REGIONAL GEOCHEMICAL VARIATIONS OF UPPER CENOZOIC VOLCANIC ROCKS IN THE CENTRAL ANDES

by

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Submitted in partial fulfilment of the requirements of the Bachelor of Science Degree with Honours.

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ABSTRACT

Regional variations in the chemical composition of Miocene-to-Recent volcanic rocks from the Central Andes are investigated on the basis of 260 chemical analyses compiled from the literature in addition to 25 new analyses for 5 trace elements. Correlations are established between major and trace element compositions and other variables such as distance from the eruptive centres from the Peru-Chile trench or crustal thickness, using the computer and multi-graphic techniques.

Among the most striking correlations are the confirmation of the previously established continent-ward increase of K_2O for all rock types, a surprising negative correlation for Na_2O with distance from the trench in one large segment of the Cordillera and the positive correlation of Li, U and Rb with crustal thickness.

Comparisons are also made between Andean rocks and those of island arcs and other tectonic regimes.

ACKNOWLEDGEMENTS

I would like to thank my parents who contributed in many ways to the success of my undergraduate studies; to Dr. Marcos Zentilli, the supervisor of this thesis, for the assistance and moral support provided at several stages of this study; to Dr. Warren Ervine whose door was never closed to my questions; and to Dr. John Peirce for critically reviewing the manuscript. The guidance by Sirish Parikh, Laboratory Technician of the Department of Geology, in the chemical analyses is gratefully acknowledged. I am indebted to Dianne Crouse for her time and patience expended in typing the manuscript.

CHAPTER 1

INTRODUCTION

The Central Andes, that part of the orogenic belt of western South America between 5°S and 30°S (Figure 1), has been the focus of a long period of magmatism which was probably initiated in the Triassic-Jurassic. The climax of this magmatic activity, however, appears to have taken place in the Miocene-Pliocene, when volcanism affected a wide elongated belt along the Central Andes. The products of this late stage of Andean Volcanism gave rise to lavas of andesitic to rhyolitic composition, grouped by Siegers et al. (1969) into a "Rhyolite Formation" with extensive ignimbrite fields and an "Andesite Formation" represented mainly by stratovolcanoes. These units cover an area of approximately 150,000 km^2, and occupy much of the high Andes (Figure 2) including the high and Western cordilleras, parts of the Altiplano or Puna, Central Valley, and Pre-Cordillera (Figure 3). This volcanism has been ascribed to the subduction of oceanic lithosphere under the South American continental margin and it appears permissible to assume that the pattern of subduction has remained relatively unchanged since the Miocene.

Chemical variations of volcanic rocks across island arcs and Andean type continental margins have been postulated in several areas (e.g. Bateman and Dodge, 1970; Dickinson, 1967; Dostal et al., 1977; Hutchinson, 1976; Jakes and White, 1971; James et al., 1976; Kussmaul, 1977; Palacios and Oyarzun, 1975; Zentilli, 1974; and Zentilli and Dostal, 1977). The Miocene-to-Recent volcanic series of the Central Andes, however, represents an ideal laboratory for testing these kinds of chemical variations. It is the main purpose of this thesis to document, on the

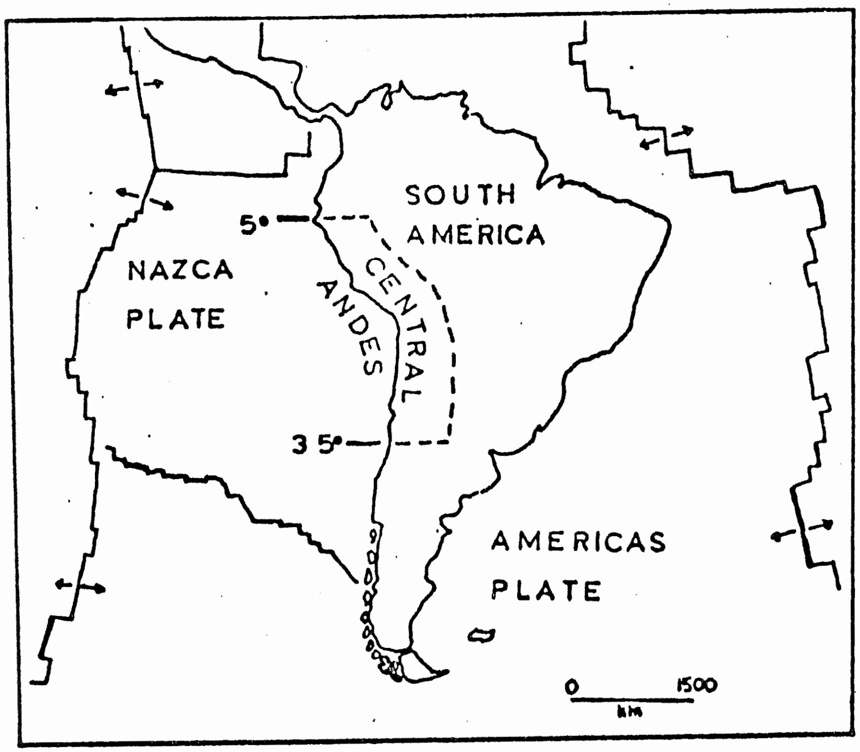


FIGURE 1: Map of South America
(after Sillitoe, 1976)

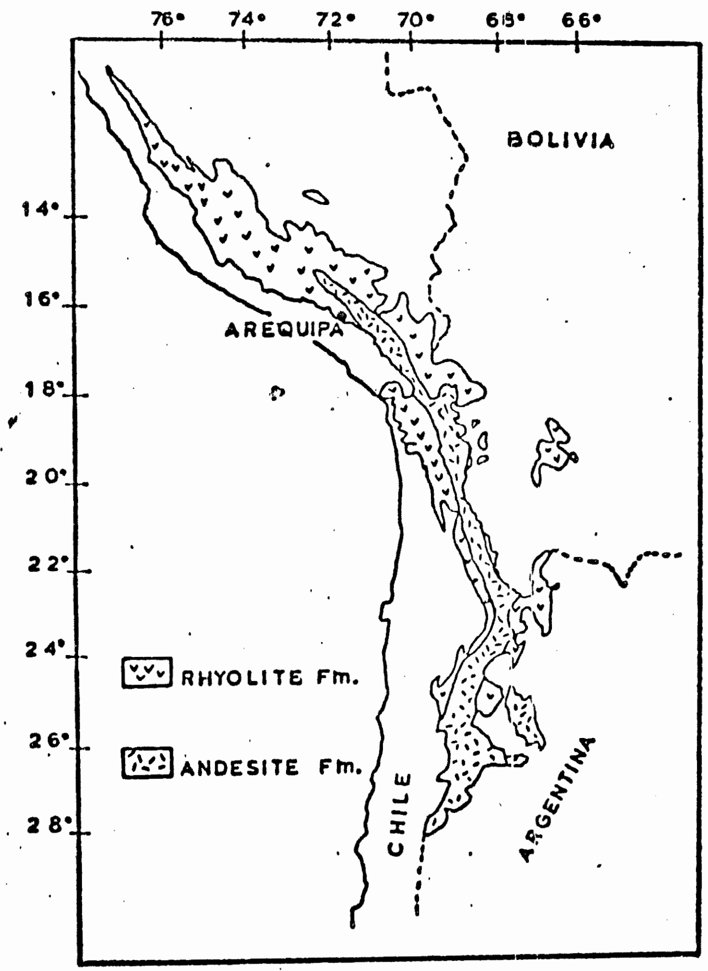
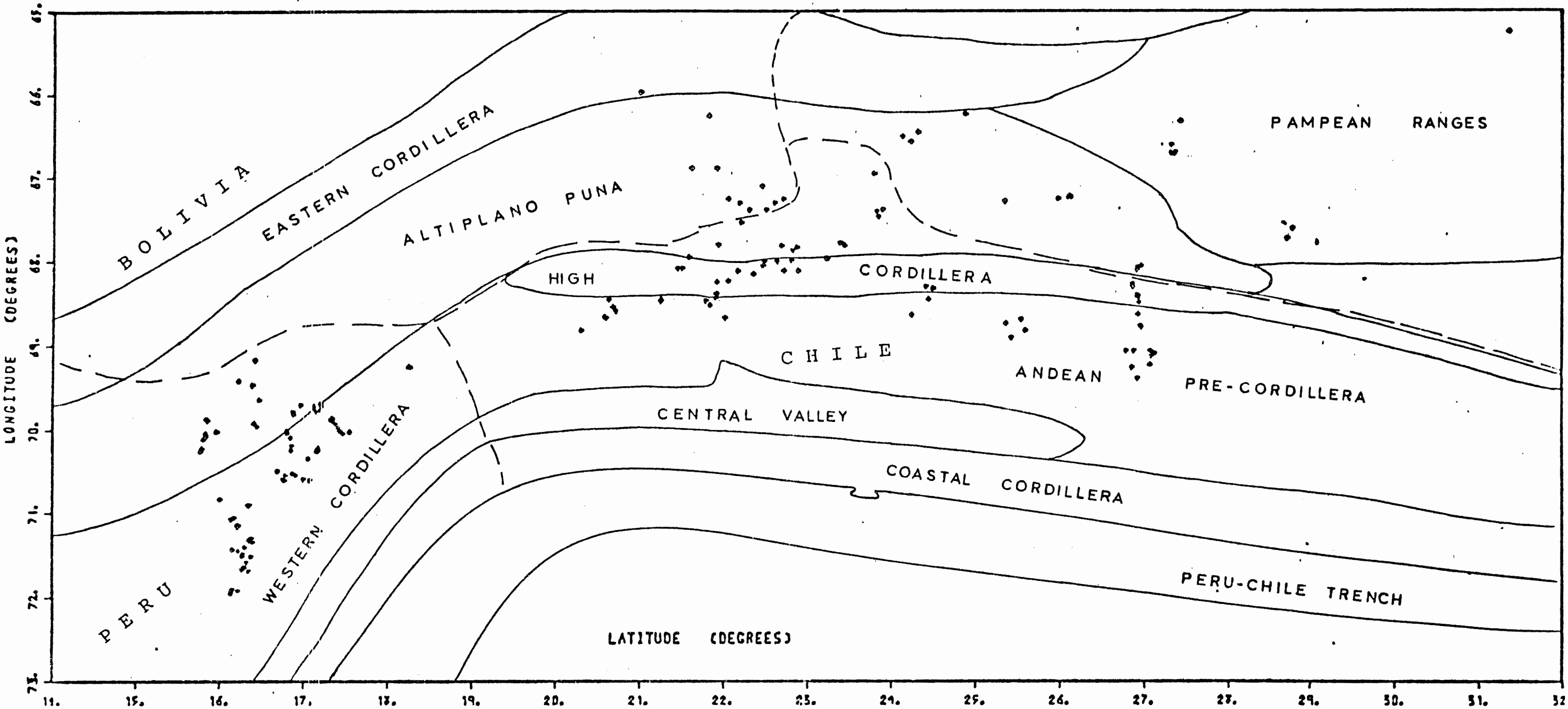


FIGURE 2: Rhyolite and Andesite Formations
(after Pichler and Zeil, 1970).


BOLIVIA
EASTERN CORDILLERA
ALTIPLANO PUNA
PAMPEAN RANGES
HIGH CORDILLERA
CHILE
ANDEAN PRE-CORDILLERA
CENTRAL VALLEY
COASTAL CORDILLERA
WESTERN CORDILLERA
PERU
PERU-CHILE TRENCH
LATITUDE (DEGREES)
LONGITUDE (DEGREES)

basis of a compilation of over 260 chemical analyses, complemented by the additional analyses of 25 samples for 5 trace elements (see Tables 1 and 2, Appendix A) the lateral variations in major and minor element compositions of volcanic rocks across the Central Andes. An attempt is made to investigate the regional variations displayed by different rock types, and to detect correlations between chemical variables and other variables such as distance of the eruptive centres from the Peru-Chile Trench, and crustal thickness. The chemistry of the volcanic rocks of the Central Andes are compared with that reported from other tectonic environments. It is out of the scope of this thesis to offer an interpretation for all variations documented, however, brief discussions and speculations in this respect are offered.

SUMMARY OF PREVIOUS KNOWLEDGE ON THE ANDES

Previous work on the geochemical and metallogenic relationships of the young Andean volcanic rocks has enlightened some of the geochemical variations across the Central Andes. Much of this work is fairly recent (< 10 years old), and has allowed previous researchers to put forward several hypothesis (4 at least) on the petrogenesis of these rocks, which will be reviewed in Chapter 4. The geochemical research can be divided into 3 groups:

1) Major elements
2) Trace elements
3) Isotopic data

Major Elements:

The most significant and better documented compositional variation across the Central Andes is the eastwards increase of potassium. Palacios and Oyarzun (1975) have correlated the K_2O content of the Central Andean volcanic rocks with depth to the Benioff Zone. Zentilli (1974), however, arguing that the Benioff Zone is arbitrarily defined preferred to plot the increase in potassium against a more empirical variable, the actual distance of the volcanic centres measured perpendicularly from the trench (herewith referred to as "distance") by means of the K-index. The K-index was defined by Bateman and Dodge (1970) for intrusive rocks of the Sierra Nevada (U.S.A.), as one thousand times the slope of a line passing through zero percent and K_2O and 45 percent SiO_2 recognizing that the relationship between K_2O and SiO_2 was not of a simple K_2O/SiO_2 type. Thus the K-index is defined as: $K_2O \times 1000/(SiO_2 - 45)$. Kussmaul et al. (1977) has shown the variation of K_2O with respect to the degrees of longitude, and Pichler and Zeil (1967) have suggested that there may be a zonation of potash content along the length of the Central Andes. Other than potassium all the other major elements have either been neglected or not studied very much with respect to their variation across the Central Andes.

Trace Elements:

The variations of most trace elements across the Central Andes are not documented. But Zentilli (1974) found an easterly increase of Ytrium, and Zentilli and Dostal (1977) showed that uranium followed a parabolic concave downwards relationship with distance, and they also suggested that Li, Sr, and Ba may also follow similar transverse variations.

Isotopic Data:

The $^{87}Sr/^{86}Sr$ isotopic value which is also considered in the present thesis, has been documented with respect to its behaviour across the Central Andes only by Zentilli (1974), who proposed that for Neogene-Quaternary volcanic rocks there is an easterly increase in initial ratios.

SOURCE OF THE DATA AND THEIR DISTRIBUTION

The majority of the data has been obtained from the published literature. This was accomplished by collecting several papers on the geochemistry of the Andean rocks. Even though many papers were collected, by no means is it implied that the research exhausted all possible publications. For example reports from the local geological surveys were not available for this study. The data from 11 different references have been selected for use in the present thesis (Table 1a, b, c). The criteria used to choose them was the following:

1. The publication contains enough information to locate the samples geographically.
2. The publication is <10 years old.
3. The data include the SiO_2 content of the sample and the major and/or trace elements.

4. There is no reason to the best knowledge of the author to doubt the validity of the data.

There is a particular paper: El-Hinnawi et al. (1969), whose data was not used in this study because of suspicion of analytical error in the determination of some trace elements. The reported values of Sn and Cu are extremely high, and do not compare to the analysis of rocks from the localities made by other researchers (Clark et al., 1976). The data were keypunched on computer cards, and for each sample were recorded: a code number; the sample number as given by the author; the source of reference; the geographical coordinates; the major and trace elements and isotopic ratios; the perpendicular distance from the trench to the sample; the age; the rock type as reported by the reference source; and other miscellaneous information. In Table 1a, b, and c the samples are code-numbered from 1 to 271, but numbers 46, 73, 91, 92, 93, 94, and 95 do not exist. Also, where there was no data, the computer print out shows a zero.

