN, E., 1970: Den svekofenniska orogena zonen i Norra Sverige — en preliminär diskussion. — GFF 92.

VESSBY, E., 1968: On the acid volcanics and the ore formation in Skellefte district, Northern Sweden. — GFF 90.

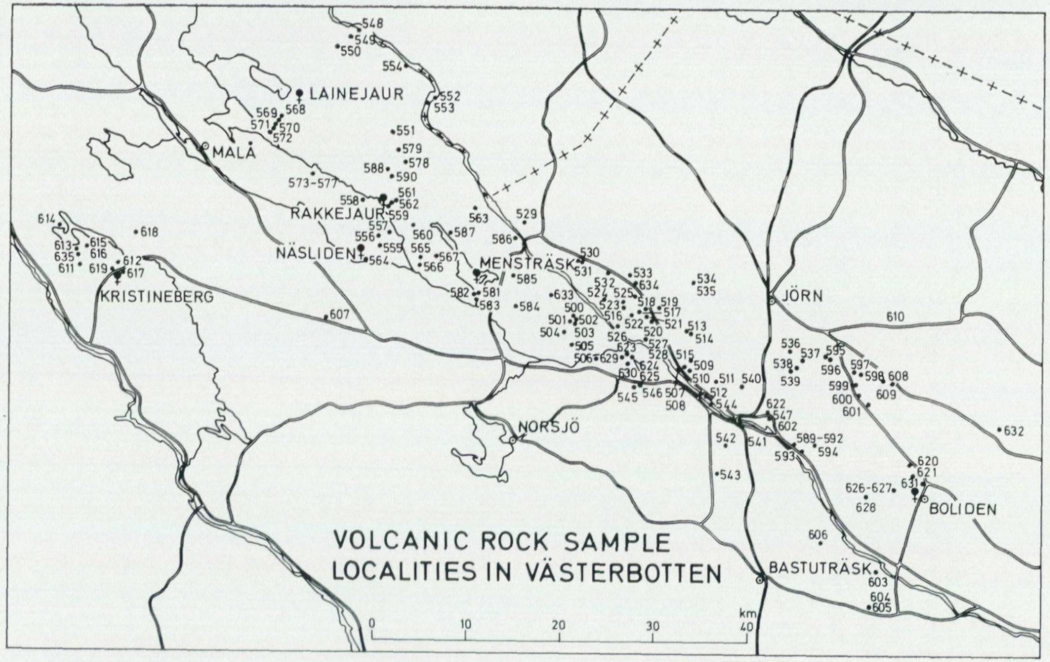

VOLCANIC ROCK SAMPLE
LOCALITIES IN VÄSTERBOTTEN
0
10
20
30
40
km
LAINEJAUR
MALÅ
RAKKEJAUR
NÄSLIDEN
MENSTRÄSK
KRISTINEBERG
NORSJÖ
JÖRN
BOLIDEN
BASTUTRÄSK
548
549
550
554
552
553
569
568
571
570
572
551
579
578
588
590
573–577
558
561
562
559
563
529
557
556
560
587
555
565
567
586
564
566
585
614
618
613
615
635
616
612
611
619
617
582
581
583
584
607
530
531
533
634
534
535
532
524
525
523
518
519
517
633
500
501
502
516
522
520
521
513
504
503
526
514
505
527
506
629
623
528
515
509
624
630
625
510
511
540
545
546
507
508
512
544
536
537
595
538
596
597
539
598
608
599
609
600
601
610
622
547
602
632
542
541
589–592
594
593
543
620
621
626–627
631
628
606
603
604
605

Plate I

APPENDIX I

Analytical results and specific gravity

PHYLLITES IN VÄSTERBOTTEN COUNTY

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
2	1.3	14	650	3	0.4	140	90	24	1.8	60	500	70	140	2.5	300	3700	180	370	2.82
4	1.7	65	300	2	0.4	230	115	14	1.1	20	1250	140	21	1.7	400	3300	150	200	2.81
5	0.9	30	500	2	0.3	150	195	18	1.7	30	600	100	18	2.0	200	4000	180	240	2.75
11	1.1	20	350	1	0.7	20	140	26	1.2	10	1950	70	80	0.2	300	17000	570	290	3.06
18	0.8	15	550	2.5	0.8	150	125	24	1.4	70	650	100	22	2.0	300	4000	200	245	2.76
20	0.3	25	750	2	0.3	90	85	19	1.3	40	950	50	21	0.3	300	4700	240	170	2.78
22	0.3	10	350	2	0.6	80	30	16	1.5	20	300	30	21	0.1	200	3000	80	85	2.76
23	0.4	20	750	2	1.1	150	115	27	1.4	90	600	90	29	0.1	300	4800	220	160	2.79
24	0.5	35	300	1.5	0.3	150	41	17	1.1	50	500	90	25	0.6	400	4200	190	220	2.75
25	0.7	44	350	3.5	0.7	170	180	26	2.2	80	550	130	19	0.7	200	5200	220	240	2.83
26	0.4	6	550	1.5	0.3	250	29	7	1.0	10	850	50	8	0.1	100	2500	70	60	2.71
27	0.4	18	600	1.5	0.3	200	55	19	1.1	110	800	150	14	0.1	500	4400	210	145	2.77
28	0.3	2	1000	2	0.3	180	90	25	1.1	90	750	110	24	0.3	300	5000	200	170	2.83
29	0.6	21	500	2	0.4	90	46	16	1.5	20	550	50	150	0.1	300	3100	80	150	2.71
32	0.3	10	650	2	0.3	250	55	12	1.0	10	750	20	22	0.2	200	3500	100	160	2.73
33	1.0	2	700	3.5	0.4	230	100	27	1.4	130	550	200	22	0.2	300	5500	340	300	2.69
34	0.3	32	250	1	0.3	20	43	16	1.1	10	1200	20	7	0.1	100	2500	20	115	2.79
35	2.3	80	600	1	0.6	50	430	18	0.9	20	1300	300	150	10.6	300	2400	140	2300	2.89
36	0.8	12	550	2	0.8	50	110	20	1.0	30	800	50	105	1.9	200	2800	100	480	2.63
37	0.4	13	700	1.5	0.3	170	65	20	1.3	140	650	100	17	0.1	400	4100	220	150	2.77
44	0.3	7	600	1	0.3	160	40	26	1.3	10	850	70	25	0.1	600	7000	120	145	2.74
45	0.3	4	750	1.5	0.6	300	33	21	1.7	40	750	100	19	0.1	300	3900	140	100	2.77
46	0.3	4	600	2	0.3	170	19	23	1.6	120	650	90	14	0.1	200	4100	140	115	2.80
47	0.3	24	450	1.5	0.3	190	12	18	1.0	30	450	170	12	0.1	300	4400	200	150	2.75
48	0.5	14	500	1.5	0.7	130	140	22	1.6	40	400	100	18	0.1	100	3900	150	160	2.76
49	0.9	7	750	2.5	0.5	170	160	27	1.7	40	350	120	75	0.7	500	4400	300	250	2.77
51	1.9	8	1200	1.5	0.3	170	280	21	0.9	30	1100	210	90	3.9	400	4500	300	380	2.73
53	0.3	15	650	2.5	0.3	120	32	20	1.3	40	600	50	22	0.1	200	4200	140	80	2.65
54	0.3	13	300	1	0.3	140	110	24	1.6	40	250	80	12	1.4	200	4800	250	115	2.77
56	0.3	15	350	3	0.6	140	37	19	1.4	50	600	90	24	0.1	200	4200	160	130	2.80
57	0.3	3	350	2	1.9	20	50	24	1.4	10	1350	60	5	0.1	1100	5500	270	95	2.98
58	0.4	8	500	1.5	0.3	300	60	14	1.3	20	650	140	21	0.2	300	3800	90	150	2.75
59	0.4	25	700	2	0.5	210	105	22	1.9	40	500	120	20	0.4	300	4600	210	200	2.75

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
60	3.6	140	350	1	0.8	40	300	21	1.1	10	1100	190	220	6.3	300	2900	140	2100	2.76
61	1.5	105	600	1	0.8	40	200	18	0.9	20	600	120	120	3.4	200	3100	130	540	2.82
62	0.9	190	600	1	0.6	50	160	14	1.2	10	1050	160	125	5.9	200	2300	100	610	2.84
63	0.3	30	700	0.5	0.3	60	55	16	1.1	10	2300	40	15	0.2	300	3800	260	270	2.82
64	0.3	50	1400	1	0.3	20	23	19	0.5	40	1550	20	11	0.3	200	3800	50	260	2.78
65	0.3	45	600	2	0.3	170	130	22	1.6	20	650	140	25	0.7	300	5200	240	290	2.76
66	0.3	5	450	1.5	0.3	140	55	16	1.4	70	550	80	6	0.1	200	4600	230	120	2.72
67	1.2	12	550	2	0.5	170	180	20	1.5	30	1000	140	27	2.8	300	4800	210	480	2.80
68	0.6	3	550	2	0.4	220	100	22	1.3	50	1100	110	20	0.6	500	7400	250	170	2.79
69	0.3	15	650	2	0.5	420	60	18	1.1	120	900	90	19	0.1	300	5100	180	100	2.72
70	0.4	16	100	0.5	0.3	70	170	21	1.8	10	1900	130	5	0.1	200	12000	470	155	3.03
71	1.0	5	500	3	0.4	160	160	23	1.3	50	800	120	28	1.7	300	3900	200	310	2.75
72	0.3	125	600	2	0.3	160	95	25	1.7	60	450	130	17	1.0	300	4400	230	200	2.79
73	0.3	8	120	1	0.3	310	170	23	0.9	10	1300	190	5	0.1	400	10000	380	180	2.88
74	0.6	13	3300	1	0.3	140	60	17	0.8	40	1000	50	24	0.1	400	2900	100	115	2.72
76	0.3	10	800	1.5	0.3	60	45	12	1.9	10	1000	30	9	0.7	200	3800	100	60	2.75
77	0.6	2	750	1.5	0.3	190	95	23	1.3	70	600	110	32	2.5	400	6300	360	250	2.75
78	0.3	4	250	1.5	0.3	20	15	19	1.1	10	600	20	6	0.1	200	1400	20	85	2.71
79	0.8	70	500	1	0.3	20	120	17	0.8	10	900	70	80	3.1	100	2000	80	590	2.85
80	1.2	4	450	2	0.6	240	250	21	1.6	30	1350	220	250	4.2	400	4700	370	520	2.81
81	0.3	17	750	1.5	0.3	120	21	15	1.2	20	600	50	17	0.1	200	3700	100	60	2.74
82	0.3	14	650	1.5	0.4	160	31	21	1.4	40	600	90	17	0.1	300	4600	170	100	2.79
83	0.3	19	800	2	0.3	200	32	24	1.6	40	600	110	46	0.1	300	4300	150	115	2.76
89	0.3	14	500	1.5	0.3	150	65	15	1.2	30	500	50	11	0.2	200	3400	90	90	2.86
93	0.5	24	450	1.5	0.3	640	80	15	1.2	30	1950	240	7	0.7	500	4700	150	200	2.75
94	0.4	10	200	1.5	0.3	240	50	15	1.2	50	700	70	16	0.1	300	3300	150	90	2.76
96	0.3	90	750	1	0.5	400	55	16	1.0	20	900	110	45	1.1	300	2800	110	270	2.83
97	3.0	100	650	2	1.1	100	420	20	1.1	10	1300	260	220	8.3	400	3000	210	1700	2.89
98	0.3	13	450	1	0.3	270	110	19	1.9	10	1500	50	11	0.1	400	4800	340	115	2.94
99	0.8	9	500	2.5	0.6	210	155	26	1.8	60	500	180	26	0.4	500	3500	340	260	2.81
106	0.3	7	650	2	0.4	150	40	20	1.3	40	550	60	18	0.1	200	4300	150	155	2.73
116	0.3	8	600	2	0.5	80	125	21	1.3	40	1450	60	30	1.5	400	4100	190	130	2.75
117	0.3	5	1100	1	0.3	20	19	16	1.3	10	850	20	12	0.1	400	2400	20	80	2.71
118	0.3	8	400	1	0.3	190	65	19	1.6	70	1000	90	7	0.3	400	6100	260	105	2.81
121	0.4	20	850	2	0.3	70	90	22	1.4	20	1200	30	21	1.4	300	2800	100	120	2.60
122	0.3	2	500	5	0.3	20	3	26	1.1	40	200	20	15	0.1	200	1100	20	75	2.72
129	0.3	16	120	0.5	0.3	150	48	17	1.3	20	1400	80	7	0.1	200	5800	270	115	2.84
130	0.3	3	800	2	0.3	390	220	23	1.6	110	900	260	7	0.9	500	8600	490	170	2.85
131	0.3	35	150	1	0.3	200	70	20	2.2	20	1850	100	4	0.7	700	5900	280	130	2.96