The locations of the 264 analysis from the Central Andes compiled for the present thesis are shown in figures 3 and 31. These samples can be considered to be representative of the late Cenozoic volcanic rocks of the Central Andes. They were subdivided into 3 geographical groups. The first group is located between latitude 15°S and 20°S, this area is called Region 1. The second group is located between latitudes 20°S and 25°S and the third group is located between latitudes 25°S and 31°S. These areas are called Region 2 and Region 3 respectively. The specific samples in each region are given prior to Table 1 (Appendix A).

Computation and Statistics:

The data were processed by the use of SPSS (Statistical package for the Social Sciences), QDGS (Quick Draw Graphic System), and Fortran programme language. With the SPSS package were obtained scatter diagrams (and their vital statistics: Pearson's correlation coefficient, least square fits, means and standard deviations) of all the major and trace elements and the $^{87}Sr/^{86}Sr$ value against distance and SiO_2. The final plots presented in this thesis were done by use of QDGS subroutines and other Fortran programmes (see Appendix A) Fig. 8, 13, 19.

Analytical Methods:

The determination of vanadium, nickel, lithium, copper, and zinc for 25 samples and 5 standard rocks was done using an Atomic Absorption Spectroscopic unit (Elmer-Perkins 503) in the laboratories of the Geology Department of Dalhousie University. A simple routine method developed by Warren and Carter (1974), (with few modifications) was used to produce the rock sample solutions, which are made by using an acid dissolution system containing hydrofluoric acid (HF). This acid not only dissolves the rock but also removes some of the compositional matrix of the sample by eliminating silica as a volatile silicon tetrafluoride (SiF_4). In this method the sample is brought into solution by digestion with a mixture of hydrofluoric (HF), nitric (HNO_3), and perchloric ($HClO_4$)

acids in a low pressure-low temperature teflon bomb. This step is followed by the evaporation of the solution to perchloric acid fumes and a final dissolution in a mixture of hydrofluoric and boric acids. In Appendix B can be found a detailed account of the methods used to prepare the solutions.

CHAPTER 2

CLASSIFICATION OF VOLCANIC ROCKS

Field names and petrographic descriptions offer limited help when comparing volcanic rocks, especially if the rocks show some alteration or contain glassy groundmass. Because terminology varies with the user, it becomes rather difficult if not impossible to compare rocks described by different workers. Therefore a uniform nomenclature based on certain criteria is necessary. Some of the classifications of common usage are those of: Streckeisen (1967); Irvine and Baragar (1971); Church (1975); and Taylor (1969):

1. Streckeisen (1966, 1967) proposed a very useful classification and nomenclature for igneous rocks according to their mineralogy. The method he recommended for the conversion of the chemical analysis to a normative mineral composition is the Rittman Norm; this norm computes in many cases sanidine instead of biotite, and its use may be misleading for rocks poor in sanidine and rich in biotite. Therefore as the author does not have a complete hand specimen description of all the samples, it was considered impractical to use this classification because it would be impossible to detect the kind of error described above.
2. Irvine and Barager (1971) use multigraphic methods to handle several variables which are used to classify the specimens according to one of 21 volcanic rock types. However, where altered rocks are suspected, an arbitrary adjustment of the Fe_2O_3/FeO (ferric ion/ferrous ion) value is introduced. Some workers

(e.g. Chayes, 1966) have rejected specimens with Fe_2O_3/FeO values > .6. Both of these procedures seemed inadequate to Zentilli (1974) and Church (1975) because a ratio close to unity will be obtained where late magmatic oxidation has taken place, and many rocks that are obviously fresh in hand specimens and in thin section (e.g. unaltered glass) may also have high ratios, perhaps due to high oxygen fugacities prevalent during the last stages of crystallization (Dr. Marcos Zentilli, personal communication, 1978).

3. Church (1975) proposed to use a greater amount of chemical data and a single variation diagram for the classification of common volcanic rock types. For each rock $A = Fe_2O_3 + FeO + 1/2\ (MgO + CaO)$ is plotted against $B = Al_2O_3/SiO_2$, where the term A is supposed to serve as an index of basicity, and in recognition of the interchange of Si and Al in feldspathic minerals, the term B is computed. This method seems to effectively polarize ultramafic compositions, and to show a trend from rhyolite to basalt with increasing values of the parameters A and B. To delimit the fields for each rock type, Church (1975) plotted the standards of Washington (1917) and to test the procedure plotted the average compositions of Daly for each rock type. The fields overlap each other, making it very difficult to classify those rocks falling in the region of overlap. Nevertheless, this procedure takes into account several chemical components and perhaps the most useful information obtained from the variation diagram of Church is the relative degree of basicity of a rock.

4. Taylor (1969) recognized very early the difficulties inherent in applying standard petrographic techniques to rocks which contain fine grained or glassy groundmass (as do many of the Central Andean volcanic rocks) and proposed that a classification based on the SiO_2 and K_2O contents (on a volatile-free basis) be used for these rocks. Taylor distinguished four varieties of andesites, the most common of which was termed ANDESITE and has a content of SiO_2 between 56 and 62% and a K_2O content between .7 and 2.5%. Taylor's low-silica-andesites have a SiO_2 content between 53 and 56% and a K_2O content between .7 and 2.5%. The potassium and trace elements in andesites of the same silica content may vary by a factor of 5. For this reason Taylor distinguished between low-K and high-K andesites, with K_2O <.7 and >2.5 respectively. The complete list of volcanic rock types is as follows:

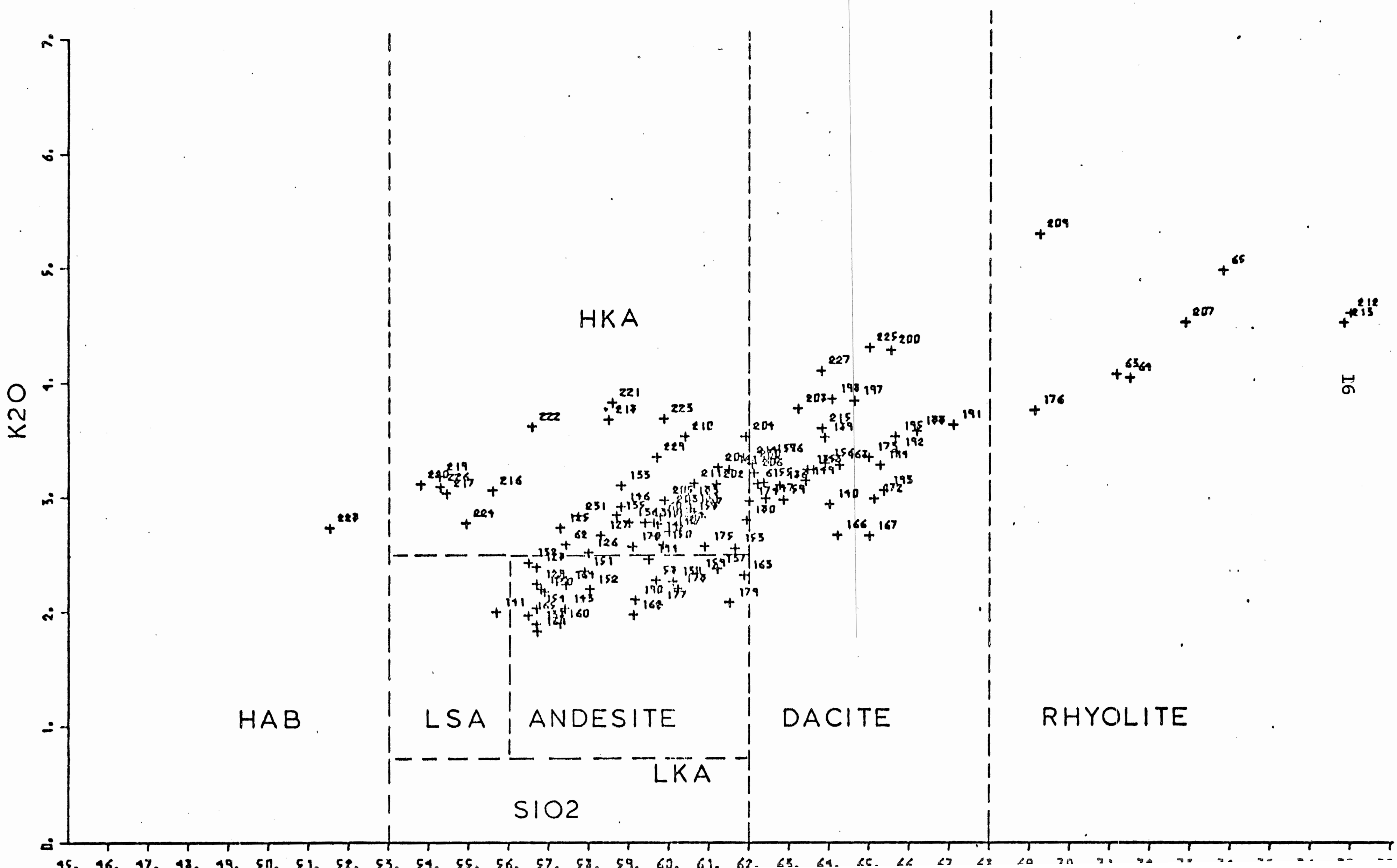
1.	High Al-basalt	<53% SiO_2	
2.	Low-silica Andesite	53-56% SiO_2	.7-2.5% K_2O
3.	Low-K Andesite	53-62% SiO_2	<.7% K_2O
4.	Andesite	56-62% SiO_2	.7-2.5% K_2O
5.	High-K Andesite	53-62% SiO_2	<2.5% K_2O
6.	Dacite	62-68% SiO_2	
7.	Rhyolite	> 68% SiO_2	

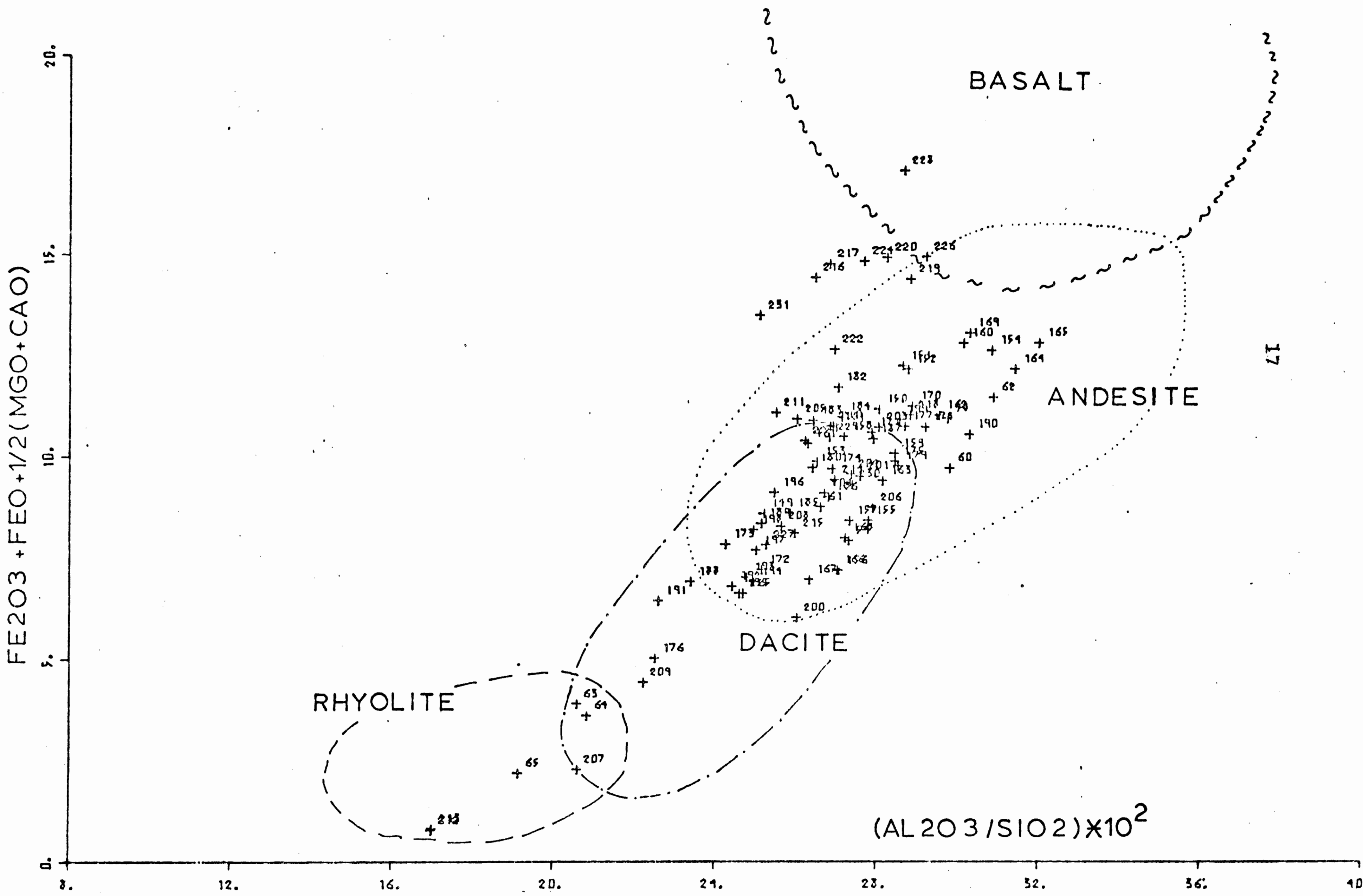
In order to break down the chemical analysis into rock types to effectively compare rocks of similar chemistry, and for the comparison of trace element contents of these rocks with those of other orogenic regions, it was found appropriate to group the rocks according to the usage of Taylor, as described above.

Classification of the Data

Region 1

Most samples from Region 1 are of dacite or andesitic composition (Figures 4 and 5), and of calc-alkaline character according to the criteria of Peacock (1931) and Wager and Deer (1939) (Figure 6). Peacock (1931) defined the calc-alkali series of rocks to be those in which the sum of Na_2O + K_2O exceeds the CaO content at SiO_2 values between 55 to 61 percent (Table 4, Appendix A). Another group of rocks called "shoshonites" have been identified for having K_2O/Na_2O values close or greater than unity. In Figure 4 the shoshonites (samples 216, 217, 218, 219, 220, 221 and 222) show higher K_2O content at any given SiO_2 than the calc-alkaline rocks. Also note that few shoshonites plot as a more or less distinct group, having a slope slightly smaller (less steep) than the rest of the rocks. Miyashiro (1973) identified the calc-alkaline series by their rapid increase in SiO_2 with respect to the Fe total/MgO value (Figure 7). Also it can be seen that several samples, and one in particular (No. 207), plot very distinctly in the tholeiitic field. A check on Table 1a indicates that it is due to a low content in MgO rather than a high content in iron. Finally, Figure 8 shows a Na_2O/K_2O versus Na_2O + K_2O plot for the rocks of Region 1; it clearly shows that all the samples fall in the region of "fresh" volcanic rocks.


K2O
HKA
HAB
LSA
ANDESITE
DACITE
RHYOLITE
LKA
SIO2



BASALT
ANDESITE
DACITE
RHYOLITE
FE2O3 + FEO + 1/2 (MGO + CAO)
(AL2O3 / SIO2) X10²
0.
5.
10.
15.
20.
8.
12.
16.
20.
24.
28.
32.
36.
40

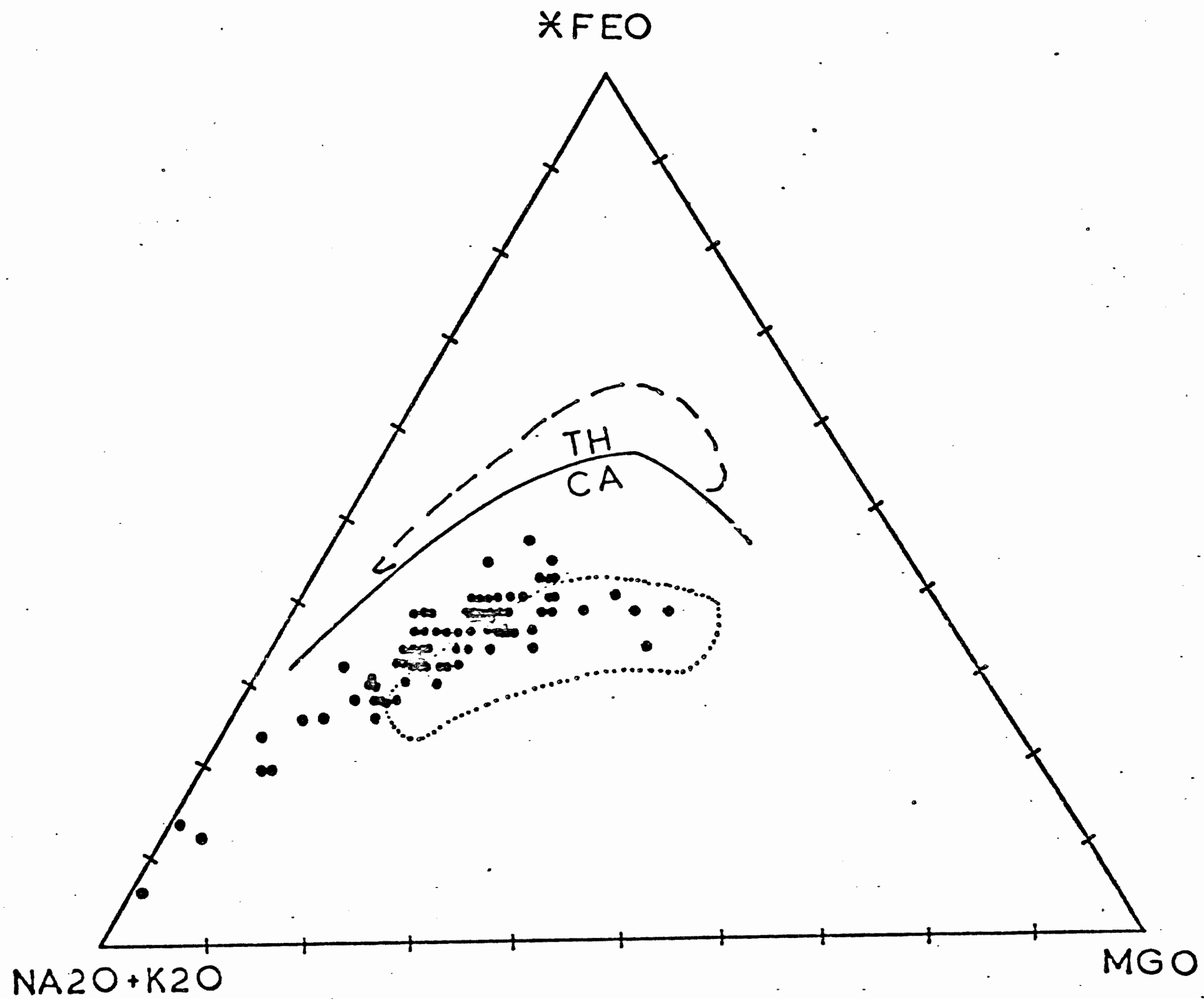
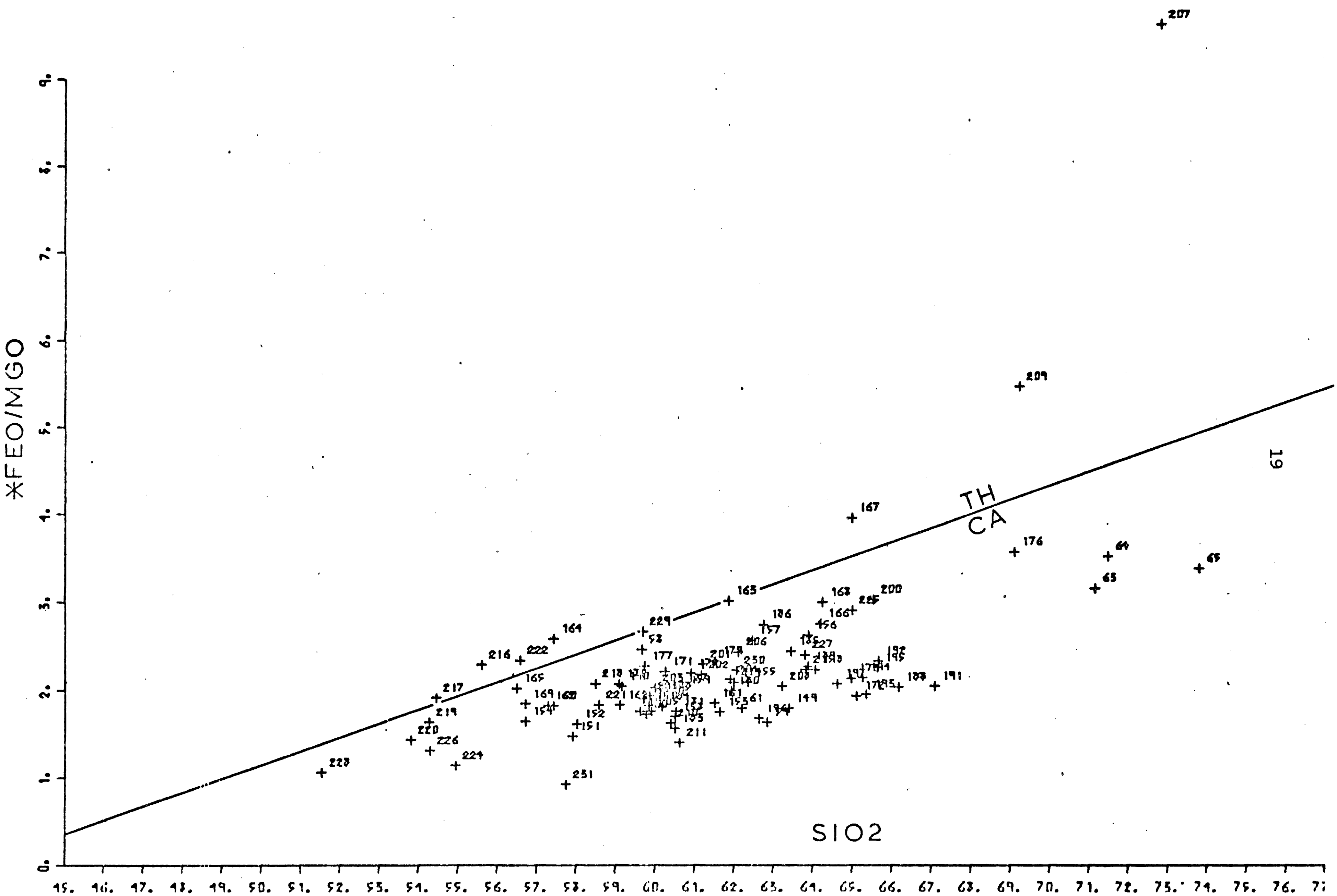


FIGURE 6: (Na2o + K2O)-total Fe-MgO triangular plot for the rocks of Region 1. In dots is the field for the volcanic rocks of shoshonitic association of New Guinea. In dashed line is the field for the volcanic rocks of Korkar and Manan Islands of New Brittain (Jakes and White, 1971). The line separating the calc-alkaline field (CA) from the tholeiitic field comes from Irvine and Baragar (1971). This diagrama shows the calc-alkaline and shoshonitic character of the rocks from Region 1.


*FEO/MGO
SIO2
TH
CA

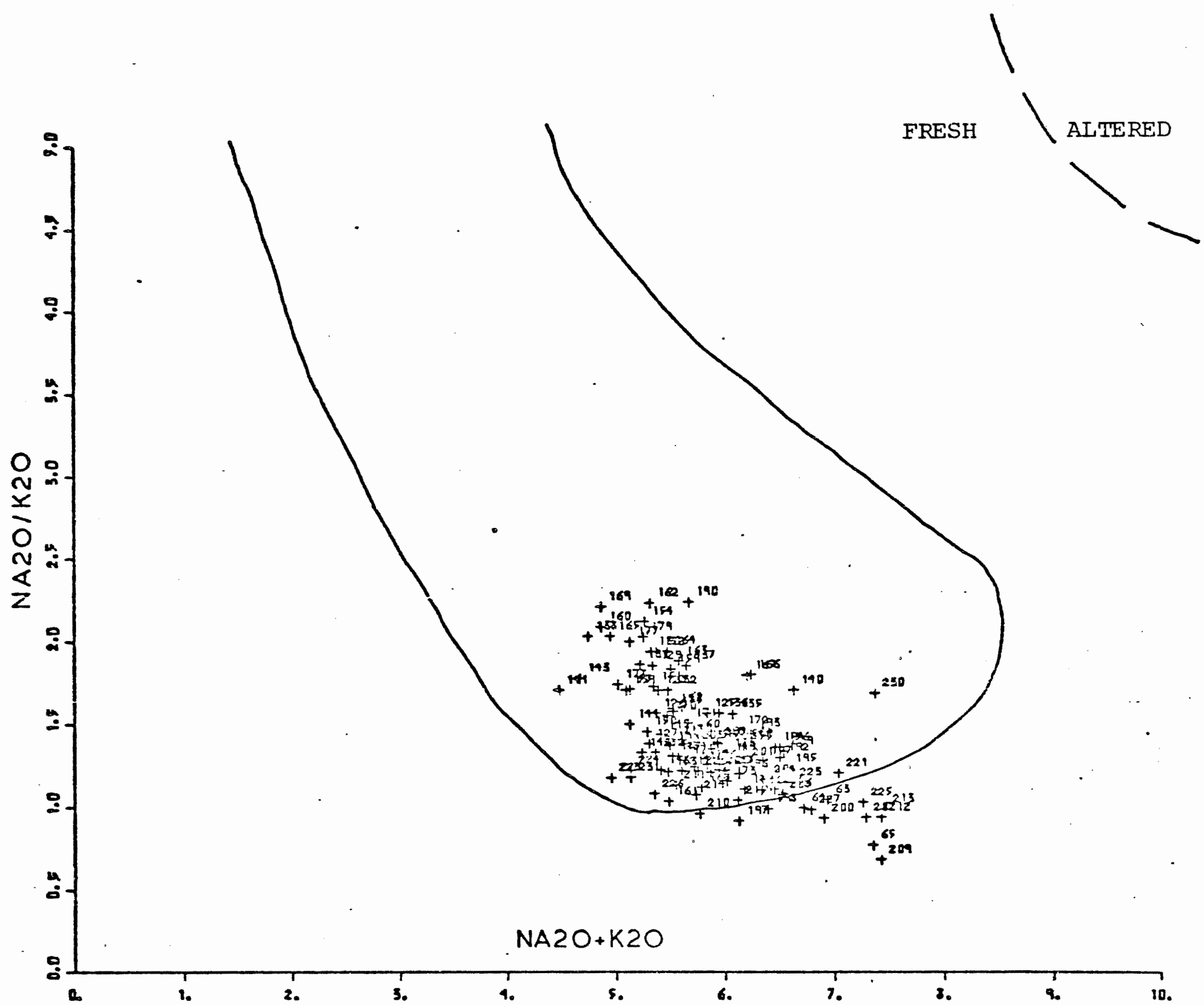


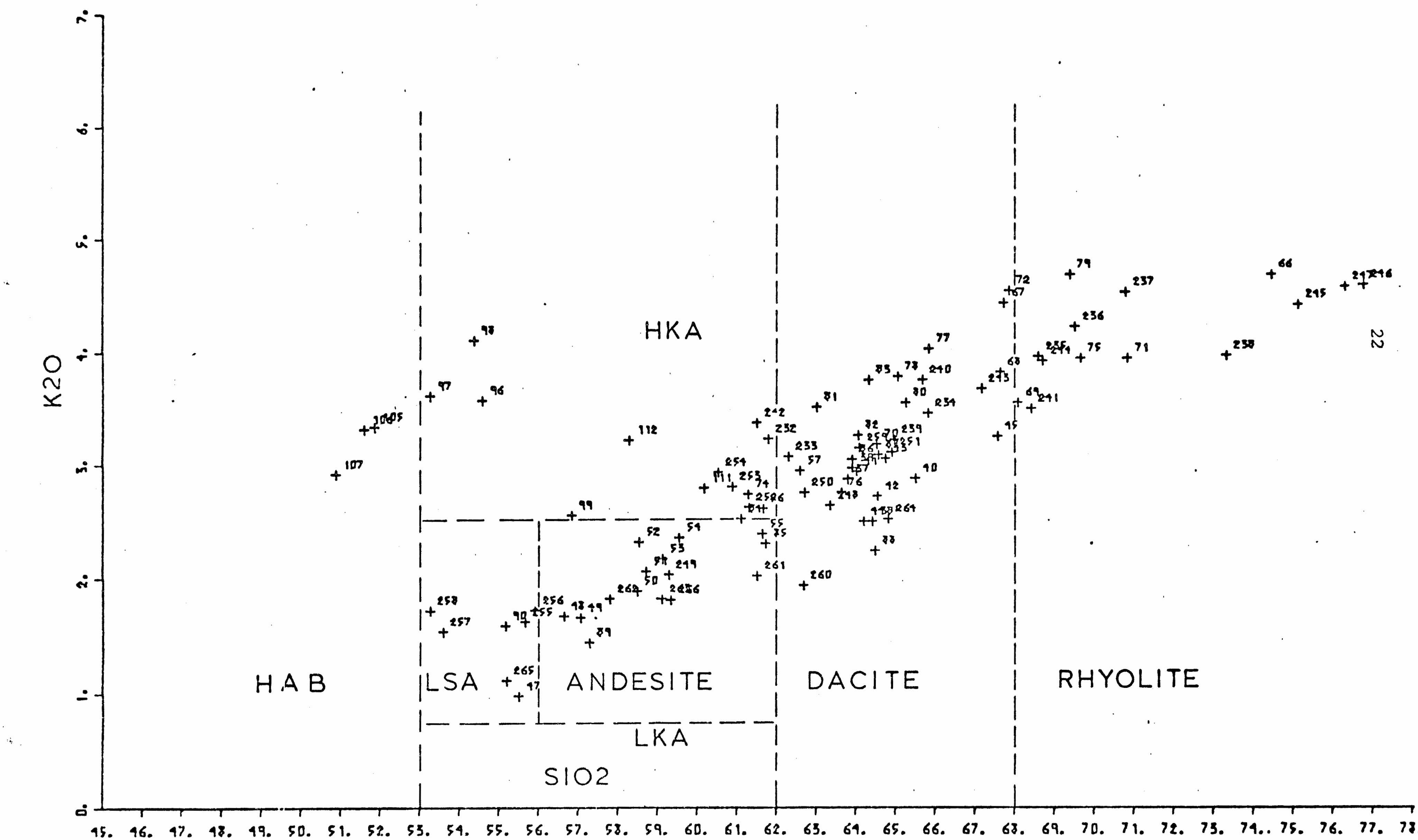
FIGURE 8: Na_2O/K_2O versus $Na_2O + K_2O$ diagram for the rock analyses of Region 1. The field marked on the diagram correspond to the "fresh" volcanic rocks from island arcs of Miyashiro (1975). Most of the samples that fall outside this field have relatively high SiO_2 values.