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
132	0.3	22	650	2	0.5	100	55	17	1.9	70	450	70	16	0.1	300	3400	120	85	2.74
133	0.3	15	450	2	0.3	340	14	16	1.2	90	550	100	21	0.1	500	3800	160	70	2.74
138	0.3	60	500	3.5	0.3	20	8	21	1.5	90	400	20	31	0.2	100	1100	20	90	2.65
139	0.3	9	70	0.5	0.5	140	80	16	0.6	10	1650	110	2	0.1	100	7100	400	105	3.05
163	0.3	2	850	2	0.4	200	80	21	1.2	40	500	130	4	0.2	300	4300	200	190	2.80
164	0.3	72	250	1	0.9	320	60	18	1.3	30	950	160	9	0.1	400	9200	380	180	2.90
165	0.4	2	1500	2.5	0.3	300	95	19	1.2	50	950	110	24	0.9	300	5100	180	150	2.76
166	0.3	9	500	2.5	0.3	170	24	17	1.1	40	500	40	25	0.1	200	3700	120	65	2.73
167	0.4	18	750	1	0.3	240	105	20	1.0	40	1000	90	9	0.2	400	6800	310	125	2.87
168	0.3	22	650	1.5	0.3	230	15	17	1.2	40	550	90	19	0.2	200	4200	130	90	2.76
169	0.3	10	550	3	0.3	360	80	18	1.6	60	800	130	16	0.7	500	4100	250	100	2.75
170	0.3	5	600	2	0.6	160	75	19	1.5	40	700	70	18	0.2	200	4000	100	95	2.76
183	0.4	23	550	1	0.6	250	110	22	1.8	60	1000	130	11	0.1	500	6000	220	150	2.85
184	0.3	2	850	1	0.3	20	10	16	0.9	30	650	20	13	0.1	300	1900	40	60	2.67
187	0.3	14	900	2	0.3	90	15	17	1.1	30	550	40	21	0.1	300	3700	80	90	2.72
200	0.3	9	550	2	0.3	100	45	17	1.1	70	400	30	15	0.4	200	3400	90	27	2.73
237	0.3	10	40	1	0.3	90	160	16	1.2	10	1900	90	3	0.2	300	9000	440	125	3.05
243	1.5	10	550	2	0.7	90	320	18	1.4	30	900	90	45	6.4	200	2900	230	400	2.89
244	0.5	25	150	0.5	0.3	1600	180	17	0.9	20	1300	680	4	0.6	500	11000	420	100	3.06
258	0.3	2	450	1.5	0.3	100	23	14	1.0	40	350	40	17	0.1	300	3200	80	75	2.67
259	0.3	15	750	1.5	0.3	130	65	23	1.4	70	500	80	36	0.4	200	4700	150	145	2.81
272	0.3	7	90	0.5	0.4	260	150	18	1.9	10	1500	150	3	0.1	300	5500	370	95	3.00
284	0.3	51	750	2	0.3	170	65	21	1.3	90	600	90	24	0.2	300	4500	180	125	2.74
285	0.3	70	600	1.5	0.3	80	17	18	1.7	40	500	20	34	0.1	200	2500	80	110	2.70
287	0.3	14	200	4.5	0.3	20	22	24	2.0	60	300	20	24	0.2	200	1000	40	150	2.65
288	0.6	3	450	5.5	0.4	50	90	24	1.9	220	500	50	32	1.1	300	2400	100	220	2.69
299	0.5	2	550	2.5	0.8	150	85	26	2.3	70	450	90	27	0.2	300	4100	210	165	2.78
300	0.4	2	450	3	0.4	100	80	21	1.8	40	450	70	23	0.2	200	3300	130	150	2.74
330	0.3	2	350	1.5	0.3	60	55	18	1.2	30	400	30	29	0.5	200	2900	110	175	2.69
332	0.3	2	400	4	0.5	90	22	16	1.6	80	500	50	30	0.1	100	2800	70	90	2.68
335	0.8	2	650	3	0.3	110	210	22	1.2	50	450	100	22	2.1	200	3700	200	280	2.71
348	0.3	16	500	6	0.5	170	60	18	2.1	780	450	80	18	0.2	200	4000	160	210	2.72
360	0.7	4	500	2.5	0.4	150	100	23	2.0	60	700	110	24	0.7	400	4100	200	220	2.79
361	0.7	2	300	4.5	0.4	130	95	27	1.5	70	550	90	28	0.8	300	3900	200	205	2.74
390	0.3	2	450	2	0.4	120	45	22	1.4	70	400	110	20	0.3	400	3100	200	170	2.72
391	0.5	6	650	3.5	0.4	110	100	24	1.8	100	450	100	25	1.1	300	3600	200	260	2.77
435	0.3	42	700	2	0.4	170	23	17	1.4	140	370	40	19	0.1	200	4500	100	80	2.75
436	0.8	5	950	2	1.2	270	180	21	1.6	30	1200	90	24	1.3	200	4000	230	195	2.88
437	0.3	19	1000	2	0.3	90	65	21	1.3	90	400	40	20	0.2	500	3900	80	100	2.79

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
438	0.7	11	620	2	0.8	80	110	20	1.0	20	400	50	48	0.9	100	3100	140	130	2.84
439	0.5	6	350	1	0.3	170	105	22	1.4	20	600	70	18	1.2	100	4200	140	240	2.79
440	0.5	5	280	2	0.4	100	60	18	1.5	30	280	50	11	0.8	100	4100	180	130	2.79
441	1.7	14	580	2	0.7	190	330	24	1.2	50	610	230	34	4.6	300	5000	410	690	2.73
442	0.3	19	650	1	0.5	150	140	25	2.4	120	370	80	25	0.1	300	5000	200	250	2.82
444	0.3	7	580	2	0.3	90	60	18	1.1	90	270	50	14	0.7	100	3200	70	105	2.74
445	0.8	33	800	2	1.1	90	160	24	0.9	20	650	50	26	2.4	100	3900	150	180	2.88
446	0.3	43	200	2	0.3	40	33	19	0.5	160	1250	20	21	0.3	650	3600	100	145	2.88
447	0.4	2	650	2	0.3	50	33	17	0.7	20	340	20	14	0.2	100	1650	20	50	2.70
448	0.8	36	250	1	0.9	250	150	22	2.7	200	950	120	13	0.2	300	7500	280	135	2.99
449	0.3	11	240	3	0.3	40	44	12	0.9	20	450	20	20	0.1	100	2300	40	105	2.78

GNEISSES IN VÄSTERBOTTEN

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
40	0.3	2	650	1	0.3	20	4	21	0.8	20	150	20	43	0.1	300	1300	20	65	2.65
42	0.3	12	350	3.5	0.6	30	7	21	1.1	80	400	20	23	0.1	200	2000	40	105	2.67
43	0.3	10	650	1.5	0.3	130	17	16	0.9	90	450	50	22	0.1	100	3900	100	100	2.73
52	0.3	2	550	4	0.3	120	4	22	1.2	40	550	50	29	0.1	300	4500	120	150	2.76
55	0.4	22	200	2	0.3	220	42	18	1.0	10	1250	100	10	0.1	600	2800	190	110	2.91
114	0.3	3	650	0.5	0.3	30	3	15	1.4	10	200	20	16	0.1	400	1200	110	14	2.67
126	0.3	8	350	1	0.3	20	6	15	0.9	10	300	20	12	0.1	200	1600	20	55	2.68
127	0.3	3	1900	1	0.3	20	3	18	0.7	10	300	20	28	0.1	300	2900	60	100	2.66
134	0.3	2	650	1.5	0.3	130	80	21	1.3	140	400	90	9	1.1	300	4900	240	125	2.76
140	0.3	3	150	2	0.3	20	13	21	1.0	20	600	20	7	0.1	400	2000	60	80	2.68
142	0.3	13	450	2	0.3	20	4	19	1.1	20	150	20	37	0.1	300	650	20	38	2.63
171	0.3	2	900	2.5	0.5	130	40	20	1.2	50	600	60	28	0.5	400	3700	160	110	2.74
179	0.3	11	350	1	0.3	20	7	20	0.3	10	650	20	3	0.1	200	2600	20	60	2.72
180	0.3	25	700	3	0.6	20	16	26	1.6	40	500	20	34	0.1	300	5700	60	180	2.73
185	0.3	2	400	0.5	0.3	20	3	16	1.3	20	400	20	7	0.4	300	1600	40	19	2.69
186	0.3	12	600	1	0.5	20	13	22	2.2	10	1650	20	3	0.1	500	4900	250	140	2.87
190	1.0	52	550	1.5	0.4	180	165	24	2.1	60	750	140	10	1.6	300	4900	410	200	2.76
191	0.3	2	500	0.5	0.3	20	9	18	0.9	20	150	20	35	0.1	200	1500	20	65	2.69
192	0.3	6	700	2.5	0.3	150	9	23	1.3	70	650	100	14	0.1	200	4900	180	170	2.77
194	0.3	3	400	2	0.3	20	55	18	1.5	10	300	20	8	0.1	300	2000	90	34	2.69
207	1	30	950	2.5	1.8	20	21	24	2.0	40	1000	20	20	0.2	400	13000	100	155	2.82

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D̄
208	0.3	2	350	0.5	0.3	20	4	21	0.7	50	250	20	6	0.1	500	3400	30	48	2.72
210	0.3	2	40	1.5	0.3	20	6	18	1.0	10	150	20	54	0.1	100	50	20	22	2.63
212	0.3	2	800	1	0.3	20	8	15	1.0	10	450	20	11	0.1	300	1000	40	27	2.68
220	0.3	12	700	3	0.7	120	15	24	1.4	50	350	20	39	0.1	200	4700	40	135	2.65
221	0.3	2	850	1	0.7	20	12	19	0.8	10	300	20	22	0.1	600	2300	50	70	2.61
222	0.3	10	650	2	0.3	20	4	24	0.9	30	350	20	21	0.1	700	1900	20	75	2.68
224	0.3	5	1500	2	0.3	60	20	25	2.2	20	900	20	10	0.1	700	13000	140	180	2.70
225	0.3	2	1100	3	0.3	50	12	21	1.4	20	650	20	28	0.1	200	2700	60	100	2.67
226	0.4	2	450	2	0.5	120	30	24	1.4	80	600	60	20	0.2	400	4100	130	125	2.77
227	0.3	10	1000	0.5	0.3	20	2	17	1.0	20	700	20	26	0.1	300	1800	20	55	2.70
229	0.4	6	1000	2.5	0.3	60	115	17	1.1	30	350	40	20	1.7	300	2700	100	115	2.81
236	0.3	2	650	0.5	0.3	140	12	17	1.2	30	650	70	21	0.1	300	4100	160	110	2.74
239	0.3	14	550	3	0.3	90	70	18	1.1	40	450	40	21	0.1	200	3200	120	130	2.74
240	0.3	2	600	2	0.5	100	44	26	1.2	40	800	40	15	0.1	400	5300	120	135	2.78
241	0.6	15	850	3.5	0.7	70	46	27	1.4	120	700	30	11	0.1	600	6200	100	150	2.75
247	0.3	8	900	3	0.3	40	60	25	1.7	40	700	20	22	0.2	400	7800	90	220	2.82
248	0.3	10	350	0.5	0.3	20	5	21	0.7	10	400	20	10	0.1	400	1100	40	55	2.67
249	0.3	2	650	1.5	0.3	80	23	17	1.1	20	350	30	31	0.1	400	3700	110	85	2.71
250	0.3	2	550	1.5	0.5	110	180	17	1.0	30	450	80	20	1.2	300	3700	130	170	2.71
251	0.3	2	550	0.5	0.3	130	10	20	1.0	30	550	40	20	0.1	400	3600	140	90	2.72
252	0.3	2	200	1	0.3	110	16	23	1.0	20	500	120	15	0.1	300	3800	120	135	2.72
253	0.3	14	550	2.5	0.3	160	43	24	1.0	40	450	130	14	0.1	400	3600	210	135	2.81
254	0.3	3	250	1.5	0.3	20	8	21	0.9	10	350	20	12	0.1	400	1600	20	60	2.70
255	0.3	7	500	2	0.3	80	22	20	1.3	40	550	40	22	0.1	300	3400	100	95	2.75
261	0.3	22	350	2.5	0.3	100	17	24	1.1	50	450	40	28	0.1	200	4000	110	135	2.70
263	0.3	2	400	1	0.3	20	27	18	0.8	20	400	20	12	0.1	300	2500	50	55	2.68
264	0.8	2	850	4	0.8	130	170	24	1.0	30	450	120	30	3.3	300	4700	270	270	2.74
265	0.3	2	1100	1	1.2	20	4	18	0.7	10	100	20	70	0.1	200	2700	60	60	2.63
266	0.3	2	650	2	0.3	120	35	22	1.6	20	550	60	29	0.2	300	4400	130	115	2.71
267	0.3	2	400	3	0.5	80	38	25	1.5	50	450	30	24	0.2	300	3000	90	125	2.74
273	0.3	11	500	2	0.3	120	48	19	1.4	30	500	50	22	0.2	300	3400	110	95	2.73
274	0.3	24	70	0.5	0.3	350	60	19	1.0	20	1550	110	3	0.2	400	9900	350	165	2.94
275	0.3	2	1000	2.5	0.3	40	26	22	0.9	10	600	20	20	0.1	400	4100	60	85	2.69
276	0.6	2	650	1.5	0.3	140	90	22	1.3	30	550	80	25	1.0	300	4300	160	130	2.73
277	0.3	2	850	2	0.3	120	65	18	0.6	30	350	60	25	0.3	300	3500	130	100	2.70
278	0.3	2	350	2.5	0.3	120	25	21	1.2	20	1050	70	14	0.2	300	4000	130	95	2.76
279	0.3	2	400	3.5	0.6	90	35	24	1.0	30	350	30	19	0.3	300	3700	110	110	2.83
280	0.4	2	500	2	0.3	130	120	23	0.9	20	300	90	16	1.0	300	4500	180	140	2.73
290	0.3	2	500	1	0.3	190	140	26	1.2	50	750	90	17	0.9	300	5800	220	70	2.80