Region 2

In region 2 there are only slight differences with Region 1. Again the bulk of the samples are of dacitic and andesitic composition (Figure 9 and 11), but the andesites of Region 1 show to be, in general, less potassic than those of Region 1. Also the samples of Region 2 are mostly of calc-alkaline character (Figure 10), though many of them have shoshonitic affinities. The variation diagram of Miyashiro (1975) (Figure 12) shows that as in Region 1 most rocks fall in the calc-alkaline field, and that some of them fall distinctly in the tholeiitic field (sample 241 in particular). A check on Table 1a again shows that it is due to very low MgO values. Figure 13 shows that most rocks are fresh according to the test for Quaternary volcanic rocks as defined by Miyashiro (1975). Again those values falling outside the field for intermediate and basic volcanic rocks from island arcs are of rhyolitic and dacitic composition. Also a comparison of Figure 13 with Figure 8 points out again at the similarity between the volcanic rocks from Region 1 and 2.

Region 3

In Region 3, as in Regions 1 and 2, the bulk of the rocks have andesitic and dacitic compositon, but there are more high-alumina basalts than in the previous regions as shown in the K_2O versus SiO_2 diagram for Region 3 (Figure 14). In this figure, the shoshonites again show a higher K_2O content at any given SiO_2 than the rest of the rocks which are of calc-alkaline character according to the criteria


HKA
HAB
LSA
ANDESITE
DACITE
RHYOLITE
LKA
SIO2
K2O

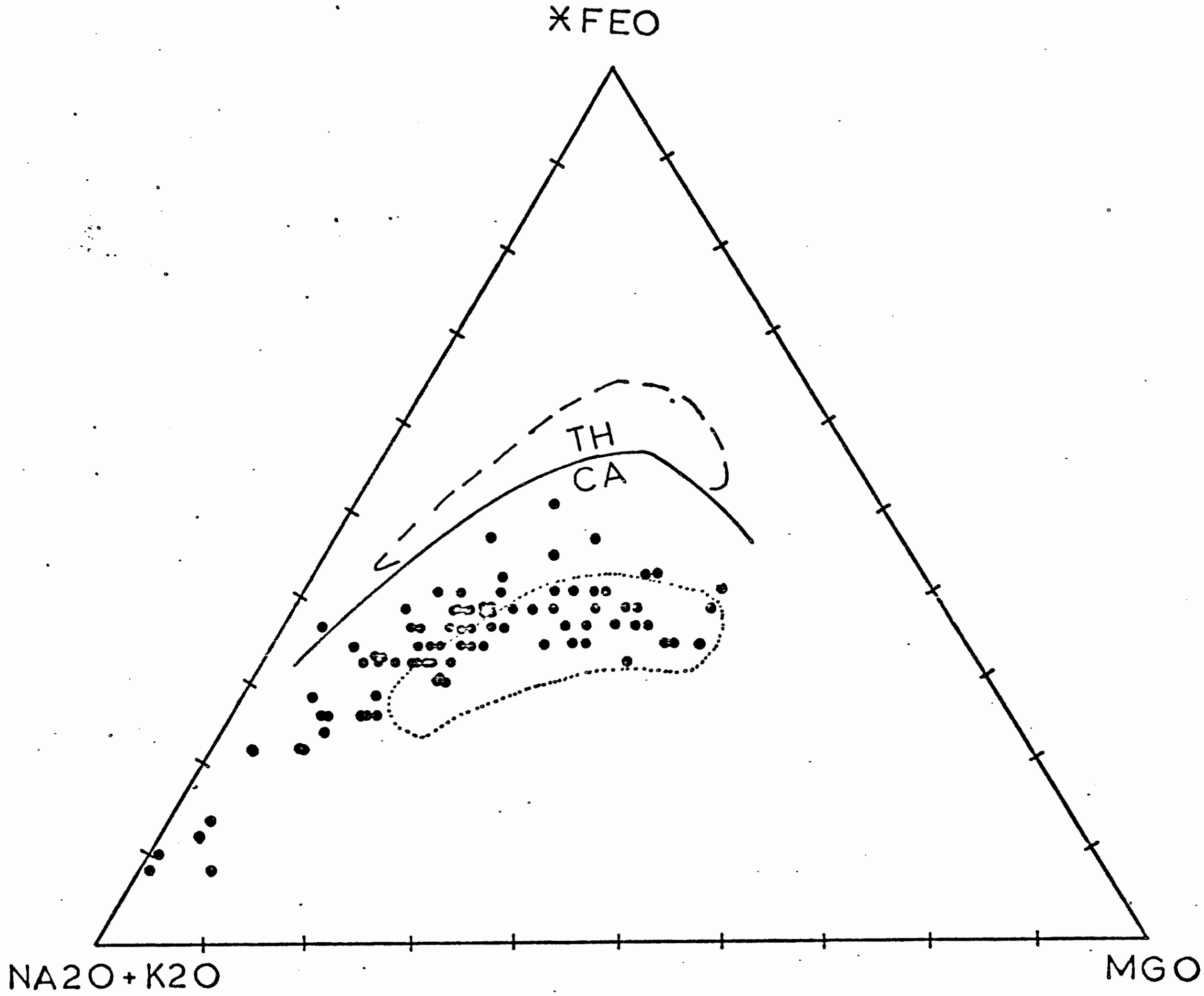
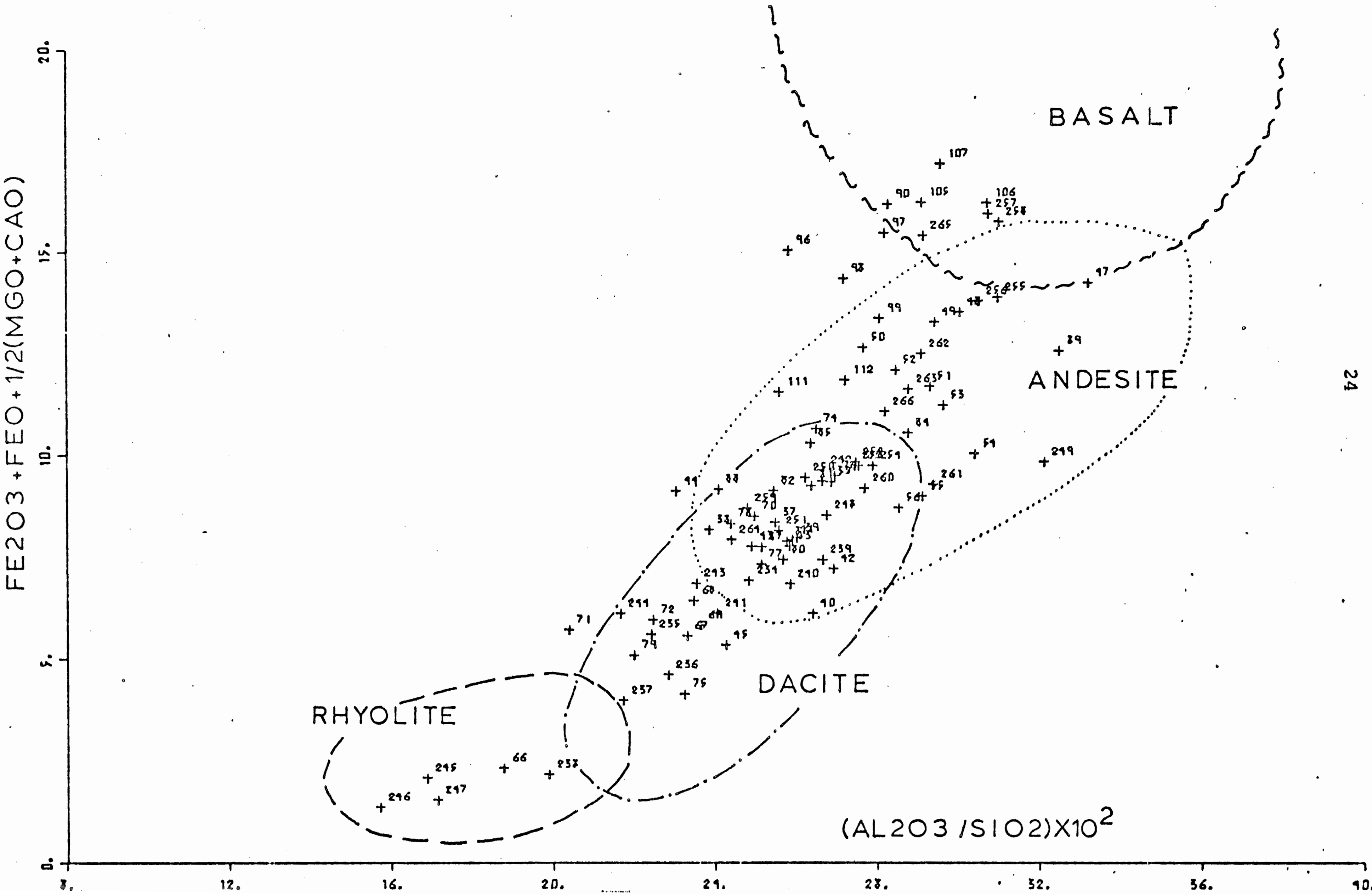
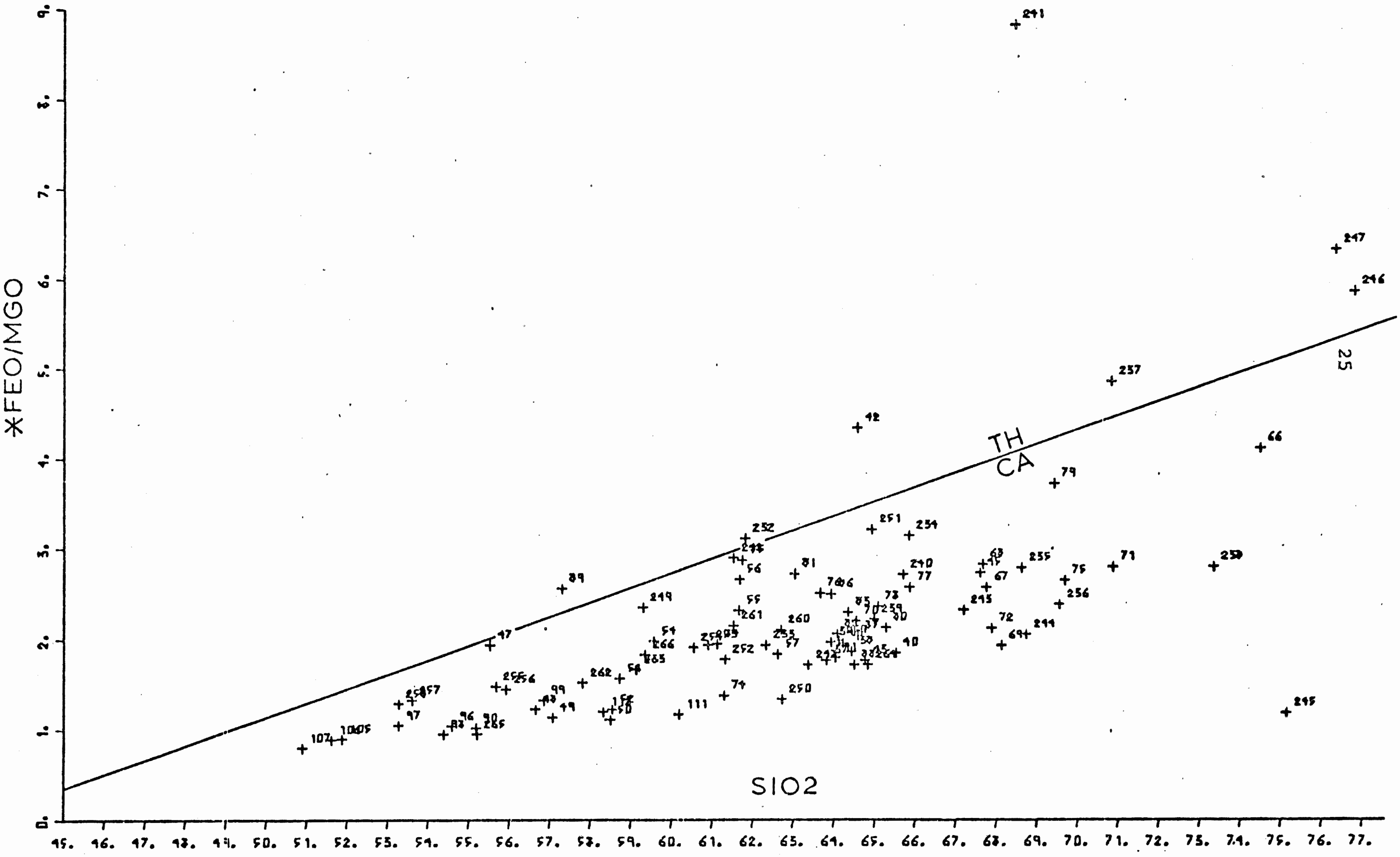


FIGURE 10: (Na2O + K2O)-total Fe-MgO triangular plot for the rocks of Region 2. In dots is the field for the volcanic rocks of shoshonitic association of New Guinea. In dashed line is the field for the volcanic rocks of Korkar and Manan Islands of New Brittain (Jakes and White, 1971). The line separating the calc-alkaline field (CA) from the tholeiitic field (TH) comes from Irvine and Baragar (1971). This diagram shows the calc-alkaline and shoshonitic character of the rocks from Region 2.


BASALT
ANDESITE
DACITE
RHYOLITE
FE2O3+FEO+1/2(MGO+CAO)
(AL2O3/SIO2)X10^2
0.
5.
10.
15.
20.
12.
16.
20.
32.
36.
40.



*FEO/MGO
SIO2
TH
CA
0.
1.
2.
3.
4.
5.
6.
7.
8.
9.
45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77.
25

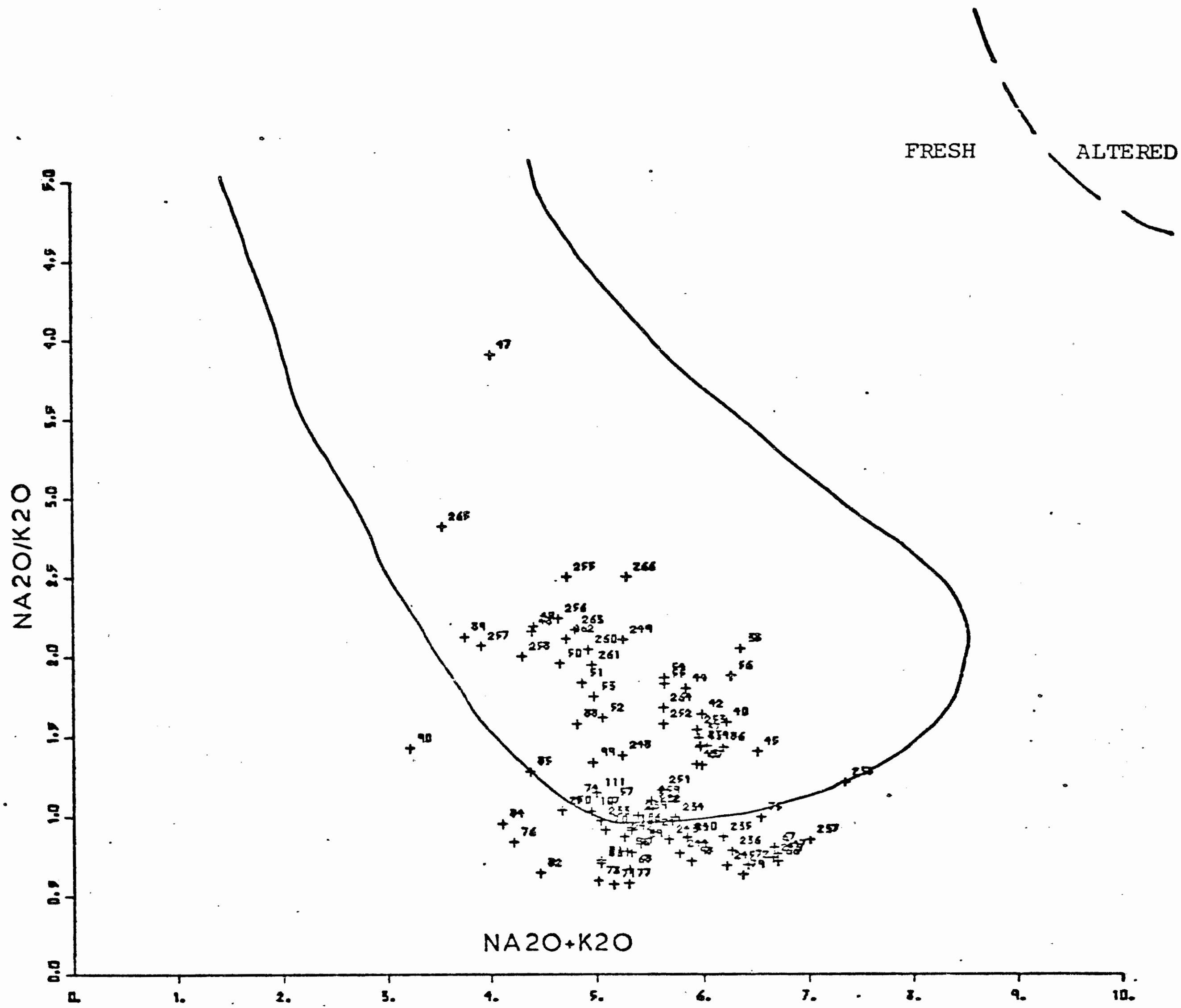
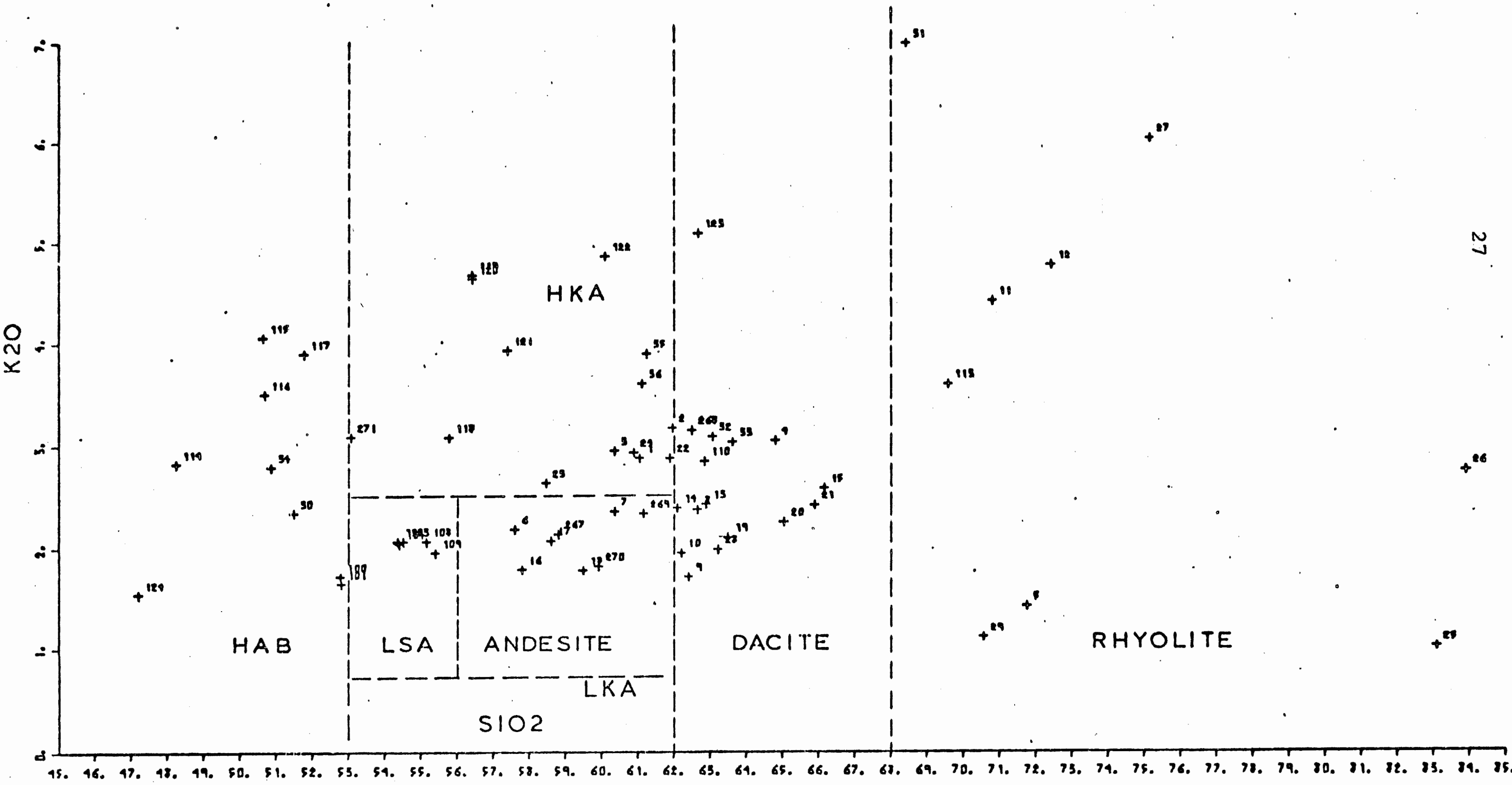


FIGURE 13: Na_2O/K_2O versus $Na_2O + K_2O$ diagram for the rock analyses of Region 2. The field marked on the diagram correspond to the " fresh " volcanic rocks from island arcs of Miyashiro (1975). Most of the samples that fall outside this field have relatively high SiO_2 values.


K2O
HKA
HAB
LSA
ANDESITE
DACITE
RHYOLITE
LKA
SIO2

of Wager and Deer (1939) (Figure 15). Figure 15 shows that the volcanic rocks of Region 3 fall well in the calc-alkaline field. Note also that some of the samples fall within the field demarked by the rocks of shoshonitic association of New Guinea. This figure is comparable to Figures 10 and 6. In Figure 14, some of the shoshonites are not as well identifiable as a different group from the rest of the rocks. This suggests that while the shoshonites and the calc-alkaline rocks can be considered to be two different populations, they are related and there is a progressive gradation between them. This fact can also be observed in the histogram for the K_2O/Na_2O values of the samples from the three Regions (Figure 16). In Figure 15 there are 2 samples that seem to be out of sequence, they are samples 25 and 26. These two samples do not follow the same trend set by the other samples (e.g. linear increases of K_2O with increasing SiO_2), but they show comparatively low K_2O . These two samples are highly siliceous (> 83 percent SiO_2) and that is the reason for being depleted in all other major elements, including K_2O (see Table la). For comparison with Figure 14 has been plotted a Church variation diagram (Figure 17). Again as in Region 1 and 2, most of the samples fall in the andesitic and dacitic fields. Note that the two highly siliceous samples (25 and 26) plot outside the rhyolite field defined by Church (1975). Sample No. 5 plots above the rhyolite field due to the fact that it is rich in Fe_2O_3. One difference between this plot and Figures 11 and 5, is that four samples fall in the trachyte field, probably because they are relatively rich in alumina and poor in iron with respect to the other samples. For

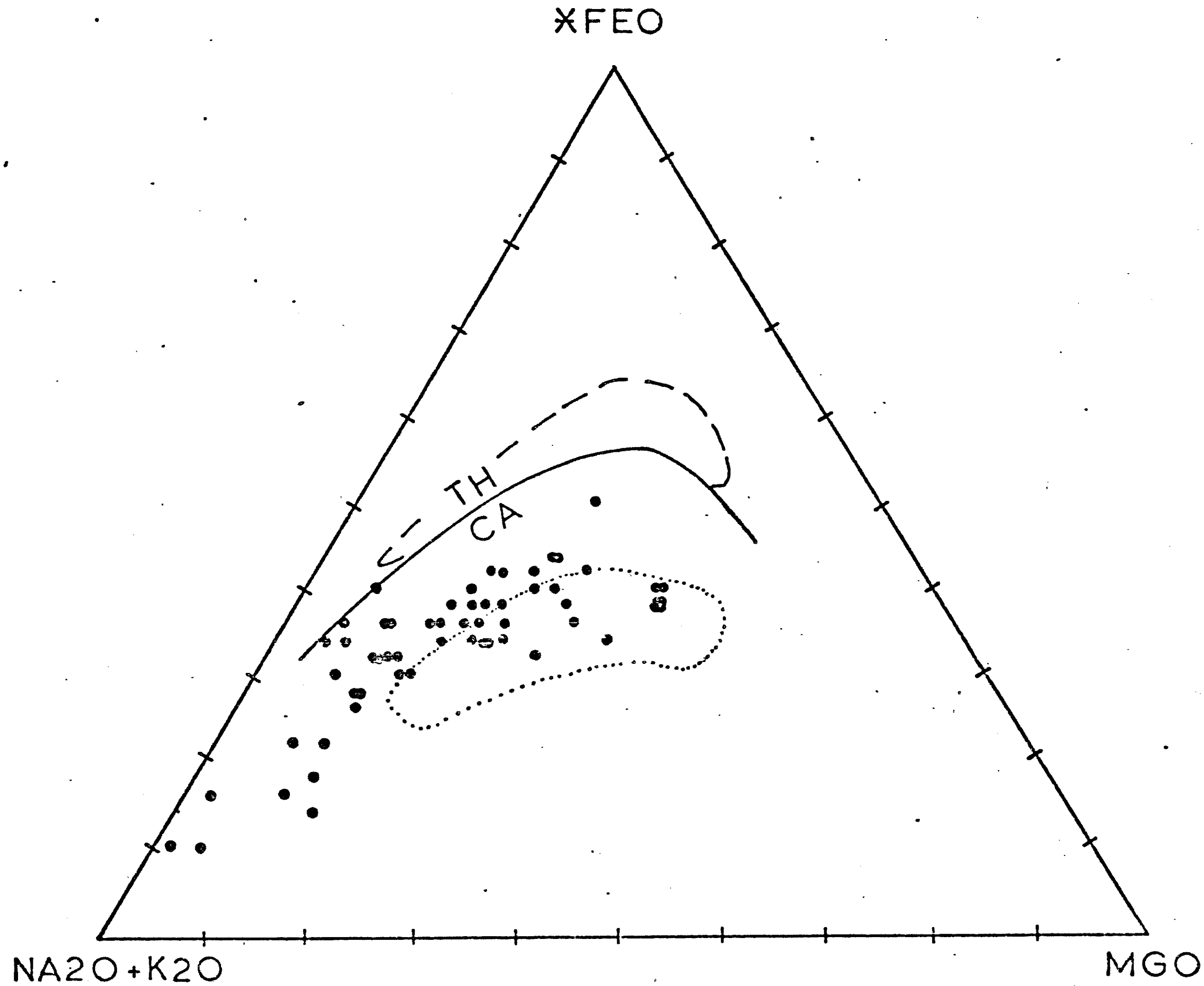


FIGURE 15: (Na2O + K2O)-total Fe-Mgo triangular plot for the rocks of Region 3. In dots is the field for the volcanic rocks of Shoshonitic association of New Guinea. In dashed line is the field for the volcanic rocks of Korkar and Manan Islands of New Brittain (Jakes and White, 1971). The line separating the calc-alkaline field (CA) from the tholeiitic field (TH) comes from Irvine and Baragar (1971). This diagram shows the calc-alkaline and shoshonitic character of the rocks from Region 3.