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
291	0.3	7	800	1	0.3	120	21	18	1.0	10	500	30	20	0.1	200	3900	120	95	2.75
292	0.3	2	300	1	0.3	130	14	21	1.3	20	550	40	17	0.1	300	4700	190	135	2.70
293	0.3	40	1000	2	0.5	180	30	30	1.8	40	750	100	26	0.1	300	6200	210	185	2.81
294	0.3	10	650	1.5	0.3	100	6	22	1.1	10	450	50	25	0.1	300	3500	110	110	2.76
295	0.3	4	650	2	0.3	100	18	21	1.3	20	800	40	22	0.1	200	4000	140	175	2.70
297	0.3	2	800	2	0.5	20	10	17	0.7	20	300	40	16	0.1	300	2600	60	65	2.71
304	0.3	2	300	4.5	0.5	120	75	27	1.5	60	800	60	22	0.1	300	4800	150	95	2.71
305	0.3	3	600	1	0.3	140	16	17	1.3	30	600	60	21	0.1	300	4100	160	160	2.70
306	0.3	2	350	2	0.5	110	38	15	0.7	10	200	50	20	0.4	200	2800	90	105	2.70
307	0.3	2	650	4	0.3	140	37	22	1.5	30	500	90	21	0.1	300	3600	20	125	2.83
308	0.3	2	550	3	0.3	140	21	22	1.3	20	450	70	21	0.1	400	3800	110	120	2.76
309	0.3	6	900	3.5	0.3	200	3	26	1.9	20	700	120	25	0.1	400	5700	280	170	2.88
310	0.3	14	550	1.5	0.3	120	38	22	2.0	30	400	60	17	0.1	300	4300	140	130	2.81
311	0.3	7	700	2	0.3	110	17	18	1.0	30	550	60	23	0.1	200	2900	110	110	2.74
317	0.4	10	550	1.5	0.3	140	55	23	1.3	30	500	50	20	0.2	200	3900	130	125	2.73
319	0.3	2	350	2.5	0.6	120	12	17	1.1	40	500	50	18	0.1	300	3900	140	85	2.72
320	0.3	15	600	1.5	0.3	120	36	20	1.7	30	400	60	20	0.1	300	3600	130	110	2.71
321	0.3	2	600	1	0.3	100	60	22	1.1	30	400	50	20	0.2	200	3600	110	140	2.72
322	0.4	2	750	1	0.4	110	80	24	1.2	40	400	70	30	0.2	300	3800	130	140	2.75
323	0.3	12	700	1.5	0.3	150	60	25	1.9	30	600	60	16	0.1	300	5400	180	130	2.76
324	0.3	6	850	0.5	0.3	80	23	15	0.9	10	450	40	19	0.1	200	2900	80	75	2.72
325	0.3	11	600	1.5	0.3	130	7	24	1.2	40	1050	120	18	0.1	300	4500	160	210	2.74
326	0.3	8	1100	3	0.9	20	19	25	1.3	50	450	20	55	0.1	200	2700	20	100	2.67
337	0.3	10	700	3	0.5	100	6	20	1.2	70	550	40	21	0.1	200	3700	130	100	2.77
338	0.3	2	550	2.5	0.4	170	85	18	1.1	50	500	80	16	0.7	300	4100	200	220	2.76
339	0.3	10	500	2.5	0.8	70	21	25	1.6	40	450	40	27	0.1	200	2800	80	100	2.72
340	0.3	5	600	0.5	0.4	80	27	18	1.7	30	350	50	31	0.1	300	3400	80	105	2.70
341	0.3	9	500	1	0.3	80	23	17	1.1	10	150	30	24	0.1	200	3400	100	120	2.69
342	0.3	2	750	1	0.3	140	75	25	1.3	30	700	90	21	0.1	300	5300	160	140	2.83
343	0.3	2	700	1	0.5	90	6	19	1.0	30	400	30	27	0.1	300	3800	130	130	2.68
345	0.3	15	500	1.5	0.3	100	55	16	1.6	60	300	50	18	0.1	200	3300	80	90	2.71
350	0.4	7	650	2.5	0.4	130	37	19	1.6	60	500	70	29	0.1	300	4200	120	95	2.79
351	0.3	2	700	3	0.3	150	45	26	1.1	40	650	90	19	0.1	300	5000	150	145	2.80
352	0.4	2	850	4	0.3	130	190	19	1.0	20	550	110	26	0.6	400	3800	210	115	2.75
353	0.3	2	600	3.5	0.3	120	41	23	0.9	70	500	50	24	0.1	300	3700	180	110	2.72
362	0.3	2	650	1	0.3	110	30	14	1.4	30	400	50	26	0.2	200	3200	70	100	2.71
363	0.3	4	500	3	1.6	70	75	19	2.0	20	1050	60	34	0.8	400	3100	100	100	3.01
364	1.3	2	400	3	1.0	120	135	23	1.1	50	500	80	22	2.9	200	3200	230	250	2.86
365	0.3	7	450	5	1.7	20	2	13	1.4	50	250	20	26	0.1	100	800	20	39	2.63

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
366	0.3	11	650	2	0.3	70	24	18	1.3	40	350	40	31	0.1	300	2600	80	80	2.67
367	0.3	4	500	1.5	0.3	100	24	22	1.6	40	400	60	18	0.2	200	3400	130	140	2.74
369	0.3	2	600	2.5	0.4	100	31	23	2.0	130	500	30	23	0.2	300	4000	130	120	2.70
371	0.3	2	850	3	0.3	150	41	25	1.1	80	500	70	28	0.1	400	4700	170	175	2.77
372	0.5	4	300	1	0.3	210	85	15	1.3	50	300	140	15	0.4	300	3500	130	150	2.74
373	0.3	5	700	2	0.3	100	34	20	1.2	30	450	50	22	0.1	200	4100	110	130	2.72
374	0.3	11	600	1	0.4	100	60	21	1.3	30	400	40	26	0.2	200	3900	130	185	2.73
375	0.3	2	300	2	1.1	90	85	24	1.5	70	500	50	23	0.1	200	3600	130	130	2.71
376	0.3	2	250	1	0.3	100	5	19	1.1	30	450	50	18	0.1	400	3500	110	110	2.74
377	0.3	2	300	0.5	0.3	90	42	24	1.3	20	450	40	18	0.2	300	4500	110	110	2.73
382	0.5	12	200	2.5	0.7	250	80	19	2.5	20	2300	120	4	0.6	1000	12000	500	160	3.11
383	0.3	2	600	3	0.3	80	21	23	1.3	40	500	30	25	0.1	300	3600	110	100	2.72
384	0.3	2	650	0.5	0.6	60	17	16	1.5	30	300	20	25	0.1	200	2300	50	60	2.67
385	0.3	6	1200	1	0.3	40	18	23	1.0	30	300	20	32	0.1	200	6000	50	120	2.70
386	0.3	2	450	2	0.5	100	37	22	1.2	50	500	60	26	0.1	300	2900	120	85	2.73
387	0.5	2	450	1.5	0.5	70	22	21	1.3	40	350	30	26	0.1	200	2700	90	80	2.70
392	0.3	2	450	3	2.1	80	22	25	1.8	160	400	40	19	0.1	100	3400	70	150	2.76
393	0.3	2	300	2	0.3	150	16	22	1.5	50	400	50	17	0.1	200	4000	130	140	2.70
394	0.3	8	450	2.5	0.3	100	26	18	1.0	20	400	50	19	0.1	200	3100	80	120	2.73
395	0.3	2	250	0.5	0.4	90	14	19	1.2	40	350	50	18	0.1	300	2900	100	90	2.68
399	0.3	2	800	2	0.3	110	36	20	1.1	40	350	50	18	0.1	300	4200	110	110	2.74
400	0.3	2	500	0.5	0.5	100	105	23	1.9	20	250	40	30	0.1	300	4300	110	145	2.72
401	0.3	8	600	1	0.3	100	80	24	0.9	60	450	100	23	0.3	200	3800	130	160	2.74
402	0.3	12	600	3.5	0.3	120	55	27	1.2	70	550	60	19	0.2	300	4600	120	140	2.75
403	0.3	8	400	3	0.3	100	31	19	1.4	120	450	40	41	0.1	200	3000	80	120	2.70
404	0.3	3	450	3	0.7	120	26	25	1.4	100	500	60	23	0.1	200	4300	170	70	2.77
405	0.3	2	750	1	0.3	100	35	20	1.1	30	350	50	24	0.1	300	4100	110	110	2.69
406	0.3	2	550	2	0.4	40	12	19	1.3	30	250	20	25	0.1	300	3100	80	95	2.68
407	0.3	4	1400	0.5	0.3	40	9	20	1.6	10	650	20	20	0.1	100	11000	40	115	2.75
408	0.3	3	550	2	1.3	90	37	25	1.6	50	450	50	26	0.2	200	3800	120	100	2.75
409	0.3	6	500	1	0.3	400	34	17	1.4	70	650	110	14	0.1	200	4000	150	90	2.75
410	0.5	16	450	2.5	0.9	210	230	29	2.3	150	400	120	20	0.4	200	4400	150	175	2.77
411	0.3	4	500	4	1.0	120	80	36	2.4	90	400	70	25	0.1	200	4600	150	190	2.72
412	0.3	2	600	2	0.4	40	18	25	1.2	30	450	20	13	0.1	400	5500	70	130	2.71
414	0.3	2	450	1	0.3	40	10	20	0.8	30	400	30	17	0.1	300	2600	50	70	2.67
415	0.5	3	800	5	0.3	150	38	22	1.7	80	950	70	33	0.1	200	4300	180	170	2.69
416	0.3	2	500	9.5	0.3	130	24	23	1.2	40	650	50	30	0.1	200	4200	140	105	2.74
417	0.6	16	900	3	0.6	80	37	23	1.7	40	850	40	30	0.1	400	9000	140	150	2.75
418	0.3	2	550	1.5	0.3	70	21	22	1.1	40	500	50	22	0.1	600	1500	110	245	2.69

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Li	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
419	0.4	2	550	5.5	0.4	120	36	20	1.5	40	350	50	24	0.1	300	3100	140	95	2.70
420	0.3	14	600	0.5	0.3	90	38	20	1.6	30	600	40	18	0.1	300	3800	90	105	2.70
421	0.3	2	350	1.5	0.3	170	28	23	1.4	40	600	60	16	0.1	200	5400	100	115	2.73
422	0.3	2	650	1.5	0.3	100	95	19	1.3	40	400	70	21	0.2	200	3400	130	100	2.71
424	0.3	2	350	4.5	0.3	140	30	23	1.2	40	700	60	24	0.2	300	4200	140	130	2.78
425	0.3	12	400	1.5	0.3	90	29	20	1.3	20	600	30	15	0.2	200	3900	90	110	2.75
426	0.3	2	850	15	0.4	120	23	20	1.3	30	450	70	26	0.1	300	4500	140	90	2.82
427	0.3	2	650	5.5	0.3	160	27	26	1.4	70	450	60	23	0.1	500	4000	120	135	2.61
428	0.4	7	350	2	0.4	110	40	22	1.3	50	400	40	30	0.1	300	4200	150	105	2.73
429	0.4	5	650	3	0.3	110	25	19	1.1	70	700	60	27	0.2	400	3900	140	110	2.73
431	0.3	2	400	6	0.3	100	38	22	1.6	90	550	70	24	0.1	300	3000	140	90	2.71
434	0.3	2	350	2.5	0.5	100	49	22	1.2	50	550	40	34	0.4	200	3800	140	100	2.71

REVSUND GRANITE IN VÄSTERBOTTEN

	Ag	As	Ba	Be	Bi	Cu	Ga	Ge	Li	Mn	Pb	S	Sr	Ti	V	Zn	D
1	0.3	34	550	5	0.4	5	22	1.2	40	250	32	0.1	100	1000	20	85	2.63
3	0.3	4	850	1.5	0.4	6	19	1.4	20	300	21	0.1	100	1200	20	60	2.65
6	0.3	18	1100	2	0.3	12	21	1.1	40	450	24	0.1	200	2600	20	100	2.68
7	0.3	19	1300	2	0.3	15	21	1.2	20	650	25	0.1	200	4000	20	150	2.71
8	0.3	4	600	2.5	0.4	8	23	1.4	60	400	17	0.1	400	2000	40	60	2.67
9	0.3	24	600	2.5	0.4	3	18	0.9	40	300	31	0.1	300	2000	20	90	2.65
10	0.3	17	1000	5	0.6	25	25	1.0	60	550	30	0.2	200	2500	30	130	2.67
12	0.3	29	1100	1.5	0.3	11	26	1.3	40	450	31	0.1	200	2700	50	125	2.66
13	0.3	24	1200	2.5	0.4	11	25	1.1	30	500	27	0.1	200	3000	20	115	2.68
14	0.3	29	1500	2	0.3	13	26	1.5	30	750	18	0.1	300	4800	20	160	2.73
15	0.3	19	1100	2.5	0.3	11	23	0.9	40	600	25	0.1	300	3800	20	125	2.69
16	0.3	2	450	4	1.0	21	19	0.9	20	300	17	0.1	100	1800	20	38	2.62
17	0.3	10	700	4	2.8	13	21	1.1	30	500	39	0.1	300	2600	40	120	2.67
19	0.3	30	950	2.5	0.3	5	20	1.2	30	250	24	0.1	200	1500	30	85	2.64
21	0.3	20	250	3.5	1.2	11	19	1.7	60	300	37	0.1	100	1100	20	70	2.64
30	0.3	18	600	1.5	0.3	24	19	0.8	20	550	18	0.1	500	3700	60	85	2.77
31	0.3	7	550	0.5	0.3	9	17	1.1	10	250	19	0.1	300	1200	40	55	2.64
38	0.3	3	150	1	0.3	3	16	1.2	50	150	85	0.1	200	450	20	45	2.60
39	0.3	8	150	0.5	0.3	7	15	0.9	10	100	55	0.1	100	450	20	50	2.60
41	0.3	2	750	4	0.6	7	23	1.4	20	300	21	0.1	300	1300	50	33	2.64
50	0.3	20	900	1.5	0.3	30	23	0.7	30	650	13	0.1	1300	4300	100	80	2.73
75	0.3	55	900	2.5	0.5	15	23	1.0	40	450	33	0.1	200	2600	20	105	2.67