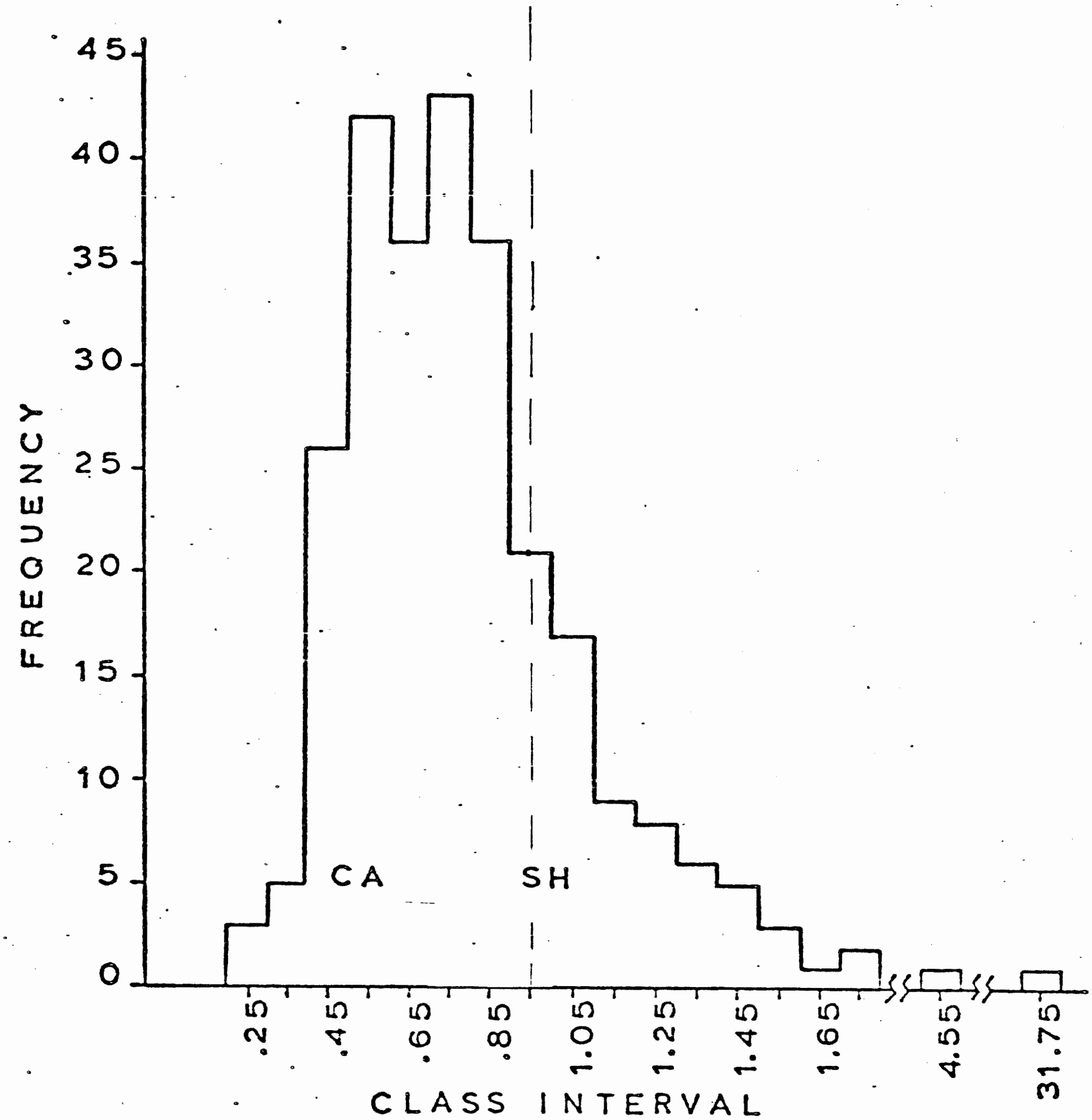
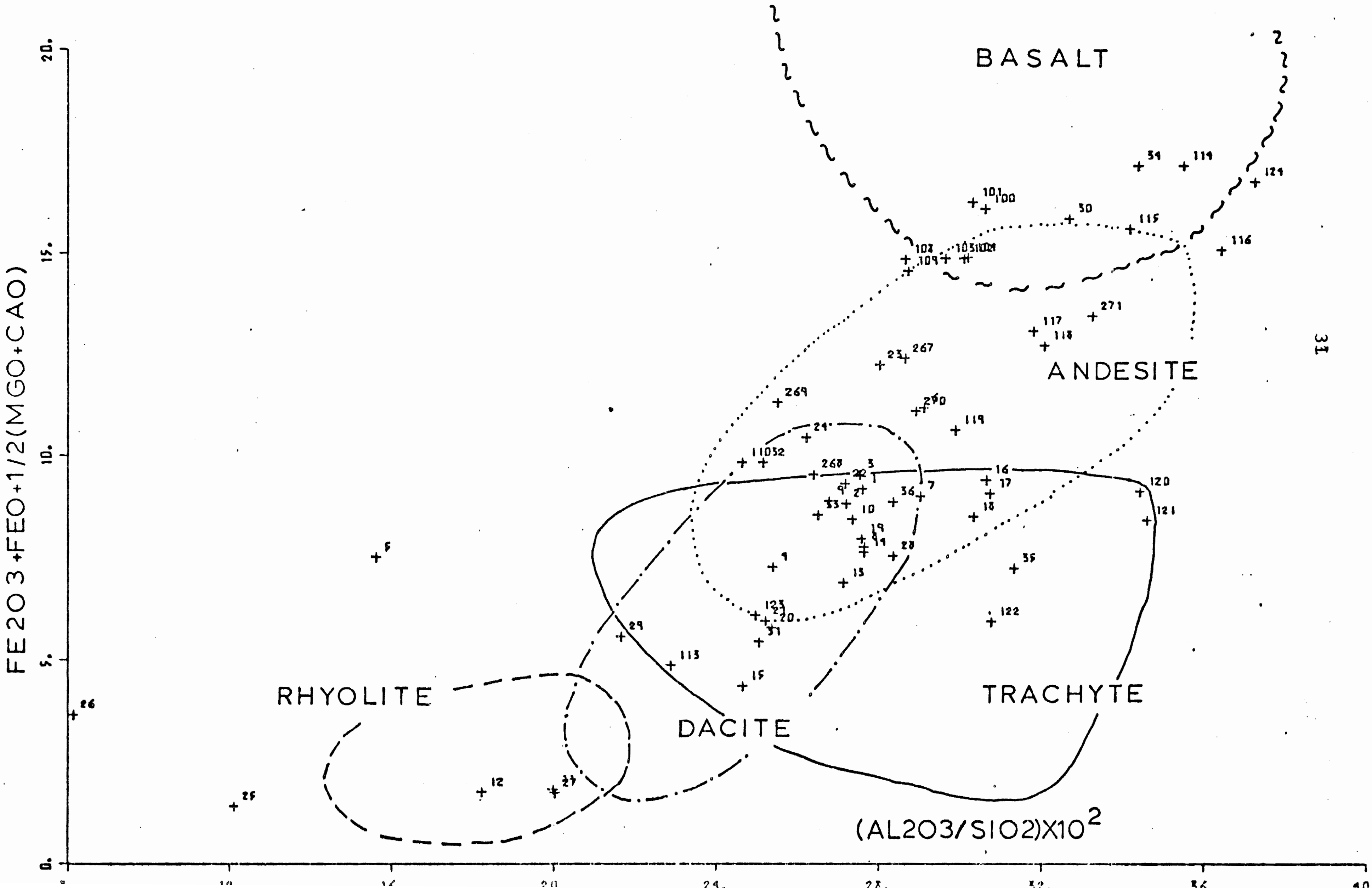


FIGURE 16: Histogram of the K_2O/Na_2O values for all the Central Andean volcanic rocks available to the present thesis. A value of K_2O/Na_2O greater than .95 has been arbitrarily taken to be "close enough to unity" so that it marks the point at which the calc-alkaline field is separated from the shoshonite field.

CA = Calc-alkaline field

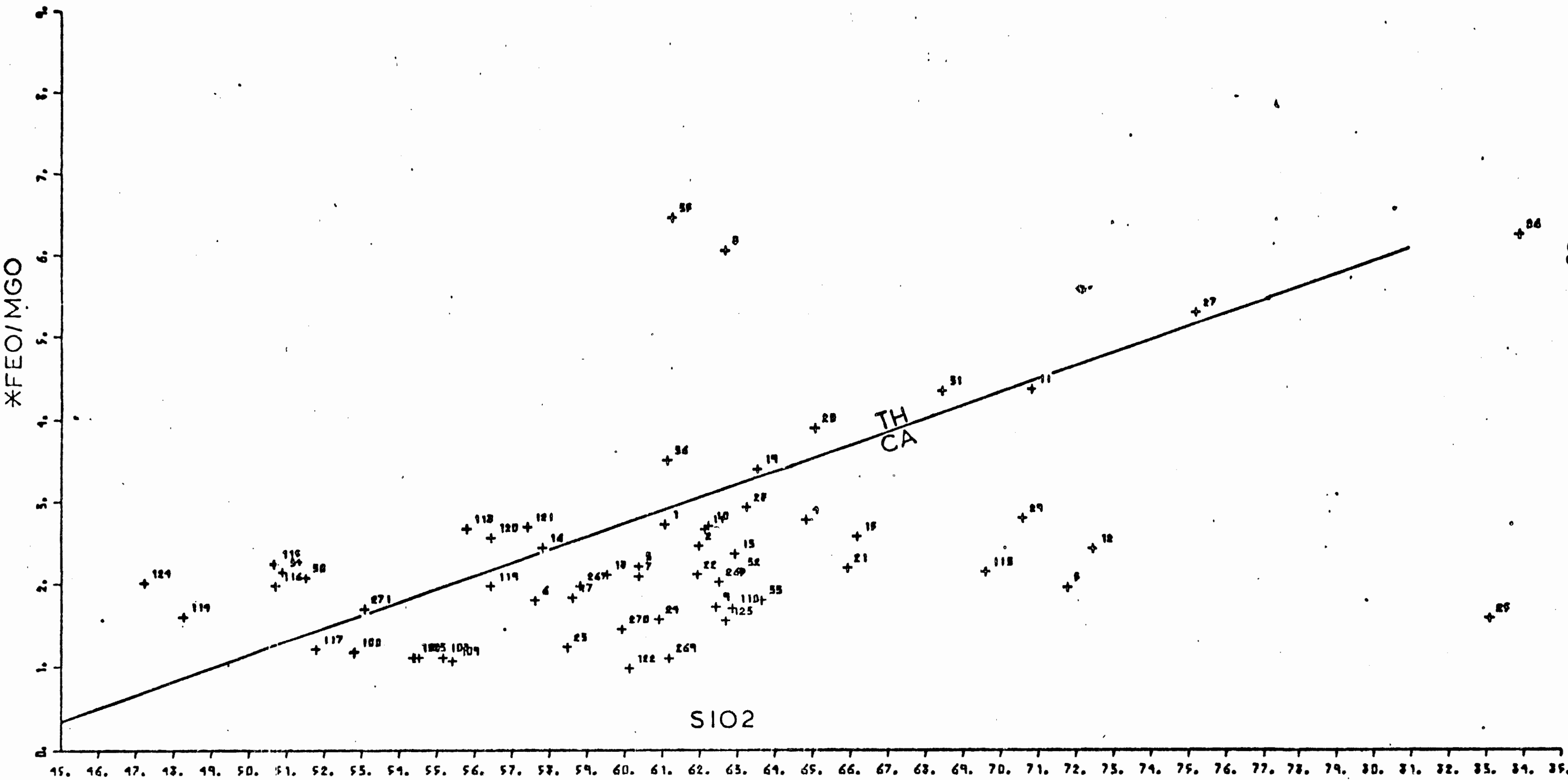
SH = Shoshonite field



BASALT
ANDESITE
TRACHYTE
DACITE
RHYOLITE
FE2O3+FEO+1/2(MGO+CAO)
(AL2O3/SIO2)X10^2
20.
15.
10.
5.
0.

comparison with Figure 15 a diagram has been plotted with FeO total/ Mgo versus SiO_2 (Figure 18) which shows the calc-alkaline character of most samples according to the criterion of Miyashiro (1973). Again as in the previous regions, some samples fall distinctly in the tholeiitic field (No. 8 and 35). These samples, as in the other 2 regions, have relatively low MgO values. Figure 19 shows the "freshness" of the samples of Region 3. Again as in the other two regions a few samples fall outside the field for fresh Quaternary volcanic rocks of Miyashiro but it is probably due to the fact that they are more siliceous. Nevertheless, diagrams 8, 13 and 19 indicate that the Neogene-Quaternary volcanic rocks of the Central Andes have relatively lower Na_2O/K_2O values than similar rocks from island arcs.

Finally a MgO-Fe total-Al_2O_3 diagram (Figure 20) has been plotted for the rocks of the 3 regions having a SiO_2 content between 51 and 56%. Pearce _et al._ (1977) distinguished in this diagram five fields representing different tectonic environments: ocean ridge and floor, ocean island, continental, orogenic, and spreading centre island. The aim of this diagram is, for Pearce _et al._ (1977), to show the relationship between major element chemistry and tectonic environments. The samples plotted in Figure 20 fall distinctly in two fields: the "orogenic" and the "ocean ridge and floor". One sample falls in the field for "spreading centre islands" but it is so close to the "orogenic" field that it may be considered to be part of the latter. The samples that fall in the "ocean ridge and floor" field have MgO values between 6.94


*FEO/MGO
SIO2
TH
CA

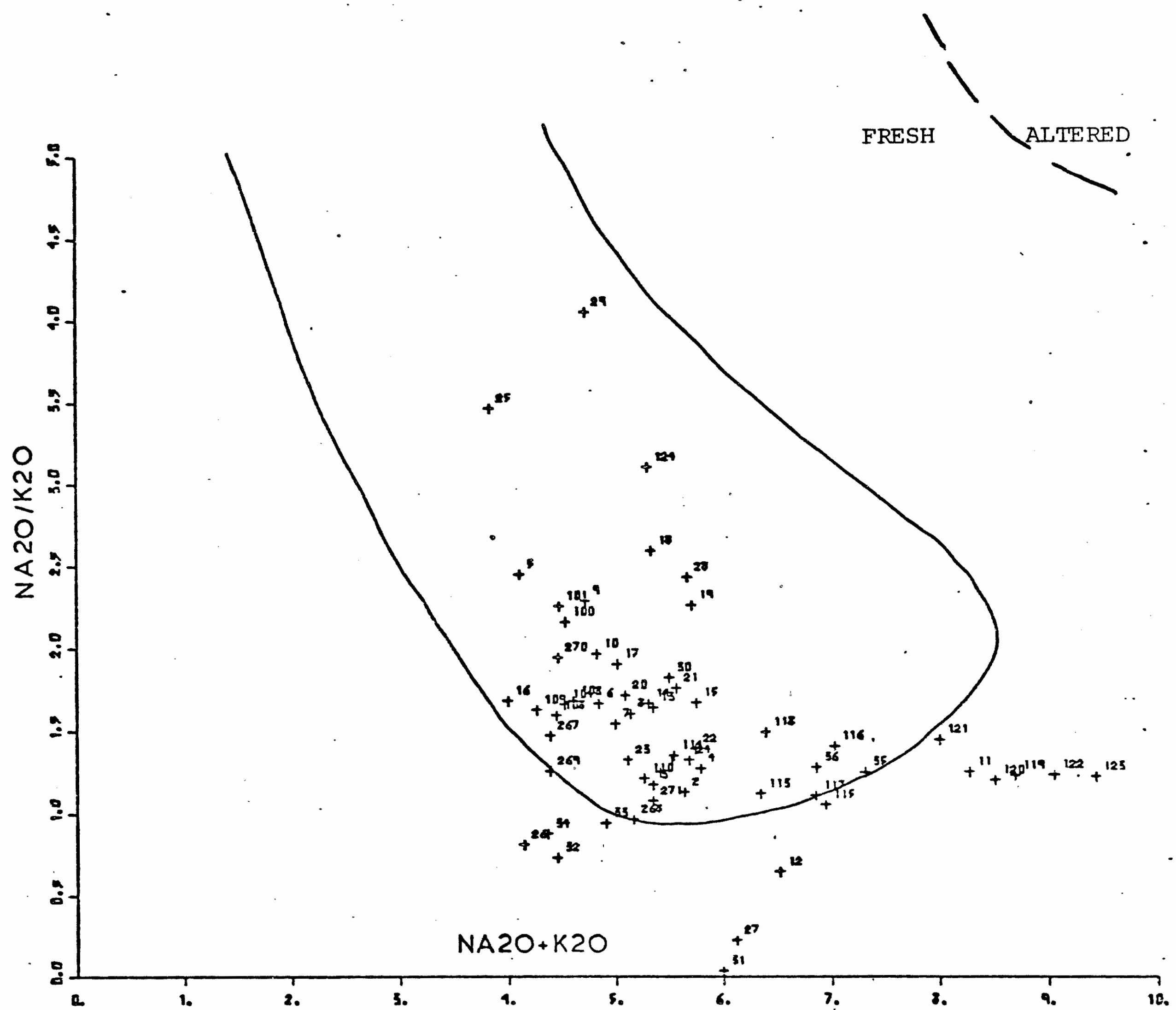


FIGURE 19: Na2O/K2O versus Na2O + K2O diagram. The field marked on the diagram correspond to the " fresh " intermediate volcanic rocks from island arcs of Miyashiro (1975). Most of the samples that fall outside this field have high SiO2 values. All samples belong to Region 3.

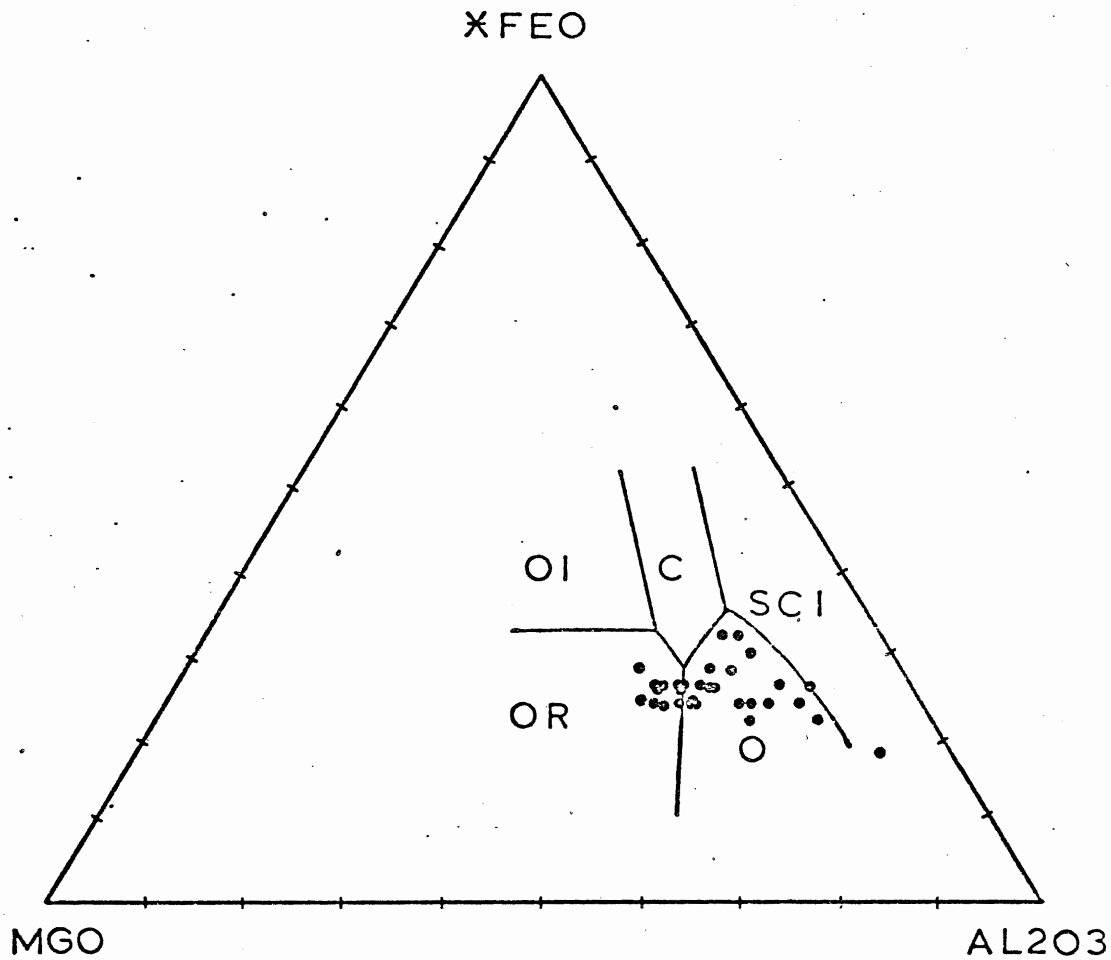


FIGURE 20: Mgo-total Fe-Al2O3 diagram (after Pearce et al, 1976) for the Central Andean rocks with SiO2 contents between 51 and 56 wt. percent.

OR = Ocean ridge and floor

OI = Ocean island

O = Orogenic

C = Continental

SCI = Spreading Center Island

and 8.76 wt. percent, which is greater than the MgO values for those samples plotting in the orogenic field which are between 2.70 and 6.98 wt. percent. Also the samples plotting in the "ocean ridge and floor" field are characterized by lower Al_2O_3 values than those plotting in the "orogenic" field (see Table la, samples No. 90, 96, 97, 98, 100, 101, 103, 104, 105, 106, and 228 plot in the "ocean ridge and floor" field. Samples No. 47, 103, 108, 109, 117, 271, 118, 217, 219, 226, 225, 256, 257, 258, and 265 plot in the orogenic field).

In the preceding paragraphs the calc-alkaline rocks have been identified on the basis of low iron enrichment in an AFM diagram and by lower than unity K_2O/Na_2O ratios, and they have been compared to Miyashiro's Fe total/MgO vs SiO_2 variation diagram. Now the trace elements may also be used to define the character of the volcanic rocks. Tholeiitic rocks have Rb values from 2 to 30 ppm (Jakes and White, 1972) and the Rb values of all the rocks of the Central Andes under study are greater than 20 ppm up to a maximum of 365 ppm. The highest values belong to rocks of shoshonitic association (K_2O/Na_2O >.95). In addition because of the positive correlation of Rb with SiO_2, the more siliceous rocks have the higher values. The Sr values of the Central Andean volcanic rocks are in 99.5 percent of the cases greater than 250 ppm and they go up to 1243 ppm. It is in accordance with the calc-alkaline and shoshonite rocks of Jakes and White (1972), and as in his case the rocks of shoshonitic association have the highest Sr values. Although the other .5 percent have very low Sr values (range from 7 71 ppm) and correspond to rocks previously identified as calc-alkaline.

Ni and Cr values are low in most rocks, agreeing with a non-tholeiitic character (tholeiites are generally enriched in Ni and Cr as a result of olivine and clinopyroxene accumulation). However, the samples with SiO_2 less than 54 percent tend to have high Ni and Cr values.

CHAPTER 3

GEOCHEMICAL VARIATIONS

After dividing all the samples into 3 geographical regions and classifying them according to the usage of Taylor (1969) it was possible to see many similarities and differences between the different rock types in the three regions. Table 5 shows the relative proportions of the different types of rock in the three regions. And Table 6 in Appendix A shows the list of elements; number of cases; mean; and standard deviation for each rock type of each region.

Note from Table 5, that the so-called "andesites" make up for 1/2 of all samples, and that the dacites make up for 1/3 of all samples, indicating the intermediate to slightly siliceous character of the Neogene-Quaternary volcanism in the Andes. The data has been plotted against distance from the trench and SiO_2 for each rock type of each region, and the results obtained are discussed below.

Basalts

Due to the lack of a statistically significant number of samples in Regions 1 and 2, it is not possible to study the geochemical covariations in these regions. However, in Region 3 there are 8 samples, but none of them show correlation with either SiO_2 or distance, except for the K-index, which varies positively with distance in a similar fashion as do the andesites in Figure 27 (see below).

TABLE 5

RELATIVE PROPORTIONS OF ANALYSIS IN THE 3 REGIONS

Region	Latitude	Basalt	Andesite	Dacite	Rhyolite	Partial Total
1	15°S to 20°S	1	71	37	6	115
2	20°S to 25°S	3	36	35	14	88
3	25°S to 31°S	8	28	16	9	61
Partial Totals		13	134	88	29	264
Percent from grand Total (= 264)		5	51	33	11	100

Andesites

In general terms the elements that constitute the andesites of the three regions are comparable in many respects, but there are also some differences. The TiO_2 and FeO content of the andesites of Region 1 tend to be higher than in Regions 2 and 3, and the CaO, Na_2O, and MgO tend to be lower in Region 1 than in the other two regions. P_2O_5 shows no covariation with distance or SiO_2 in none of the regions, except for an exponential increase with increasing distance from the trench in Region 1 (Figure 21). The other major elements have comparable ranges and means in the three regions. The behaviour of TiO_2 varies from region to region. In Region 1 it shows an exponential positive increase with distance; in Region 2 it shows a linear increase; and in Region 3 it shows no covariation. However in the three regions TiO_2 shows a linear decrease with increasing SiO_2. Al_2O_3 has a more uniform covariation than TiO_2, because it decreases linearly with distance in Regions 1 and 2, although it shows no variation in Region 3. Also Al_2O_3 does not correlate with SiO_2 in any of the 3 regions. Fe_2O_3 shows a slight covariation with distance and SiO_2 (positive and negative respectively) in Region 1, but no covariation in Regions 2 or 3. FeO shows no covariation with distance or SiO_2 in Regions 1 and 3, but in Region 2 it shows a slight positive covariation with distance and a very good negative covariation with SiO_2. MnO behaves the same in the three regions showing no covariation with either distance or SiO_2. MgO can be correlated with SiO_2 in the three regions, and can be negatively

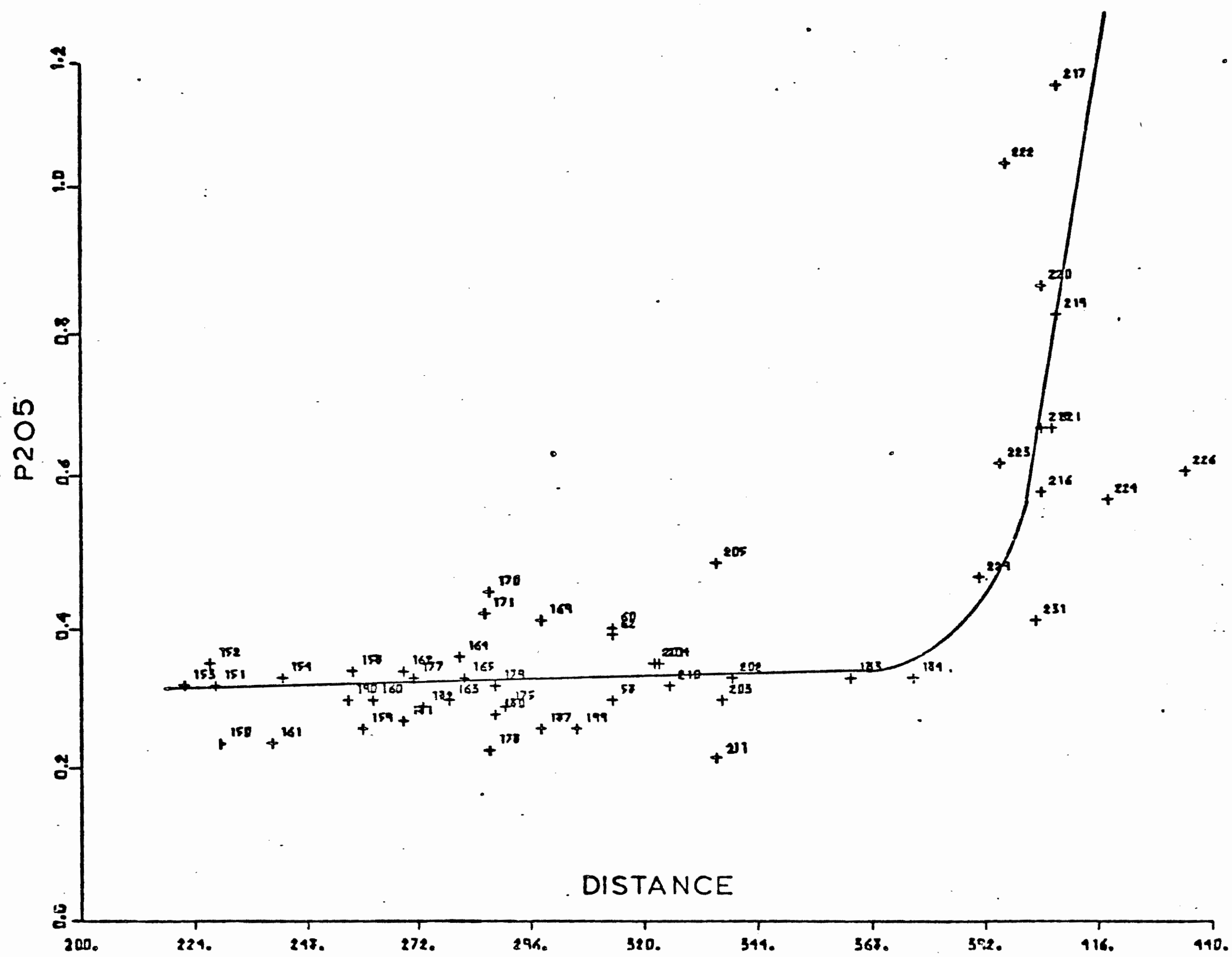


FIGURE 21: Plot of P_2O_5 versus distance from the Peru-Chile Trench for the andesites of Region 1. P_2O_5 is in weight percent and distance is in km.

correlated with distance in Region 1. In Regions 2 and 3, MgO shows no covariation with distance. CaO shows no correlation with distance, but it shows a very good negative correlation with SiO_2 in the three regions. Na_2O shows a different behaviour in the 3 regions. In Region 1 it shows no covariation with distance, while in Region 2, it shows a negative correlation (Figure 22) and in Region 3 it shows a positive correlation (Figure 23). With respect to SiO_2, Na_2O is independent. K_2O shows no correlation with distance in Region 3, but it shows a better correlation in Region 2 and an even better correlation in Region 1 (Figure 24). K_2O in andesites showed no variation with SiO_2 in any of the three regions. The K-index for the three regions was computed and plotted against distance. Figures 25 and 26 show the K-index versus distance for all the rock types of Regions 1 and 2 respectively. Note in these diagrams the similarity in shape (i.e. similar behaviour of the K-index), which is of step-like form. This behaviour of the volcanic rocks of these two regions is comparable to the behaviour of the rocks of the Sierra Nevada batholith studied by Bateman and Dodge (1970). From these two figures it is possible to divide Regions 1 and 2 into two broad longitudinal zones of differential K_2O values. The boundary line in Region 1 would be at approximately 360 km from the trench, and in Region 2 it would be approximately at 490 km. However, even though this way of demarking zones for potassium seems reasonable, it is not truly valid because Figures 25 and 26 represent a compressed picture of what is happening in a broad area. Thus below will be described a better way of zoning the potassium in the Central Andes. But first a reference to Region 3 is necessary. For

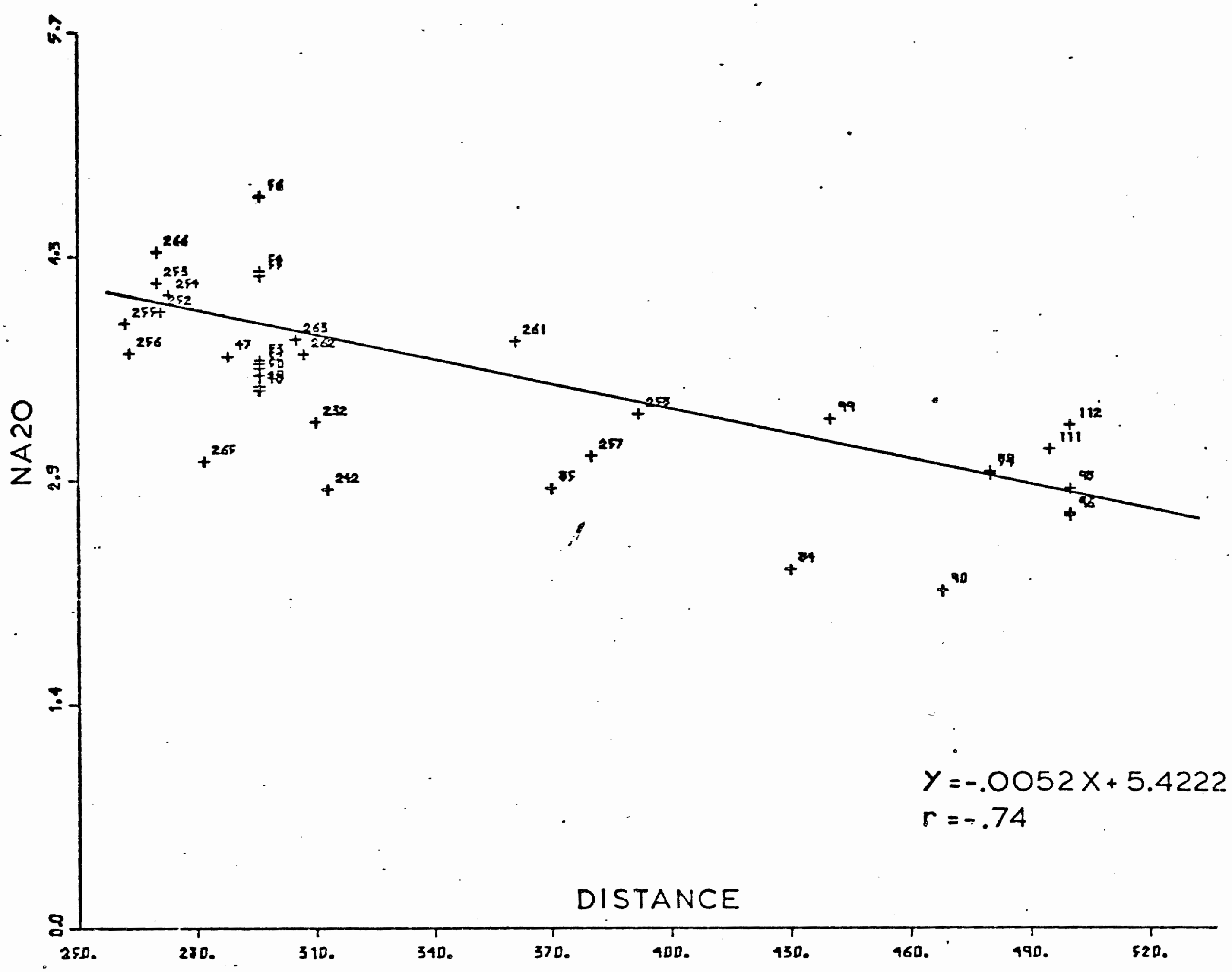


FIGURE 22: Na_2O versus distance from the Peru-Chile Trench diagram for the andesites of Region 2. The code number (NMBR) for each rock analysis appears beside each data point. Na_2O is in weight percent. Distance is in km.