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cu	Ga	Ge	Li	Mn	Pb	S	Sr	Ti	V	Zn	D
84	0.4	2	450	2.5	0.4	5	22	1.0	30	200	40	0.1	200	850	20	50	2.64
85	0.3	4	700	2.5	0.3	3	20	1.1	50	350	16	0.1	400	1600	20	42	2.67
86	0.3	4	1000	3	0.4	7	20	1.0	20	500	34	0.1	400	2100	20	70	2.68
87	0.3	15	250	4.5	0.3	2	24	1.6	60	200	49	0.1	100	900	20	60	2.63
88	0.3	9	300	5	0.7	5	29	2.0	90	250	60	0.1	200	900	30	65	2.64
90	0.3	13	700	2.5	0.3	5	20	0.8	30	350	33	0.1	200	1600	20	70	2.63
91	0.7	14	550	1.5	0.3	8	22	1.2	30	300	34	0.1	200	1700	20	70	2.61
92	0.3	15	550	1.5	0.3	3	19	1.1	40	300	36	0.1	200	650	20	42	2.63
95	0.3	2	1600	1.5	0.3	13	22	0.8	10	600	24	0.1	200	3800	20	150	2.70
100	0.3	18	1800	3	0.3	23	22	1.0	30	600	29	0.1	600	6600	80	125	2.72
101	0.3	17	1700	2	0.3	25	24	0.8	30	550	29	0.1	500	5900	60	145	2.73
102	0.3	2	400	1.5	0.3	7	15	0.9	20	100	45	0.1	300	300	50	29	2.61
103	0.3	3	750	3.5	0.3	18	19	1.1	40	500	34	0.1	400	2200	40	55	2.67
104	0.3	3	450	1.5	0.3	7	19	0.7	10	600	11	0.1	700	1800	50	45	2.71
105	0.3	56	300	9	0.6	9	22	1.2	100	250	39	0.2	100	1200	20	75	2.64
107	0.3	3	350	1.5	0.3	2	19	1.2	20	200	34	0.1	100	1000	20	26	2.58
108	0.3	6	550	3	0.3	24	22	1.0	40	350	32	0.1	200	2900	30	75	2.65
109	0.3	7	650	2	0.3	8	23	1.0	50	500	44	0.1	100	4100	20	100	2.69
110	0.3	23	650	2	3.6	10	22	1.1	60	450	31	0.1	200	3600	30	95	2.69
111	0.3	70	100	5	1.0	3	25	2.6	70	900	25	0.1	100	250	20	60	2.64
112	0.3	3	700	1	0.8	14	22	1.2	30	550	39	0.1	200	3400	20	125	2.68
113	0.3	14	1300	2	0.3	28	22	0.9	10	700	44	0.2	300	5900	60	170	2.72
115	0.3	13	850	1.5	0.3	19	21	1.1	40	350	29	0.1	200	3200	20	100	2.67
119	0.3	6	550	3	0.3	29	23	0.9	20	750	19	0.2	500	7600	70	145	2.74
120	0.3	6	950	3.5	0.3	8	22	1.4	40	600	23	0.1	400	3000	30	70	2.69
123	0.4	3	850	1	1.4	135	18	0.8	10	300	26	0.1	400	1200	30	27	2.64
124	0.3	24	550	1.5	0.3	9	21	1.2	40	200	29	0.1	100	1700	20	60	2.62
125	0.3	9	20	1	0.3	2	8	0.4	10	80	5	0.1	200	600	20	13	2.63
128	0.3	4	1000	2	0.3	7	22	0.6	30	400	34	0.1	700	2200	40	65	2.67
135	0.3	6	900	3.5	0.3	14	22	1.2	40	450	34	0.1	400	2300	110	85	2.72
136	0.3	2	300	5	0.3	7	19	1.2	70	300	43	0.1	200	850	20	48	2.61
137	0.3	3	200	1.5	0.4	5	19	1.1	30	250	33	0.1	200	750	30	45	2.64
143	0.3	2	900	1	0.3	12	22	0.8	10	350	25	0.1	200	3100	20	70	2.67
172	0.3	4	550	3.5	0.3	12	22	1.2	60	600	28	0.1	400	2200	80	80	2.68
173	0.3	5	800	3.5	0.3	8	19	1.1	30	400	29	0.1	300	3100	20	95	2.70
174	0.3	10	500	3.5	0.6	8	25	1.3	70	300	35	0.1	100	2100	20	80	2.66
175	0.3	2	1500	2	0.3	25	25	1.4	50	1000	25	0.4	400	4900	60	135	2.73
176	0.3	16	1200	2	0.3	14	22	1.2	30	500	24	0.1	300	4900	20	95	2.69
177	0.3	18	900	2.5	0.3	9	22	1.0	60	400	26	0.1	200	3700	30	95	2.68

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cu	Ga	Ge	Li	Mn	Pb	S	Sr	Ti	V	Zn	D
178	0.3	24	650	1.5	0.3	12	20	1.0	20	350	25	0.1	200	3300	30	75	2.66
181	0.3	2	1700	2.5	0.3	18	24	1.0	30	600	24	0.1	400	3900	40	150	2.72
182	0.3	2	950	1	0.3	3	18	0.7	40	150	30	0.1	300	1100	20	55	2.64
188	0.3	18	1100	2	0.3	11	23	1.4	30	350	18	0.1	200	3300	20	90	2.57
189	0.3	26	950	2	0.3	9	22	1.4	40	350	24	0.1	200	3300	20	70	2.69
193	0.3	10	1400	2	0.5	27	25	1.7	50	800	24	0.1	300	10000	60	150	2.77
195	0.3	4	950	3	0.3	9	22	1.4	60	650	22	0.1	500	2700	50	90	2.70
196	0.3	8	800	2	0.4	30	27	1.5	30	600	12	0.1	300	4700	50	110	2.75
197	0.3	35	1000	3	0.6	34	21	1.2	60	600	23	0.1	400	2800	40	75	2.69
198	0.3	15	700	2	0.9	20	24	1.7	40	500	41	0.1	200	3700	20	130	2.66
199	0.3	17	400	4	1.7	11	24	1.3	90	400	42	0.1	100	2600	40	75	2.66
201	0.4	27	900	2.5	0.3	10	22	1.1	40	450	26	0.1	300	3900	20	100	2.69
202	0.3	10	1000	3.5	0.3	19	24	1.1	30	800	25	0.1	400	5900	120	115	2.77
203	0.3	25	700	1.5	0.3	17	20	0.9	30	400	30	0.1	200	3600	20	110	2.66
204	0.4	34	950	2	0.8	13	24	1.2	30	450	24	0.1	300	3600	40	95	2.70
205	0.3	4	500	1.5	0.3	14	18	0.9	30	350	21	0.1	300	1000	20	36	2.62
206	0.3	24	900	1	0.3	23	17	0.9	50	400	31	0.1	200	2900	20	70	2.67
211	0.3	10	1200	3	0.3	15	23	1.2	20	600	27	0.1	400	6600	90	140	2.73
213	0.3	5	350	3	0.3	3	22	1.4	60	200	49	0.1	100	1200	20	60	2.65
214	0.3	12	450	1.5	0.3	5	21	1.2	20	400	24	0.1	400	2300	30	70	2.68
215	0.3	29	700	2	0.6	14	25	1.2	40	400	33	0.1	300	2900	80	85	2.63
216	0.3	30	700	2	0.3	10	19	1.1	20	200	26	0.1	100	1900	20	70	2.68
217	0.3	29	650	3.5	0.3	13	21	1.1	60	550	75	0.1	200	3500	20	130	2.63
218	0.3	22	1100	1.5	0.3	19	24	1.8	20	650	23	0.1	300	6800	60	140	2.74
219	0.3	15	1100	2	0.3	19	22	1.0	30	550	25	0.1	300	5000	20	105	2.73
223	0.3	2	700	2.5	0.3	7	27	1.1	40	450	25	0.1	400	3000	60	80	2.66
228	0.3	2	1000	3	0.3	7	19	0.8	70	300	25	0.1	300	1900	20	55	2.66
230	0.3	4	600	4	0.4	3	21	1.1	40	350	36	0.1	300	1800	30	20	2.61
231	0.3	9	300	3.5	1.6	10	20	1.2	100	350	40	0.1	100	1700	20	65	2.65
233	0.3	54	500	2.5	0.8	10	24	1.2	50	350	31	0.1	200	2600	20	75	2.66
234	0.3	20	700	2	0.3	8	22	1.0	40	400	32	0.1	200	4000	30	85	2.65
235	0.3	9	1400	1.5	0.3	16	23	1.3	30	600	25	0.1	400	5100	50	135	2.70
238	0.3	11	450	0.5	1.6	42	21	0.3	20	450	22	0.1	400	3000	40	85	2.71
242	0.3	18	450	2	0.6	8	23	1.4	40	300	35	0.1	200	1800	30	60	2.86
245	0.3	8	600	1.5	0.4	9	18	0.9	30	300	30	0.1	200	3300	30	90	2.66
246	0.3	6	1100	3	0.3	15	21	1.2	20	600	24	0.1	300	4900	50	110	2.68
256	0.3	8	450	3	0.4	6	18	1.0	70	350	28	0.1	200	1300	20	65	2.62
257	0.3	32	200	11	2.3	3	25	2.2	150	300	29	0.1	100	1100	20	80	2.64
260	0.3	11	1200	2.5	0.3	12	21	1.3	10	650	25	0.1	200	5400	20	140	2.63

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cu	Ga	Ge	Li	Mn	Pb	S	Sr	Ti	V	Zn	D
262	0.3	14	1200	1.5	0.3	18	24	1.2	10	650	19	0.1	300	6500	70	160	2.74
268	0.3	2	700	1	0.6	7	15	1.4	20	250	55	0.1	200	800	30	40	2.63
269	0.3	2	1500	4	0.3	20	23	1.1	60	850	79	0.1	300	4700	50	170	2.70
270	0.3	2	800	2.5	0.5	3	18	1.1	130	200	24	0.1	300	1300	20	45	2.65
271	0.3	31	700	2.5	1.1	26	22	1.6	60	450	31	0.2	300	3900	70	110	2.70
282	0.3	2	1100	1.5	0.4	25	23	1.1	40	500	30	0.1	200	4500	40	140	2.70
283	0.3	4	20	1.5	1.8	5	19	1.5	40	90	20	0.1	100	100	20	30	2.61
286	0.3	25	700	3.5	0.9	18	22	1.4	80	400	31	0.1	200	3200	60	100	2.69
296	0.3	13	700	3	0.3	9	24	1.1	50	500	17	0.1	500	3500	70	85	2.71
298	0.3	6	450	2.5	0.3	2	17	0.8	70	300	22	0.1	300	1500	20	50	2.64
301	0.3	6	400	2	0.3	12	24	0.8	40	150	7	0.1	700	1200	50	65	2.65
302	0.3	12	1400	3	0.3	14	27	1.5	40	650	28	0.1	200	5100	30	170	2.74
303	0.3	11	300	2	0.3	2	22	1.3	60	250	40	0.1	200	1800	20	75	2.64
312	0.3	3	1400	4	0.3	14	27	1.0	40	700	31	0.1	300	3200	20	190	2.72
313	0.3	5	1300	2.5	0.3	7	26	1.3	20	300	46	0.1	200	1600	20	60	2.63
315	0.3	22	800	5.5	0.6	9	29	1.5	90	400	41	0.1	200	2000	20	130	2.66
316	0.3	12	90	5.5	3.1	3	23	2.2	130	200	31	0.1	100	700	20	65	2.61
318	0.3	10	800	1.5	0.7	22	24	1.3	40	550	29	0.2	300	4900	90	125	2.67
327	0.3	4	1100	3.5	0.6	16	26	0.9	60	500	43	0.1	300	3000	30	125	2.71
328	0.3	5	1300	3.5	0.3	11	24	0.9	40	450	44	0.1	200	2600	30	105	2.66
329	0.3	3	50	6	4.7	5	26	1.9	90	150	25	0.1	200	550	30	90	2.63
331	0.3	25	1000	4.5	0.5	16	24	1.2	80	600	46	0.1	200	3400	20	145	2.69
333	0.3	9	1200	4	0.4	11	31	1.5	60	450	39	0.1	200	2500	20	115	2.66
334	0.3	2	450	5	1.2	14	25	1.2	50	250	40	0.1	300	3200	40	120	2.67
336	0.3	7	800	1	0.3	16	20	0.8	30	250	25	0.1	200	4300	20	120	2.69
344	0.3	6	1100	2.5	0.4	12	25	1.5	40	300	39	0.1	200	2100	40	90	2.69
346	0.3	2	600	1.5	0.5	13	25	1.0	40	200	38	0.1	100	2200	20	120	2.67
347	0.3	13	600	3.5	0.7	11	23	1.2	80	350	43	0.2	200	1400	20	95	2.64
349	0.3	2	950	1	0.3	19	21	1.1	10	450	40	0.1	300	5000	40	115	2.75
354	0.3	10	1300	2.5	0.3	16	22	0.9	30	350	41	0.1	300	2100	20	90	2.69
355	0.3	5	1100	3	1.0	15	27	1.2	50	450	42	0.1	300	3100	20	125	2.66
356	0.8	16	1200	2	0.5	13	24	1.3	40	400	42	0.1	300	2300	20	105	2.64
357	0.3	12	1200	2	0.9	19	27	1.5	40	500	42	0.1	200	3300	20	140	2.72
358	0.3	11	1100	2.5	0.3	10	24	1.2	30	300	44	0.1	200	1500	20	80	2.74
359	0.5	19	450	5.5	1.0	6	26	1.4	110	250	39	0.1	200	1500	20	105	2.67
368	0.3	6	800	3	0.7	18	30	1.5	140	700	30	0.1	300	4700	50	220	2.66
370	0.3	8	950	1.5	0.4	24	21	1.0	30	400	32	0.2	200	4200	50	115	2.71
378	0.3	3	200	4.5	1.5	3	23	2.0	90	250	28	0.1	200	1100	20	85	2.64
379	0.3	5	900	5	0.6	17	26	1.6	30	650	38	0.1	200	3700	20	150	2.70

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cu	Ga	Ge	Li	Mn	Pb	S	Sr	Ti	V	Zn	D
380	0.3	22	1000	3.5	1.2	20	24	2.0	50	550	36	0.1	200	3900	40	140	2.79
381	0.3	13	1200	4	0.4	20	24	1.1	50	450	37	0.1	300	3800	30	130	2.71
388	0.3	11	1100	2.5	0.3	12	25	1.1	40	500	38	0.1	200	3700	20	260	2.70
389	0.4	22	1000	3	0.5	20	24	1.1	60	550	30	0.1	200	4000	30	140	2.72
396	0.3	9	300	2.5	1.0	7	22	0.8	40	90	40	0.1	100	2100	20	100	2.64
397	0.3	12	900	3.5	0.5	10	22	1.1	70	300	35	0.2	200	2100	20	85	2.68
398	0.3	7	950	4.5	0.4	15	28	1.3	60	500	36	0.1	300	2600	20	105	2.72
413	0.3	8	1700	3	0.3	12	22	0.9	20	450	33	0.1	200	4800	30	95	2.69
423	0.3	12	1200	2	0.4	17	24	1.4	30	400	36	0.1	200	3100	20	105	2.70
430	0.3	20	1200	3.5	1.0	15	23	1.7	40	750	33	0.1	300	5000	60	125	2.72
432	0.3	13	650	3	0.3	34	20	1.1	30	600	24	0.1	200	4800	80	80	2.73
433	0.3	2	700	1.5	0.3	26	22	1.2	70	500	22	0.1	200	4800	60	125	2.68

VOLCANICS IN VÄSTERBOTTEN

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
500	0.5	21	280	1	0.3	90	48	19	0.9	810	80	5	0.15	500	5400	290	100	2.76
501	0.5	3	240	1	0.3	30	15	14	0.9	670	30	8	0.02	300	1500	40	50	2.69
502	0.5	10	730	1	0.3	30	11	13	0.8	650	20	10	0.01	200	1600	60	50	2.68
503	0.5	3	370	1	0.7	30	25	15	0.8	970	30	15	0.01	200	1800	40	90	2.69
504	0.5	6	250	1	0.3	50	25	12	1.2	680	20	13	0.02	200	600	20	85	2.69
505	0.5	11	190	1	0.3	80	47	16	0.8	1700	100	13	0.01	600	450	320	85	2.92
506	0.5	4	1100	1	0.3	30	18	11	1.0	310	20	5	0.8	100	1200	20	1300	2.68
507	0.5	2	510	1	0.3	70	23	15	1.0	1100	40	10	0.02	200	2400	80	45	2.71
508	0.5	2	530	1	0.3	20	15	10	0.8	450	20	16	0.02	100	1000	30	50	2.66
509	0.5	4	110	1	0.8	30	8	13	0.5	320	20	8	0.01	100	1200	30	5	2.66
510	0.5	4	240	1	0.3	30	55	13	0.9	1750	40	11	0.01	300	2500	120	90	2.80
511	0.5	3	760	1	0.3	1200	39	14	1.0	1450	400	20	0.01	900	3900	230	100	2.88
512	0.5	2	520	1	0.3	50	12	17	1.1	450	30	10	0.01	200	2300	80	45	2.65
513	0.5	2	340	1	0.3	2100	40	10	0.9	1500	900	9	0.01	500	2500	230	85	2.91
514	0.5	6	410	1	0.7	30	95	17	0.7	380	30	10	0.01	300	2000	110	35	2.66
515	0.5	8	1050	1	0.3	90	15	17	1.2	1150	70	12	0.02	400	2600	140	60	2.72
516	1	5	630	1	0.3	50	6	15	0.8	550	30	5	0.02	400	1300	75	30	2.73
517	0.5	47	1300	1		150	55	20	1.0	1550	100	12	0.06	700	12500	320	120	2.82
518	0.5	11	940	2	0.5	20	15	18	2.7	770	20	13	0.01	200	1600	50	85	2.76
519	0.5	2	500	1	0.3	20	2	14	0.8	550	20	7	0.1	100	1700	60	75	2.71
520	1.5	5	800	1	0.3	1030	230	14	1.3	1700	350	17	0.03	100	3500	290	95	2.89

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
521	0.5	20	380	1	0.3	260	95	16	1.1	1750	150	9	0.01	1300	5000	300	100	2.89
522	0.5	9	540	1	0.7	130	28	19	1.1	1550	100	11	0.02	900	5200	320	100	2.91
523	0.5	32	750	1	0.3	70	7	19	0.7	1000	60	5	0.01	700	3500	110	60	2.72
524	0.5	3	210	1	0.3	40	28	8	1.0	440	20	7	0.01	200	950	20	20	2.66
525	0.5	4	560	1	0.3	30	10	15	0.7	670	30	7	0.01	200	1500	40	55	2.71
526	0.5	55	390	1	0.3	210	17	17	1.2	1600	130	6	0.04	1500	4000	180	90	2.82
527	1.5	11	960	1	0.3	160	60	12	0.8	490	80	13	0.01	200	2900	130	100	2.75
528	0.5	7	420	1		350	70	19	0.6	1700	220	6	0.04	600	11600	270	125	2.77
529	1.0	21	520	1	0.3	840	90	15	1.0	1600	340	9	0.03	800	4200	300	90	3.02
530	0.5	39	390	1	0.3	50	21	17	0.3	2000	70	5	0.2	200	5000	350	110	2.77
531	0.5	31	220	1	0.3	40	65	16	0.4	1850	80	43	0.09	200	4700	340	350	2.75
532	0.5	7	60	1	0.3	40	30	15	1.0	1100	50	8	0.02	400	3000	170	80	2.74
533	0.5	2	290	1	0.3	60	30	19	0.9	1150	60	9	0.15	400	5800	290	140	2.77
534	0.5	3	1100	1	0.3	30	26	14	0.9	550	20	26	0.06	100	700	30	100	2.63
535	0.5	2	910	1	0.3	160	60	18	0.4	1500	150	13	0.2	900	10000	230	145	2.87
536	0.5	11	270	2	0.5	180	30	20	0.4	1200	130	12	0.08	1300	5100	200	140	2.84
537	0.5	2	50	1	0.3	40	4	14	1.3	500	20	3	0.02	200	450	40	10	2.66
538	0.5	4	120	1	0.3	30	17	13	1.0	4100	20	5	0.1	100	1400	20	15	2.70
539	0.5	13	220	1	0.3	120	4	16	0.9	1300	90	5	0.04	500	3300	280	40	2.87
540	0.5	5	120	1	0.3	20	3	14	1.0	230	20	7	0.03	100	750	50	10	2.70
541	0.5	3	570	1	0.3	140	41	16	0.8	2000	100	5	0.02	600	4200	290	90	2.90
542	0.5	5	1100	1	2.5	170	14	18	1.0	2300	140	11	0.3	900	4700	400	75	3.02
543	0.5	2	790	2	0.5	20	3	14	1.0	450	20	7	0.35	300	1400	50	25	2.75
544	0.5	2	290	1	0.3	30	40	12	0.9	1100	40	5	0.05	200	2400	60	100	2.74
545	0.5	13	580	1	0.3	20	15	14	0.9	450	30	12	0.02	300	1700	60	65	2.65
546	0.5	2	1800	1	0.3	20	3	14	1.2	590	20	3	0.01	200	1200	20	120	2.69
547	0.5	5	550	1	0.3	20	17	13	0.9	580	20	5	0.1	100	250	30	80	2.66
548	0.5	6	350	1	0.3	120	110	19	0.9	2300	120	6	0.03	500	7600	390	140	3.07
549	0.5	2	200	1	0.3	80	55	18	0.5	1750	100	3	0.06	500	5700	210	125	2.85
550	0.5	2	240	1	0.3	50	20	14	1.0	850	40	8	0.06	200	1800	90	75	2.71
551	0.5	4	380	1	0.3	20	19	15	0.7	660	20	3	0.02	200	1600	40	70	2.71
552	0.5	2	360	1	0.3	40	37	17	0.7	870	60	4	0.01	500	2800	140	85	2.71
553	0.5	7	260	1	0.3	40	8	16	0.8	780	60	6	0.03	500	2700	140	75	2.73
554	0.5	6	470	1	0.3	60	115	11	0.6	1150	60	3	0.05	400	5300	220	75	2.72
555	1	25	540	1	0.3	240	75	15	1.2	1900	150	25	0.03	700	2800	360	190	2.86
556	0.5	11	2200	1	0.3	1600	45	8	0.9	1700	450	2	0.03	500	2400	260	90	2.94
557	0.5	2	7200	1	0.3	40	11	11	0.7	290	30	4	0.01	100	600	50	20	2.64
558	0.5	33	690	1	0.3	30	4	18	1.2	520	30	4	0.01	100	500	40	50	2.64
559	0.5	2	400	2	0.3	20	10	17	0.9	400	30	5	0.06	200	1500	50	75	2.62

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
560	0.5	2	440	1	0.3	40	55	17	0.9	900	50	2	0.05	400	6000	190	110	2.71
561	0.5	2	530	1	0.3	70	12	14	0.5	780	70	3	0.03	600	3100	120	60	2.80
562	0.5	4	250	1	0.3	1800	22	12	1.0	1500	260	2	0.04	700	3000	280	120	2.83
563	0.5	37	1000	1	0.3	480	55	16	0.8	1300	150	8	0.02	1000	5200	220	115	2.86
564	0.5	2	590	1	0.3	1400	17	12	0.7	1450	480	9	0,02	900	3600	240	100	2.92
565	0.5	6	570	2	0.3	40	33	18	1.0	580	30	6	0.01	200	1400	40	65	2.74
566	0.5	4	300	1	0.3	40	70	13	0.6	700	50	6	0.03	200	1800	80	85	2.70
567	0.5	3	480	1	0.3	30	18	15	1.2	1200	30	8	0.02	200	800	20	115	2.70
568	0.5	8	590	1	0.3	30	49	16	1.1	860	40	25	0.06	300	2500	30	145	2.75
569	0.5	4	320	1	0.4	60	120	18	0.9	1550	80	3	0.04	500	7500	290	100	2.87
570	0.5	11	310	2	0.3	20	17	14	0.7	540	30	8	0.01	200	2000	30	65	2.71
571	0.5	19	330	1	0.3	30	39	20	1.2	500	20	37	0.02	100	1900	30	150	2.66
572	0.5	6	430	2	0.3	20	40	18	1.4	820	20	20	0.05	200	2100	20	150	2.68
573	0.5	2	180	1	0.3	30	85	17	0.5	1300	70	6	0.01	500	5400	300	95	2.82
574	0.5	2	340	1	0.3	80	70	18	0.7	1800	110	2	0.02	400	6600	400	115	2.84
575	0.5	14	620	1	0.3	30	65	18	0.5	1600	70	6	0.01	300	4500	230	130	2.74
576	0.5	24	340	1	0.3	30	33	2	0.9	1250	40	5	0.03	200	3400	90	120	2.74
577	0.5	18	380	1	0.3	50	55	15	0.6	1450	80	2	0.10	400	4700	300	90	2.76
578	0.5	10	100	1	0.3	40	11	18	0.6	1200	70	7	0.03	500	4100	250	60	2.75
579	0.5	15	410	1	0.3	30	13	18	1.0	790	40	10	0.00	300	2700	120	60	2.69
580	0.5	5	180	1	0.3	50	15	22	0.6	1100	70	4	0.02	600	3300	130	100	2.77
581	0.5	2	690	1	0.3	40	25	15	0.4	890	60	7	0.01	400	2000	90	55	2.74
582	0.5	10	340	2	0.3	70	45	19	1.1	550	70	8	0.03	400	4300	190	50	2.73
583	0.5	5	310	1	0.3	70	25	12	0.6	1300	110	8	0.06	300	1200	40	50	2.72
584	0.5	2	240	1	0.3	30	65	9	1.1	620	20	8	0.[illegible]	200	1500	30	45	2.69
585	0.5	3	300	1	0.3	20	22	15	0.9	880	30	4	0.05	200	1700	30	70	2.73
586	0.5	2	760	1	0.3	30	75	14	0.6	760	40	8	0.08	400	1500	70	60	2.71
587	0.5	4	920	1	0.3	1400	225	15	1.0	1500	570	6	0.03	800	5000	250	100	2.89
588	0.5	3	240	1	0.3	70	29	19	0.6	930	60	2	0.04	600	2900	120	65	2.74
589	0.5	4	220	1	0.3	700	2	15	0.9	1900	260	6	0.03	600	3800	270	150	2.71
590	0.5	11	550	1	0.3	20	9	16	1.0	410	20	7	0.01	200	450	30	30	2.66
591	1	2	1200	2	1.7	20	9	29	1.2	570	30	12	0.03	200	450	30	65	2.70
592	0.5	6	410	1	0.3	40	31	16	0.9	1550	60	7	0.01	400	4700	230	105	2.72
593	0.5	3	170	1	0.4	90	65	17	0.3	1600	80	7	0.08	400	6300	410	125	2.85
594	0.5	5	430	1	0.3	20	20	14	0.5	620	30	8	0.02	300	1700	40	65	2.69
595	0.5	2	280	1	0.5	20	13	15	0.7	710	20	5	0.01	200	2000	40	45	2.67
596	0.5	14	270	1	0.3	80	50	17	0.6	2350	100	3	0.3	400	6800	430	95	2.87
597	0.5	5	130	1	0.3	180	40	18	0.3	1350	140	10	0.07	1000	8900	250	125	2.80
598	0.5	3	550	2	0.3	40	41	18	0.9	710	40	11	0.03	300	850	80	50	2.67

Appendix I, continued

	Ag	As	Ba	Be	Bi	Cr	Cu	Ga	Ge	Mn	Ni	Pb	S	Sr	Ti	V	Zn	D
599	0.5	2	420	1	0.3	20	10	16	0.9	700	20	6	0.01	400	1200	50	65	2.69
600	0.5	2	510	2	0.3	20	2	17	0.9	350	20	4	0.01	300	1200	40	45	2.69
601	0.5	29	2400	1	0.3	780	15	15	0.5	1700	210	8	0.01	700	5200	280	110	2.95
602	5	46	540	1	0.3	30	5	12	0.4	320	20	14	2.2	200	1000	40	120	2.71
603	0.5	17	450	1	0.3	20	2	10	0.9	190	20	10	0.08	200	1200	30	50	2.65
604	0.5	2	640	1	0.3	20	2	15	0.7	610	20	7	0.01	100	1500	30	60	2.68
605	0.5	2	990	1	0.3	20	5	15	0.8	610	20	9	0.04	200	1600	40	50	2.69
606		3	760	1	0.3	50	14	18	0.9	1300	50	10	0.1	500	4600	130	95	2.75
607	0.5	5	750	3	0.3	300	65	20	1.2	620	200	19	0.2	300	6100	270	250	2.75
608	0.5	3	150	1	0.3	60	21	13	0.6	960	40	9	0.3	400	1700	80	65	2.71
609	0.5	13	220	1	0.3	20	46	18	0.6	1050	30	12	0.1	200	3600	100	120	2.96
610	0.5	3	370	1	0.3	100	185	12	1.1	300	70	8	0.09	200	3900	180	150	2.71
611	0.5	2	600	1	0.3	20	15	12	0.4	560	20	12	0.25	100	1700	20	40	2.73
612	0.5	2	2900	1	0.7	20	110	14	0.3	1000	20	4	0.15	100	2700	30	2100	2.73
613	0.5	3	490	1	0.6	20	2	12	0.5	1000	20	6	0.02	100	2300	30	45	2.68
614	0.5	2	1400	1	0.3	20	4	14	0.3	780	20	2	0.03	200	2600	40	40	2.72
615	0.5	2	940	1	0.3	20	5	13	0.5	440	20	2	0.01	200	1900	20	10	2.69
616	0.5	2	1200	1	0.3	20	7	17	0.7	470	20	3	0.10	100	2800	30	10	2.71
617	0.5	3	220	1	0.3	20	4	16	0.8	370	20	50	0.04	600	3100	90	30	2.74
618	0.5	2	650	1	0.3	20	3	11	0.6	420	20	4	0.01	200	1000	30	40	2.67
619	0.5	2	670	1	0.3	20	2	13	0.3	520	20	11	0.01	100	1600	30	50	2.66

APPENDIX II

Factor matrices

PHYLLITES IN VÄSTERBOTTEN

No transformation

Varimax matrix accounting for 99.3 percent of total problem variance

Factor		1	2	3	4	5	6	7	8	9	10	11
Sum of squares		2.032	3.553	1.603	2.198	1.067	1.027	1.043	1.013	1.068	1.211	1.037
1.000	As	-0.075	.369	-0.089	-0.028	-0.016	.024	.022	-0.022	-0.011	-0.042	.012
1.000	Ba	-0.098	.016	.091	.038	.971	-0.029	-0.047	.018	.008	.076	.054
1.000	Be	-0.167	-0.020	.113	.085	-0.038	.039	.033	-0.055	.309	.142	.087
1.000	Bi	.044	.233	.135	.033	-0.031	-0.086	-0.097	.011	-0.002	-0.047	-0.062
.982	Cr	.129	-0.128	-0.061	-0.955	.006	-0.050	-0.097	-0.083	.020	-0.056	-0.034
.968	Cu	.235	.848	.108	0.183	.019	-0.090	.037	-0.078	-0.048	-0.051	-0.144
1.000	Ga	.232	.110	.660	-0.004	.024	-0.034	-0.123	.023	-0.000	.012	-0.070
1.000	Ge	.084	-0.063	.167	-0.011	-0.080	.008	-0.043	-0.085	.145	.032	.057
1.000	Li	-0.004	-0.069	.077	-0.017	.011	.035	-0.004	.031	.957	.070	.010
1.000	Mn	.315	.146	-0.093	-0.086	.024	-0.071	-0.170	.002	-0.086	-0.382	-0.082
.965	Ni	.246	.408	.035	-0.823	-0.053	-0.046	-0.138	-0.088	-0.007	-0.005	-0.124
.999	Pb	-0.039	.720	-0.013	.038	.020	.010	-0.015	-0.032	-0.051	.014	.025
.968	S	-0.088	.920	-0.065	-0.016	.018	-0.094	.001	-0.076	-0.049	.011	-0.069
1.000	SiO_2	-0.218	-0.174	-0.038	.136	.063	.046	.054	.012	.014	.123	.922
.997	Sr	.129	.000	.135	-0.185	.052	.053	-0.932	.011	.004	-0.154	-0.052
.995	Ti	.869	-0.097	.107	-0.260	-0.074	-0.004	-0.060	.114	-0.001	-0.162	-0.114
.984	V	.789	.123	.187	-0.253	-0.100	-0.065	-0.153	-0.018	-0.012	-0.074	-0.222
.988	Zn	-0.056	.925	-0.015	.006	-0.017	-0.024	-0.028	-0.062	.008	-0.069	-0.045
1.000	Al_2O_3	.110	-0.047	.944	.011	.098	-0.076	-0.095	.130	.090	.103	-0.017
1.000	Fe_2O_3	.037	.134	.078	-0.063	.029	-0.966	.046	.068	-0.035	-0.075	-0.041
.999	FeO	.133	.284	-0.011	-0.048	-0.038	.108	-0.002	-0.099	-0.005	-0.004	-0.094
.992	MgO	.309	.077	.128	-0.561	-0.104	.046	.008	.004	-0.016	-0.333	-0.128
.998	CaO	.164	.059	-0.122	-0.097	-0.098	-0.094	-0.168	-0.037	-0.086	-0.894	-0.127
1.000	Na_2O	.069	-0.164	.128	.134	.018	-0.071	-0.010	.950	.029	.030	.011
1.000	K_2O	-0.287	.086	.218	.145	.236	.105	.125	-0.146	.047	.146	.076
Eigenvalue		5.64	3.78	2.95	1.71	1.35	1.19	1.10	0.96	0.90	0.78	0.75
Percent		22.6	15.1	11.8	6.8	5.4	4.7	4.4	3.8	3.6	3.1	3.0

Appendix II, continued

PHYLLITES IN VÄSTERBOTTEN — No transformation

Varimax matrix accounting for 99.3 percent of total problem variance

Factor		12	13	14	15	16	17	18	19	20	21	22
Sum of squares		.992	.968	.999	1.086	.996	.448	.870	.734	.169	.443	.274
1.000	As	.064	.907	.033	.032	-0.100	.062	-0.009	-0.040	-0.004	.041	-0.011
1.000	Ba	-0.028	-0.013	-0.033	.074	-0.027	.006	-0.127	-0.011	-0.002	-0.026	.003
1.000	Be	.032	-0.115	-0.069	-0.144	.863	.011	-0.136	.115	.000	-0.054	.045
1.000	Bi	.940	.058	.083	-0.069	.027	.037	.001	-0.009	.002	.005	.021
.982	Cr	-0.031	-0.038	.031	-0.008	-0.034	-0.001	.053	-0.025	-0.013	.027	-0.024
.968	Cu	.139	-0.002	.170	-0.083	-0.009	-0.072	.005	-0.060	.196	-0.065	.003
1.000	Ga	.118	-0.054	-0.007	-0.272	.239	-0.012	-0.259	.054	-0.001	.018	.508
1.000	Ge	.066	-0.027	.020	-0.949	.108	-0.007	-0.024	.025	.005	.011	.037
1.000	Li	-0.003	-0.007	-0.003	-0.137	.210	-0.018	-0.026	.043	-0.001	-0.003	-0.001
1.000	Mn	.015	.065	.123	.047	-0.165	.009	.189	-0.762	.005	.052	-0.017
.965	Ni	-0.004	.065	.021	.006	-0.018	-0.032	.045	-0.021	.033	.029	.035
.999	Pb	.102	.161	-0.015	.020	.023	.655	-0.078	-0.014	-0.005	.025	-0.006
.968	S	.074	.138	.204	.068	.006	.045	-0.021	-0.033	.041	-0.110	.004
1.000	SiO_2	-0.065	.010	-0.094	-0.063	.071	.009	-0.050	.049	-0.004	-0.037	-0.013
.997	Sr	.098	-0.020	.001	-0.048	-0.025	.006	.078	-0.094	.002	-0.001	.022
.995	Ti	.030	-0.031	.078	-0.039	-0.131	-0.005	.137	-0.119	-0.172	.011	.045
.984	V	.042	-0.093	.122	-0.117	-0.050	-0.023	.120	-0.129	.259	.121	.013
.988	Zn	.069	.185	.008	.063	-0.030	.038	-0.024	-0.025	-0.177	.198	.027
1.000	Al_2O_3	.102	-0.067	-0.009	-0.100	.023	-0.002	-0.065	.036	.007	.031	-0.051
1.000	Fe_2O_3	.079	-0.019	-0.092	.007	-0.028	-0.004	.060	-0.037	.003	-0.011	.006
.999	FeO	.087	.031	.921	-0.022	-0.056	-0.006	-0.020	-0.071	.004	.010	-0.001
.992	MgO	.016	.137	.029	-0.044	-0.157	.032	.091	-0.106	.006	.594	.010
.998	CaO	.053	.036	-0.004	.038	-0.115	-0.008	.095	-0.197	.001	.079	-0.002
1.000	Na_2O	.010	-0.019	-0.091	.084	-0.041	-0.011	.087	-0.001	-0.003	.000	.004
1.000	K_2O	-0.005	.016	.033	-0.039	.167	.049	-0.803	.161	-0.004	-0.040	.057
Eigenvalue		0.70	0.53	0.48	0.41	0.37	0.32	0.27	0.22	0.17	0.15	0.11
Percent		2.8	2.1	1.9	1.6	1.5	1.3	1.1	0.9	0.7	0.6	0.4

Appendix II, continued

GNEISSES IN VÄSTERBOTTEN No transformation

Varimax matrix accounting for 99.5 percent of total variance

Factor		1	2	3	4	5	6	7	8	9	10	11
Sum of squares		4.211	1.257	1.160	1.078	1.353	1.054	1.073	1.165	1.047	.991	1.292
1.000	As	.128	-0.011	-0.020	-0.003	-0.010	-0.036	.964	.118	.043	.096	-0.035
1.000	Ba	-0.140	-0.038	-0.956	.038	-0.020	.022	.019	.033	-0.016	.008	.133
1.000	Be	.086	-0.005	-0.017	.089	-0.022	-0.065	-0.043	.014	-0.969	.044	.085
1.000	Bi	-0.095	.042	.017	-0.010	-0.096	-0.949	.038	.106	-0.069	.123	.110
.968	Cr	.950	.024	.092	.016	-0.012	.088	.033	-0.027	-0.025	.071	-0.031
.998	Cu	.347	.013	.012	.021	-0.441	-0.052	.037	-0.056	.002	.092	-0.026
1.000	Ga	.125	-0.056	-0.014	.267	.003	-0.077	.074	.034	-0.106	.145	.043
.999	Ge	.171	-0.051	-0.011	-0.006	.046	-0.161	.129	.237	-0.060	.866	-0.005
1.000	Li	.165	.089	.050	.136	-0.009	-0.163	.021	-0.085	-0.115	.130	.012
.988	Mn	.387	-0.216	.007	.053	.028	-0.043	.105	.297	-0.044	.125	-0.143
.998	Ni	.833	-0.043	.055	.071	-0.191	.037	.073	.013	-0.038	.010	-0.069
1.000	Pb	-0.166	.132	-0.122	-0.040	.015	-0.106	-0.038	-0.062	-0.091	-0.005	.926
.999	S	.148	.002	-0.017	-0.026	-0.950	-0.093	.004	.024	-0.022	-0.047	-0.018
1.000	SiO_2	-0.415	.061	.078	-0.177	.075	.015	-0.038	-0.148	.117	-0.108	.015
.999	Sr	.083	-0.930	-0.046	.032	.001	.047	-0.000	.085	-0.012	,040	-0.137
.994	Ti	.308	-0.132	-0.240	.005	.020	-0.071	.117	.058	-0.014	.204	-0.092
.998	V	.694	-0.186	.054	.030	-0.271	.039	.112	.159	-0.037	.128	-0.092
1.000	Zn	.374	-0.033	-0.098	.117	-0.247	-0.034	.101	.035	-0.026	.105	.011
1.000	Al_2O_3	.134	-0.028	-0.043	.941	.022	.012	-0.004	.074	-0.095	-0.007	-0.028
1.000	Fe_2O_3	.114	-0.088	-0.033	.077	-0.025	-0.113	.132	.924	-0.013	.190	-0.070
.978	FeO	.652	-0.090	-0.036	.063	-0.235	-0.115	-0.001	.114	-0.106	.103	-0.066
.963	MgO	.835	-0.067	.064	.135	.037	.016	.101	.151	-0.047	.062	-0.141
.992	CaO	.145	-0.406	.091	-0.005	-0.011	-0.037	.174	.085	.083	.043	-0.233
1.000	Na_2O	-0.313	-0.141	.099	.015	.019	.036	.029	-0.075	.099	-0.101	-0.149
1.000	K_2O	-0.068	.213	-0.333	.087	.085	-0.125	-0.010	-0.103	-0.062	-0.006	.474
Eigenvalue		7.53	3.39	2.22	1.51	1.45	1.33	1.05	0.88	0.74	0.67	0.62
Percent		30.1	13.6	8.9	6.0	5.8	5.3	4.2	3.5	3.0	2.7	2.5

Appendix II, continued

GNEISSES IN VÄSTERBOTTEN No transformation

Varimax matrix accounting for 99.5 percent of total variance

Factor		12	13	14	15	16	17	18	19	20	21	22	23
Sum of squares		1.020	.877	1.005	.811	1.056	1.050	.789	1.420	.176	.239	.553	.196
1.000	As	-0.019	.025	-0.023	-0.057	-0.059	.065	-0.022	.112	.003	-0.016	-0.005	.006
1.000	Ba	.047	.044	.079	-0.055	-0.007	.130	.005	-0.040	.002	.007	.106	-0.005
1.000	Be	-0.098	.067	.079	-0.016	-0.081	.017	-0.000	-0.022	.005	-0.005	.024	.003
1.000	Bi	-0.146	.011	.031	-0.021	-0.062	.051	-0.032	.030	.005	.005	.049	-0.003
.968	Cr	-0.097	.053	.099	-0.049	.009	.053	-0.030	.033	-0.067	.029	-0.024	-0.077
.998	Cu	-0.084	.041	.058	-0.091	-0.086	.027	-0.797	-0.030	.002	-0.024	-0.026	.023
1.000	Ga	-0.159	.087	.026	-0.160	-0.882	.134	-0.064	-0.020	.008	-0.009	.058	.005
.999	Ge	-0.156	.087	.112	-0.081	-0.153	.160	-0.073	.081	.009	-0.023	-0.003	.001
1.000	Li	-0.916	.063	.032	-0.055	-0.142	.006	-0.057	-0.083	.002	-0.005	.027	.004
.988	Mn	.047	.232	.049	-0.045	-0.043	.207	.051	.665	.288	-0.093	-0.077	.019
.998	Ni	-0.044	.056	.121	-0.117	-0.049	-0.048	-0.192	-0.035	.011	-0.014	.042	.407
1.000	Pb	-0.003	-0.016	.123	-0.003	-0.022	-0.061	.014	-0.146	-0.007	.014	.121	-0.008
.999	S	.002	.039	.007	-0.127	.013	-0.002	-0.203	-0.006	.002	-0.028	-0.032	.015
1.000	SiO_2	.095	-0.797	-0.034	.137	.117	-0.135	.043	-0.181	-0.012	.029	-0.014	-0.008
.999	Sr	.076	.038	-0.115	-0.021	-0.056	.078	.007	.238	.018	-0.027	-0.077	.006
.994	Ti	.003	.121	.009	-0.153	-0.169	.785	-0.007	.257	-0.010	-0.043	-0.016	-0.011
.998	V	-0.032	.131	.129	-0.115	--0.050	.151	-0.110	.183	.013	-0.468	-0.018	.010
1.000	Zn	-0.084	.143	.087	-0.786	-0.231	.173	-0.096	.052	.008	-0.027	.016	.017
1.000	Al_2O_3	-0.123	.108	-0.014	-0.068	-0.213	.007	-0.013	.017	.004	-0.005	.034	.006
1.000	Fe_2O_3	.083	.095	.067	-0.022	-0.029	.043	.035	.138	.007	-0.021	-0.044	-0.000
.978	FeO	-0.096	.200	.200	-0.181	-0.176	.418	-0.162	.117	.247	.054	-0.037	.005
.963	MgO	-0.046	.174	.062	-0.095	-0.108	.169	-0.060	.254	.034	.004	-0.053	-0.148
.992	CaO	.125	.078	-0.171	-0.033	.065	.174	.004	.750	-0.157	.012	-0.149	-0.022
1.000	Na_2O	.033	-0.026	-0.897	.061	.025	-0.024	.043	.074	-0.007	.021	-0.049	-0.012
1.000	K_2O	-0.059	.019	.101	-0.024	-0.116	-0.030	.040	-0.259	-0.008	.007	.687	.011
Eigenvalue		0.55	0.48	0.42	0.39	0.31	0.29	0.24	0.20	0.17	0.16	0.14	0.12
Percent		2.2	1.9	1.7	1.6	1.2	1.2	1.0	0.8	0.7	0.7	0.6	0.5

Appendix II, continued

REVSUND GRANITES IN VÄSTERBOTTEN No transformation

Varimax matrix accounting for 99.3 percent of total problem variance

Factor		1	2	3	4	5	6	7	8	9	10	11
Sum of squares		4.093	1.020	1.004	1.017	1.024	1.018	1.040	1.024	1.060	1.096	1.080
.999	As	-0.034	.015	-0.051	-0.071	.011	-0.028	.975	.007	-0.020	.025	.046
.999	Ba	-0.632	.050	.148	.003	.019	-0.133	-0.033	-0.099	.122	.027	.002
.999	Be	.049	-0.025	-0.297	-0.060	.044	.037	.112	.080	.014	.021	-0.085
.999	Bi	.115	-0.036	-0.153	.041	-0.015	.044	.019	-0.057	-0.079	.018	.011
1.000	Cu	-0.206	-0.032	.071	-0.016	.067	-0.036	-0.008	-0.956	.003	-0.094	.039
.999	Ga	-0.406	.055	-0.153	.029	.012	.023	.053	.002	.053	-0.012	-0.052
.999	Ge	-0.026	.017	-0.171	.052	-0.001	.054	.125	.087	.007	-0.011	-0.042
1.000	Li	.100	-0.006	-0.874	.048	.049	.045	.067	.090	-0.025	.044	-0.084
.998	Mn	-0.685	-0.021	.041	-0.060	.136	-0.085	.087	-0.103	.200	-0.145	.027
1.000	Pb	.053	.176	-0.069	.005	.003	.021	-0.051	.041	-0.099	.071	-0.941
1.000	S	-0.104	-0.025	-0.035	.002	.986	-0.046	.011	-0.061	-0.013	-0.070	-0.002
1.000	SiO_2	.160	.008	-0.034	-0.014	-0.047	.977	-0.027	.034	-0.046	.002	-0.019
.999	Sr	-0.129	-0.227	.044	-0.042	-0.006	-0.003	-0.066	-0.103	.095	-0.294	.136
.962	Ti	-0.866	.105	.073	-0.047	.055	-0.063	.023	-0.124	.138	-0.228	.099
.999	V	-0.270	-0.052	.038	-0.051	.093	.001	-0.031	-0.110	.085	-0.895	.077
.988	Zn	-0.902	.044	-0.066	-0.038	.062	-0.058	.031	-0.018	.082	.032	-0.105
.995	Al_2O_3	-0.203	-0.138	.034	-0.027	.044	-0.062	-0.133	-0.044	.051	-0.162	.097
.998	Fe_2O_3	-0.194	-0.066	.019	-0.069	-0.015	-0.048	-0.022	-0.003	.958	-0.073	.094
.942	FeO	-0.925	.105	.058	-0.008	.010	-0.073	-0.028	-0.108	-0.007	-0.105	.056
1.000	MgO	-0.066	.010	.032	-0.988	-0.002	.014	.068	-0.015	.063	-0.040	.005
.967	CaO	-0.563	-0.081	.122	-0.078	.044	-0.055	.043	-0.052	.108	-0.231	.181
1.000	Na_2O	.203	-0.915	-0.008	.014	.032	-0.010	-0.017	-0.035	.075	-0.050	.191
1.000	K_2O	.005	.183	-0.067	.024	.043	-0.053	.094	.031	.020	.104	-0.186
Eigenvalue		6.08	3.43	2.28	1.24	1.15	1.05	1.02	0.86	0.83	0.70	0.69
Percent		26.4	14.9	9.9	5.4	5.0	4.6	4.4	3.7	3.6	3.0	3.0

Appendix II, continued

REVSUND GRANITES IN VÄSTERBOTTEN

No transformation

Varimax matrix accounting for 99.3 percent of total problem variance

Factor		12	13	14	15	16	17	18	19	20	21
Sum of squares		1.071	1.417	1.090	1.070	1.021	.827	.794	.489	.361	.226
.999	As	.101	.094	-0.018	.076	-0.085	.033	.032	-0.012	-0.020	-0.001
.999	Ba	-0.069	-0.118	.195	.063	.053	.106	-0.087	.668	-0.048	.002
.999	Be	.185	.041	-0.171	.084	-0.882	.152	.030	-0.023	-0.013	.010
.999	Bi	.159	.013	-0.944	.014	-0.143	.042	.049	-0.070	.018	.009
1.000	Cu	-0.075	-0.046	-0.053	-0.028	.066	-0.002	-0.056	.036	-0.025	-0.005
.999	Ga	.242	-0.140	-0.062	.090	-0.198	.815	-0.013	.060	-0.017	.007
.999	Ge	.908	.055	-0.180	.084	-0.173	.170	.105	-0.031	-0.039	.005
1.000	Li	.189	.058	-0.191	.073	-0.309	.123	.032	-0.069	.014	.012
.998	Mn	.147	-0.156	.067	-0.069	-0.042	.041	-0.144	.074	-0.576	-0.015
1.000	Pb	.038	.111	.010	.170	-0.073	.037	.077	-0.002	.008	.013
1.000	S	.000	-0.037	.013	.033	-0.032	.008	.001	.007	-0.030	-0.001
1.000	SiO_2	.043	.053	-0.041	-0.042	-0.030	.013	.003	-0.045	.019	.002
.999	Sr	-0.173	-0.359	.087	-0.198	.043	.013	-0.763	.062	-0.062	-0.011
.962	Ti	.005	-0.099	.053	-0.011	.102	-0.027	-0.046	.050	.023	-0.247
.999	V	.016	-0.198	.015	-0.107	.018	.007	-0.172	-0.013	-0.041	-0.012
.988	Zn	.021	.013	-0.038	.070	-0.019	.215	.019	.022	.047	.287
.995	Al_2O_3	-0.035	-0.893	-0.013	-0.164	.019	.103	-0.163	.060	-0.031	.028
.998	Fe_2O_3	.005	-0.058	.075	.015	-0.011	.034	-0.052	.044	-0.044	-0.004
.942	FeO	-0.021	-0.124	.070	-0.034	-0.009	.106	-0.008	.060	-0.061	-0.019
1.000	MgO	-0.041	-0.032	.036	-0.020	-0.040	-0.016	-0.022	-0.000	-0.014	-0.003
.967	CaO	-0.081	-0.520	.150	-0.218	.114	.033	-0.254	-0.034	-0.082	-0.284
1.000	Na_2O	-0.015	-0.144	-0.040	-0.180	-0.023	-0.040	-0.130	-0.021	-0.006	-0.002
1.000	K_2O	.084	.190	-0.015	.912	-0.078	.069	.119	.026	.019	.010
Eigenvalue		0.56	0.52	0.46	0.42	0.36	0.33	0.29	0.25	0.18	0.15
Percent		2.4	2.3	2.0	1.8	1.6	1.4	1.3	1.1	0.8	0.7

Appendix II, continued

VOLCANICS IN VÄSTERBOTTEN   No transformation

Varimax matrix accounting for 99.2 percent of total problem variance

Factor		1	2	3	4	5	6	7	8	9	10	11
Sum of squares		1.046	3.896	.990	1.010	1.020	1.921	1.014	1.037	1.020	1.080	1.075
1.000	As	.060	.031	-0.015	.078	.143	.062	.006	.028	.018	-0.065	.016
1.000	Ba	-0.033	.058	-0.172	-0.045	-0.014	-0.100	-0.126	-0.019	.068	.030	.007
.976	Cr	-0.103	.969	.034	-0.020	-0.025	-0.004	-0.002	.055	.041	-0.032	-0.052
1.000	Cu	.054	.240	.042	.034	-0.011	.171	-0.117	.038	.036	-0.070	-0.933
1.000	Ga	.224	-0.099	-0.051	.062	-0.071	.118	.006	.063	-0.068	-0.042	-0.001
1.000	Ge	-0.042	.047	-0.031	.079	-0.057	-0.074	.049	.983	-0.036	.015	-0.031
.999	Mn	.075	.288	.148	-0.039	-0.044	.293	-0.022	-0.021	.048	-0.831	-0.089
.970	Ni	-0.016	.949	.066	.010	-0.014	.058	.013	.021	.089	-0.069	-0.132
1.000	Pb	-0.021	.005	-0.033	.989	.019	.015	-0.010	.077	-0.048	.023	-0.029
1.000	S	-0.076	-0.064	.026	.021	.974	-0.042	-0.092	-0.059	.010	.028	.009
.980	SiO_2	-0.250	-0.520	-0.110	.002	.083	-0.439	-0.033	.076	-0.113	.238	.117
.996	Sr	.183	.381	.182	-0.007	-0.040	.109	.029	-0.028	-0.035	-0.108	-0.003
.998	Ti	.171	.177	.071	-0.026	-0.005	.512	-0.037	-0.141	.019	-0.158	-0.213
.962	V	.288	.391	.156	-0.005	.006	.505	.009	-0.055	.029	-0.233	-0.198
1.000	Zn	-0.026	-0.021	.007	.011	.092	-0.002	-0.974	-0.050	.109	-0.013	-0.102
.999	Al_2O_3	.825	-0.121	.047	-0.038	-0.123	.254	.042	-0.067	-0.024	-0.079	-0.070
.982	Fe_2O_3	.205	.534	.132	.026	.020	-0.125	-0.007	.008	.081	-0.316	-0.161
.989	FeO	.116	.086	.095	.024	-0.042	.939	.003	-0.059	.107	-0.137	-0.118
.977	MgO	.013	.902	.065	.013	-0.047	.199	.007	-0.016	.101	-0.150	-0.093
.997	CaO	.128	.324	.218	-0.025	-0.042	.073	.047	-0.078	.137	-0.234	-0.092
.999	Na_2O	.014	-0.197	.156	.057	-0.012	-0.117	.124	.042	-0.937	.041	.036
1.000	K_2O	-0.045	-0.177	-0.864	.049	-0.039	-0.159	.012	.045	.205	.138	.053
Eigenvalue		7.32	2.72	1.68	1.43	1.38	1.24	1.00	0.80	0.75	0.66	0.62
Percent		33.3	12.3	7.6	6.5	6.3	5.6	4.5	3.6	3.4	3.0	2.8

Appendix II, continued

VOLCANICS IN VÄSTERBOTTEN No transformation

Varimax matrix accounting for 99.2 percent of total problem variance

Factor		12	13	14	15	16	17	18
Sum of squares		1.102	1.214	1.042	.517	.871	1.288	.680
1.000	As	-0.969	.039	-0.012	-0.043	-0.097	-0.080	-0.031
1.000	Ba	-0.011	-0.045	-0.963	.001	.014	.039	-0.010
.976	Cr	.001	-0.096	-0.033	.003	-0.037	-0.055	-0.023
1.000	Cu	.020	.004	.008	-0.071	-0.008	-0.075	-0.061
1.000	Ga	-0.038	.939	.046	-0.073	-0.092	-0.068	-0.033
1.000	Ge	-0.026	.049	.017	.042	.016	.052	.005
.999	Mn	-0.095	.058	.050	-0.071	-0.083	-0.239	-0.120
.970	Ni	.006	-0.023	-0.007	-0.076	-0.052	-0.135	.061
1.000	Pb	-0.073	.050	.041	.008	.003	.014	-0.005
1.000	S	-0.140	-0.067	.013	.002	.021	.033	-0.003
.980	SiO_2	.146	-0.180	-0.037	.079	.203	.468	.158
.996	Sr	-0.195	.176	.030	-0.119	-0.761	-0.282	-0.120
.998	Ti	-0.133	.236	.003	-0.642	-0.207	-0.165	-0.150
.962	V	-0.161	.169	.012	-0.134	-0.084	-0.294	-0.428
1.000	Zn	.006	-0.007	-0.121	-0.011	.015	.030	-0.001
.999	Al_2O_3	-0.085	.364	.052	-0.079	-0.145	-0.150	-0.099
.982	Fe_2O_3	-0.060	.075	-0.048	-0.155	-0.264	-0.213	-0.582
.989	FeO	-0.023	.074	.113	-0.071	-0.017	-0.018	.064
.977	MgO	-0.042	-0.025	-0.027	.002	-0.142	-0.087	-0.211
.997	CaO	-0.104	.080	.062	-0.074	-0.207	-0.808	-0.091
.999	Na_2O	.020	.069	.075	.008	-0.014	.099	.026
1.000	K_2O	-0.022	.063	-0.248	.033	.128	.192	.064
Eigenvalue		0.53	0.42	0.37	0.34	0.22	0.20	0.15
Percent		2.4	1.9	1.7	1.6	1.0	0.9	0.7

Appendix II, continued

ACID VOLCANICS IN VÄSTERBOTTEN No transformation

Varimax matrix accounting for 99.4 percent of total problem variance

Factor		1	2	3	4	5	6	7	8	9	10	11
Sum of squares		2.133	1.013	1.111	1.024	1.027	2.477	1.957	1.028	1.021	1.198	1.045
.999	As	-0.104	-0.023	.005	.243	.052	.038	.022	-0.027	.052	.109	.044
1.000	Ba	.021	-0.182	.030	-0.012	-0.035	-0.001	-0.085	.133	-0.054	.012	-0.957
.987	Cr	-0.058	.008	-0.033	.011	.063	.978	.019	.004	.048	.048	-0.016
.998	Cu	-0.117	.042	.061	.003	-0.003	.232	.051	.175	.022	.012	.013
.998	Ga	-0.236	-0.093	-0.932	-0.074	.129	.098	.073	-0.004	.079	.071	.031
1.000	Ge	.046	-0.023	-0.110	-0.061	.972	.051	-0.096	-0.045	.107	-0.022	.034
1.000	Mn	-0.031	.086	.013	-0.046	.016	.025	.158	.014	-0.064	.069	.064
.982	Ni	-0.199	.026	-0.094	-0.018	-0.006	.862	.378	-0.003	-0.015	.026	.014
1.000	Pb	.014	-0.037	-0.067	.026	.104	.027	-0.031	-0.019	.981	.056	.050
.998	S	.114	.038	.077	.945	-0.066	.004	-0.060	.098	.028	.012	.013
.985	SiO_2	.388	-0.012	.175	.105	.058	-0.213	-0.732	.056	-0.016	-0.170	-0.041
1.000	Sr	-0.368	.236	-0.176	-0.014	-0.075	.196	.443	-0.082	-0.001	.325	.083
.999	Ti	-0.607	.083	-0.015	-0.014	-0.087	.455	.140	.074	.037	.219	.072
.959	V	-0.652	.111	-0.042	.027	.012	.534	.204	-0.064	-0.061	.146	.048
1.000	Zn	.031	.006	.005	.093	-0.047	-0.002	-0.070	.959	-0.020	.042	-0.132
.978	Al_2O_3	-0.851	-0.020	-0.336	-0.172	-0.043	.067	.146	-0.035	-0.009	.115	-0.017
.999	Fe_2O_3	-0.164	.034	-0.067	.015	-0.019	.081	.053	.048	.062	.950	-0.017
.997	FeO	-0.301	.120	.038	-0.037	.016	.202	.113	-0.029	.087	-0.091	.125
.999	MgO	-0.249	-0.016	-0.051	-0.063	-0.111	.207	.037	-0.037	-0.010	.184	.064
.992	CaO	-0.049	.156	.010	-0.018	-0.082	.180	.937	-0.047	-0.046	-0.024	.076
1.000	Na_2O	-0.073	.214	-0.086	-0.022	.037	-0.034	-0.095	-0.139	.070	-0.059	.075
1.000	K_2O	.044	-0.892	-0.110	-0.045	.028	-0.045	-0.188	-0.011	.051	-0.046	-0.228
Eigenvalue		6.20	2.12	1.88	1.68	1.54	1.30	1.12	1.04	0.87	0.83	0.68
Percent		28.2	9.6	8.5	7.6	7.0	5.9	5.1	4.7	4.0	3.8	3.1

Appendix II, continued

ACID VOLCANICS IN VÄSTERBOTTEN

No transformation

Varimax matrix accounting for 99.4 percent of total problem variance

Factor		12	13	14	15	16	17	18	19
Sum of squares		1.060	1.022	1.133	1.094	0.049	.441	.885	.149
.999	As	.026	.947	.039	-0.070	.005	.002	.043	.002
1.000	Ba	.066	-0.044	.014	-0.054	.071	-0.025	.067	-0.006
.987	Cr	.004	.023	-0.098	.059	-0.002	.024	-0.036	.009
.998	Cu	-0.031	-0.042	-0.930	.072	.038	-0.007	-0.127	.016
.998	Ga	.015	-0.012	.059	.036	-0.080	.053	.020	.002
1.000	Ge	-0.016	.047	.003	-0.080	-0.033	-0.022	-0.004	-0.007
1.000	Mn	-0.967	-0.024	-0.029	.045	-0.008	.003	-0.104	.008
.982	Ni	-0.042	.018	-0.122	.132	.053	.039	-0.081	.008
1.000	Pb	.060	.047	-0.019	-0.003	-0.060	-0.000	-0.042	.003
.998	S	.049	.246	-0.004	-0.050	.020	-0.005	.022	-0.001
.985	SiO_2	.145	-0.078	.088	-0.255	-0.028	-0.048	.264	.042
1.000	Sr	-0.005	.005	.016	.077	-0.131	.624	-0.067	.014
.999	Ti	-0.108	.025	-0.239	.186	.042	.055	-0.281	.376
.959	V	-0.024	.019	-0.288	.133	-0.026	.113	-0.210	-0.041
1.000	Zn	-0.014	-0.024	-0.155	-0.030	.129	-0.025	.016	.006
.978	Al_2O_3	.001	.134	.005	.169	-0.108	.072	-0.066	-0.035
.999	Fe_2O_3	-0.072	.110	-0.015	.135	.060	.079	.042	.014
.997	FeO	-0.206	-0.086	-0.230	.323	.096	.035	-0.765	.025
.999	MgO	-0.052	-0.091	-0.085	.870	.121	.031	-0.206	.016
.992	CaO	-0.121	-0.014	-0.020	-0.072	.093	.076	.034	.033
1.000	Na_2O	-0.006	-0.005	.039	-0.100	-0.938	.040	.057	-0.004
1.000	K_2O	.109	.027	.054	.009	.253	-0.078	.079	-0.008
Eigenvalue		0.64	0.51	0.43	0.33	0.23	0.19	0.16	0.11
Percent		2.9	2.3	2.0	1.5	1.1	0.9	0.7	0.5

Appendix II, continued

BASIC VOLCANICS IN VÄSTERBOTTEN No transformation

Varimax matrix accounting for 98.8 percent of total problem variance

Factor		1	2	3	4	5	6	7	8	9	10	11
Sum of squares		4.603	2.669	1.425	1.012	1.778	1.140	1.054	1.167	1.023	1.043	1.106
.996	As	.120	.009	.010	-0.183	-0.140	-0.018	.078	.003	-0.047	-0.007	-0.945
.996	Ba	-0.325	-0.187	.002	-0.333	.054	.083	.003	.071	-0.023	-0.023	-0.141
.975	Cr	-0.936	-0.157	-0.099	-0.022	.069	.099	-0.042	-0.081	-0.091	.084	.086
.999	Cu	-0.105	-0.068	.056	-0.061	-0.070	-0.008	-0.961	.089	-0.139	.073	.074
.957	Ga	.811	.100	.020	-0.004	-0.043	-0.047	-0.052	.446	.047	-0.083	-0.007
.999	Ge	-0.192	-0.136	.017	-0.004	.081	-0.007	-0.154	-0.130	-0.931	.125	-0.050
.994	Mn	.055	-0.245	,541	.045	-0.086	.076	-0.043	-0.020	-0.016	-0.229	-0.064
.967	Ni	-0.889	-0.132	-0.120	-0.003	.040	.182	-0.150	-0.028	-0.046	.046	.111
.989	Pb	-0.032	-0.046	.077	-0.071	-0.947	-0.015	-0.044	-0.095	-0.062	-0.024	-0.085
.999	S	.156	.036	.234	.063	-0.002	-0.074	.083	.114	.129	-0.925	-0.006
.988	SiO_2	.374	.019	-0.209	-0.064	-0.032	-0.322	.044	-0.102	.093	-0.150	.021
.996	Sr	-0.009	-0.320	-0.222	.066	.039	-0.092	.129	.083	-0.106	.019	-0.157
.984	Ti	.268	.165	.030	-0.112	.009	-0.082	-0.099	.899	.137	-0.112	-0.006
.989	V	.174	-0.011	.926	.053	-0.083	.032	-0.054	.035	-0.013	-0.196	.002
.987	Zn	.056	.164	.022	.058	-0.893	-0.036	-0.037	.112	.179	.020	-0.074
.976	Al_2O_3	.918	-0.068	.072	-0.044	.109	.079	-0.037	-0.057	.031	.031	.115
.988	Fe_2O_3	-0.232	-0.864	.254	.030	.096	-0.067	-0.126	-0.048	-0.115	-0.002	.173
.994	FeO	.216	.918	.101	-0.016	-0.044	.101	.015	.166	.033	-0.031	.030
.978	MgO	-0.914	-0.144	.048	.014	.005	.122	-0.075	-0.126	-0.100	.100	.111
.988	CaO	.063	-0.830	-0.038	.187	-0.018	.174	.029	-0.008	-0.067	.021	-0.123
.998	Na_2O	.226	-0.036	-0.039	.130	-0.044	-0.931	-0.010	.084	-0.010	-0.066	-0.018
.997	K_2O	.054	.182	-0.073	-0.877	-0.030	.147	-0.080	.118	-0.004	.076	-0.227
Eigenvalue		5.83	2.79	2.37	1.94	1.73	1.46	1.33	1.16	0.93	0.53	0.49
Percent		26.5	12.7	10,8	8,8	7.8	6,6	6.0	5.3	4,2	2,4	2,2

Appendix II, continued

BASIC VOLCANICS IN VÄSTERBOTTEN No transformation

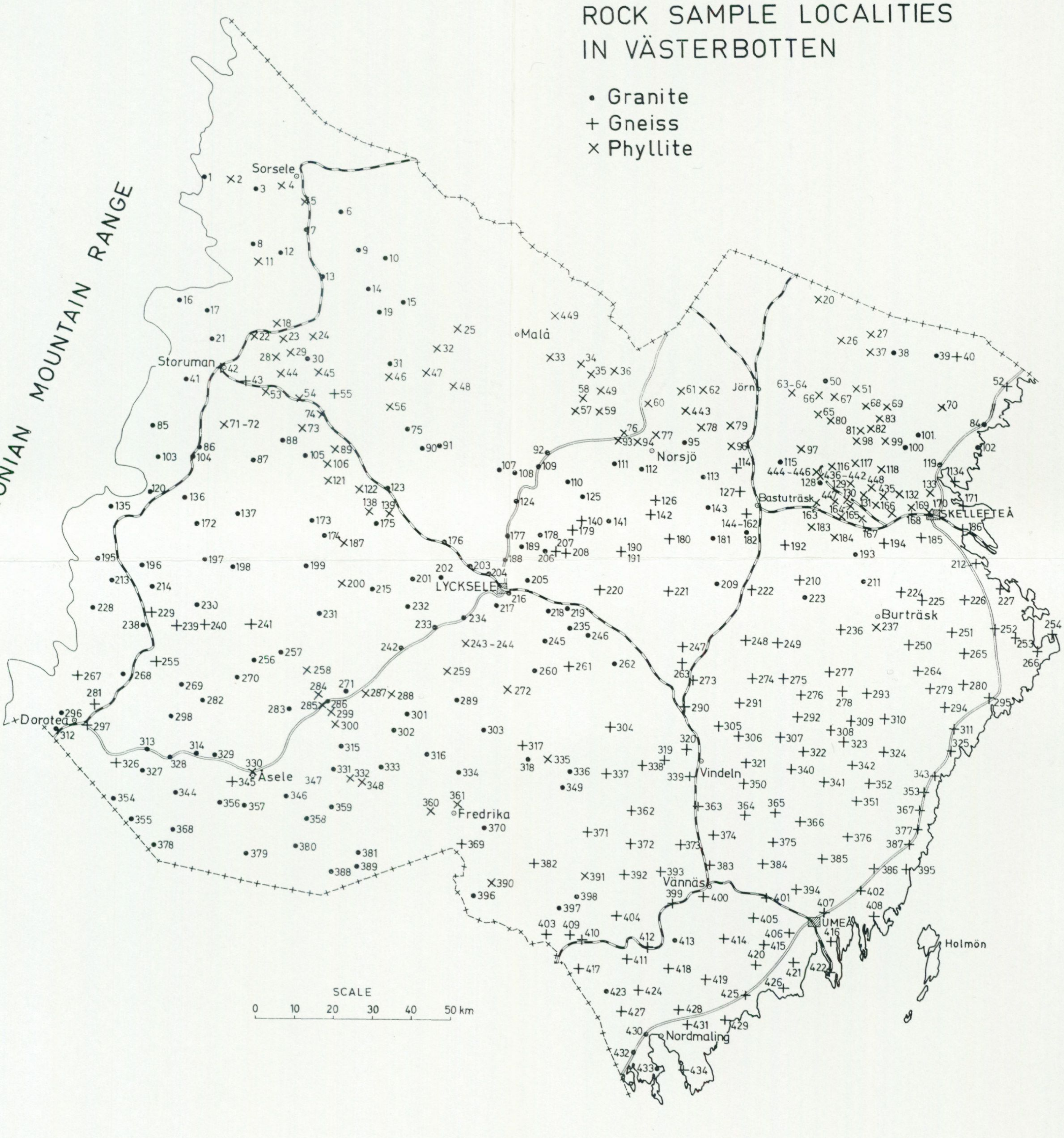
Varimax matrix accounting for 98.8 percent of total problem variance

Factor		12	13	14	15	16
Sum of squares		.615	.955	.912	1.021	.212
.996	As	.030	-0.123	-0.103	-0.021	-0.002
.996	Ba	.030	-0.021	-0.841	.019	-0.003
.975	Cr	-0.055	-0.025	-0.009	-0.115	-0.040
.999	Cu	.017	.096	-0.000	-0.022	.002
.957	Ga	.045	-0.158	.108	.116	.151
.999	Ge	.008	-0.087	-0.018	-0.061	.007
.994	Mn	.697	.117	-0.052	-0.248	-0.011
.967	Ni	.013	-0.063	.076	-0.126	.210
.989	Pb	-0.066	-0.034	.016	.035	.221
.999	S	.095	.014	-0.016	.092	.001
.988	SiO_2	-0.155	.149	-0.026	.777	.010
.996	Sr	-0.062	-0.868	-0.017	-0.110	.008
.984	Ti	-0.013	-0.057	-0.075	-0.077	-0.022
.989	V	.114	.164	.012	-0.085	.000
.987	Zn	.130	.084	.026	-0.020	-0.280
.976	Al_2O_3	-0.085	-0.049	.202	-0.181	.016
.988	Fe_2O_3	.039	-0.123	-0.151	.045	-0.079
.994	FeO	.037	.149	.055	-0.155	-0.014
.978	MgO	-0.056	-0.101	-0.132	-0.138	-0.018
.988	CaO	.190	-0.061	.024	-0.398	.094
.998	Na_2O	-0.031	-0.082	.067	.182	-0.004
.997	K_2O	-0.028	.066	-0.277	.058	.005
Eigenvalue		0.34	0.27	0.24	0.18	0.16
Percent		1.5	1.2	1.1	0.8	0.7

PLATE II

ROCK SAMPLE LOCALITIES IN VÄSTERBOTTEN

- • Granite
- + Gneiss
- × Phyllite



PRISKLASS F

Distribueras genom
LiberKartor
162 89 VÄLLINGBY

Schmidts Boktryckeri AB
Helsingborg 1980

ISBN 91-7158-172-3