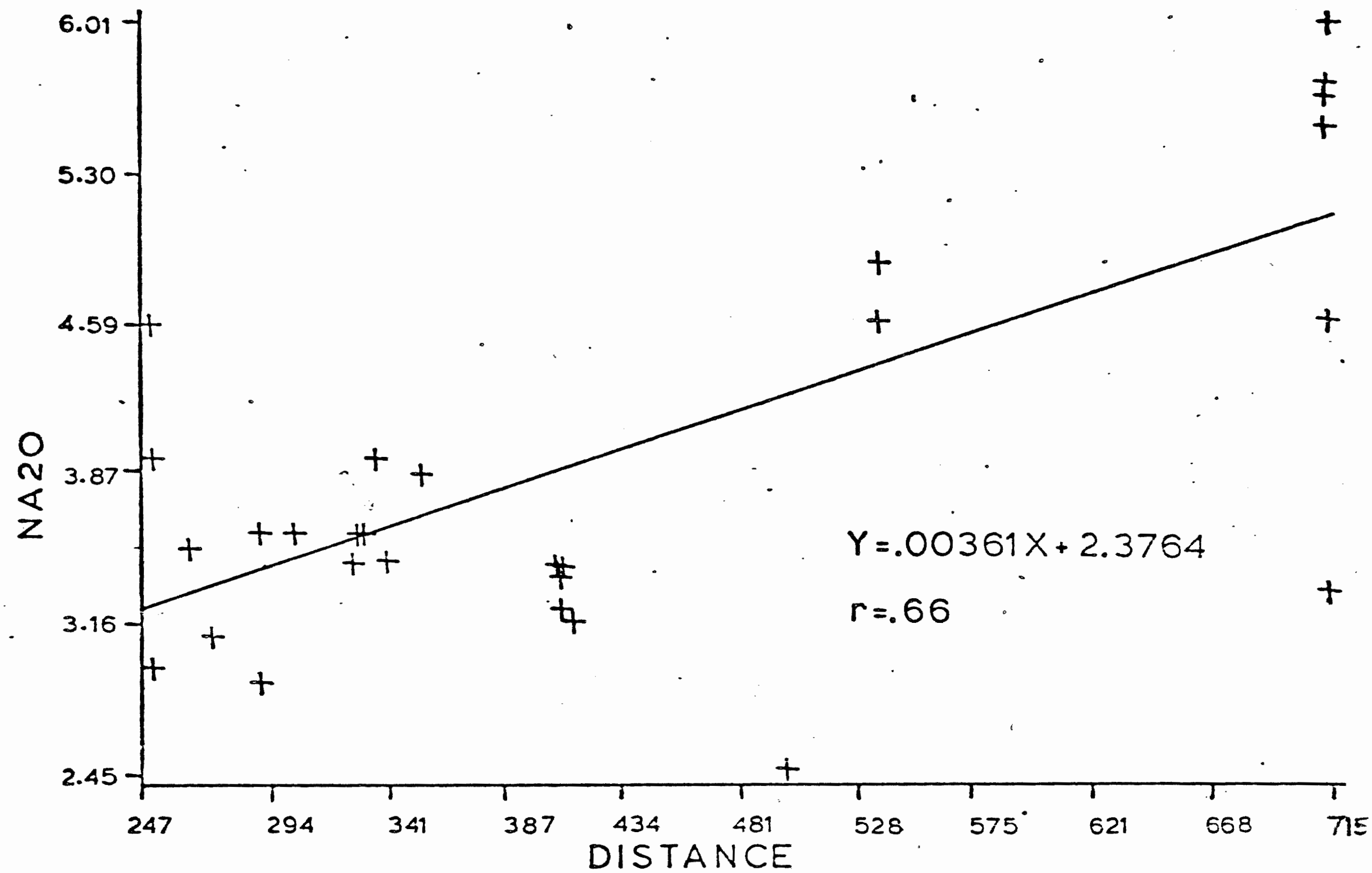


FIGURE 23: Na_2O versus distance from the Peru-Chile Trench diagram for the andesites of Region 3. The code number for each rock analysis (NMBR) appears beside each data point. Na_2O is in weight percent. Distance is in km.

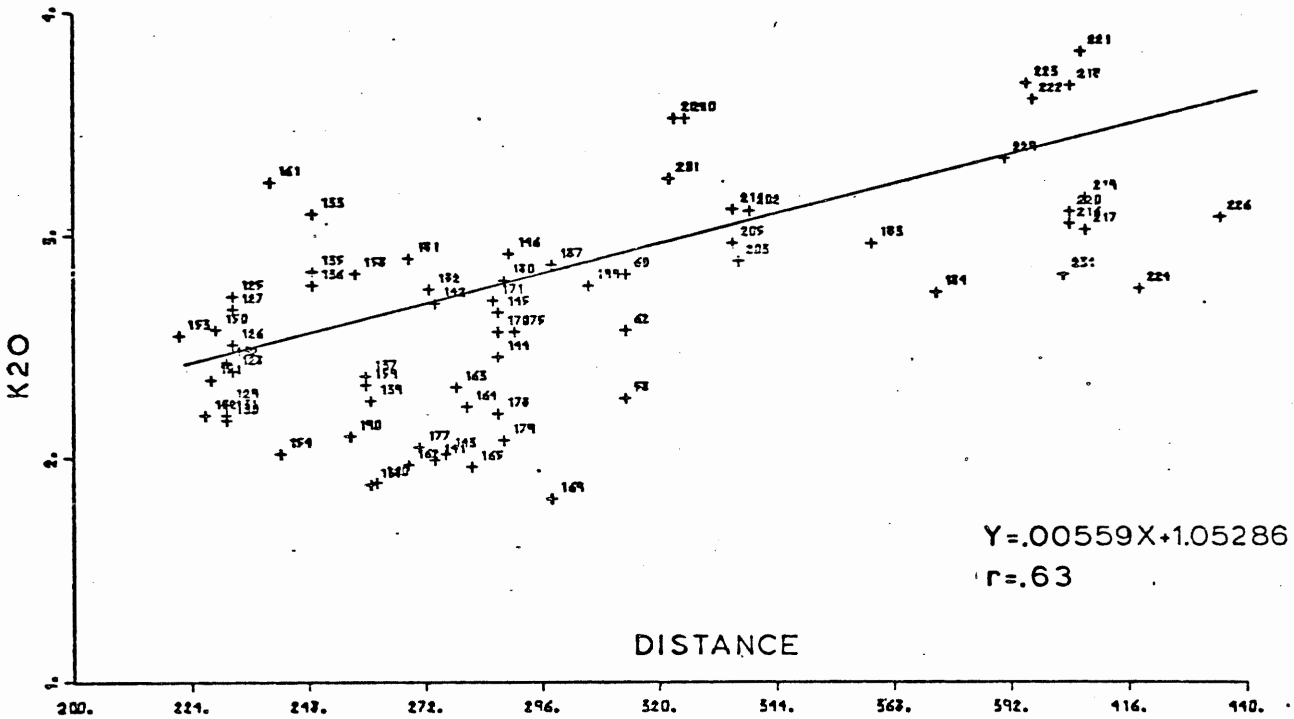


FIGURE 24: Plot of K_2O (in weight percent) versus distance from the Peru-Chile Trench for the rock analyses of the andesites of Region 1. The distance is in km.

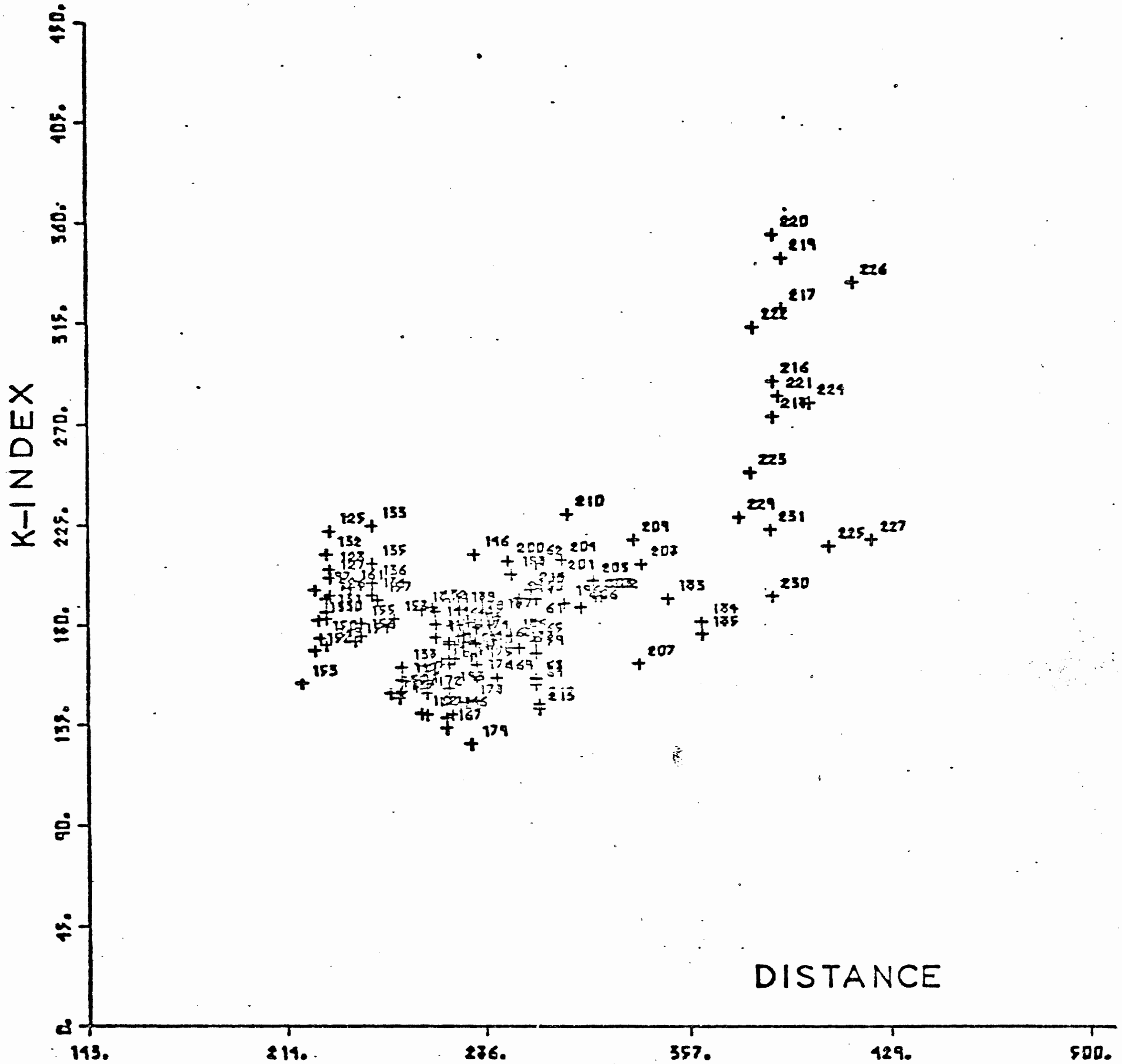


FIGURE 25: Plot of K-index versus distance for all the analyses of Region 1. The distance is in km. The code number (NMBR) appears beside each data point.

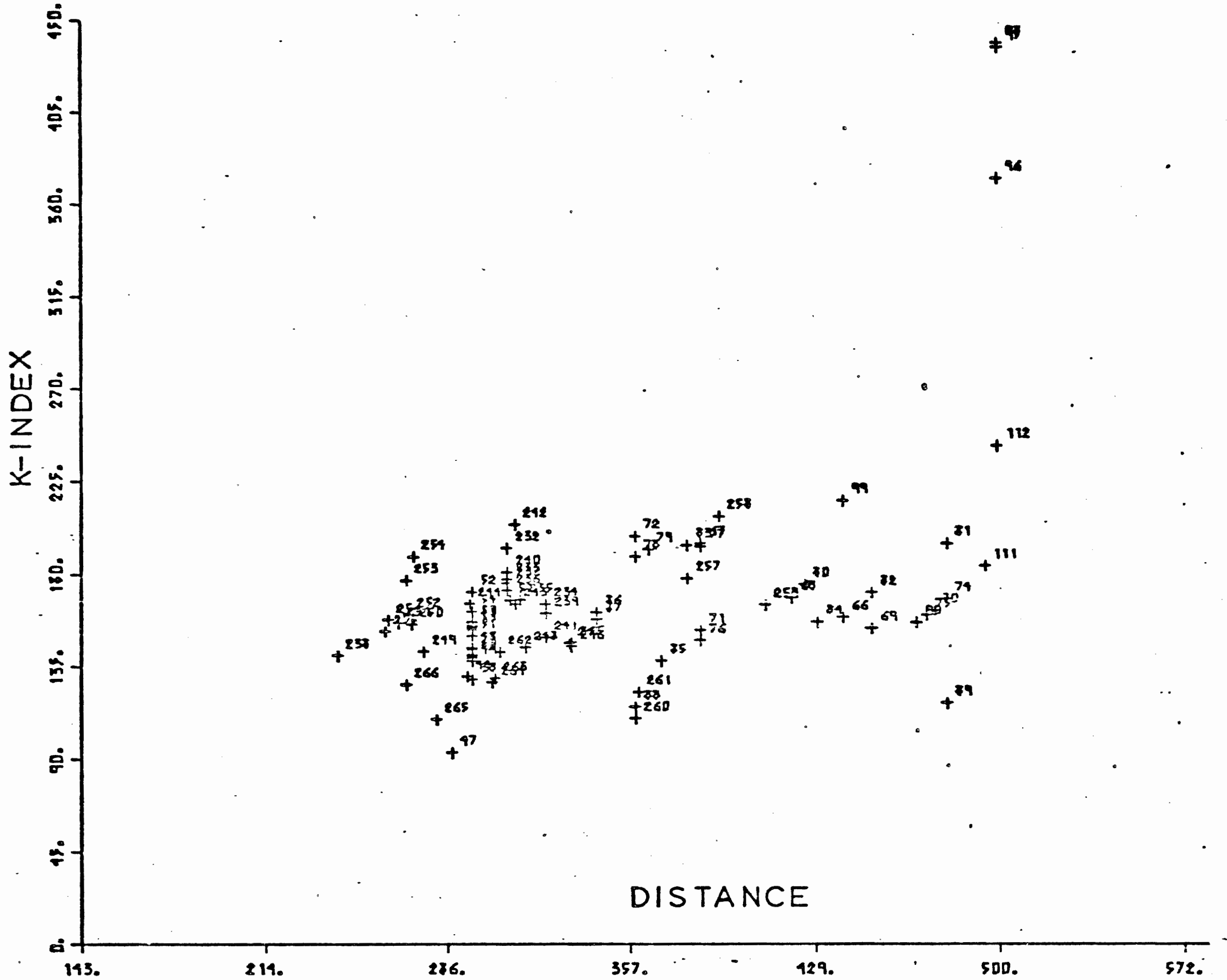
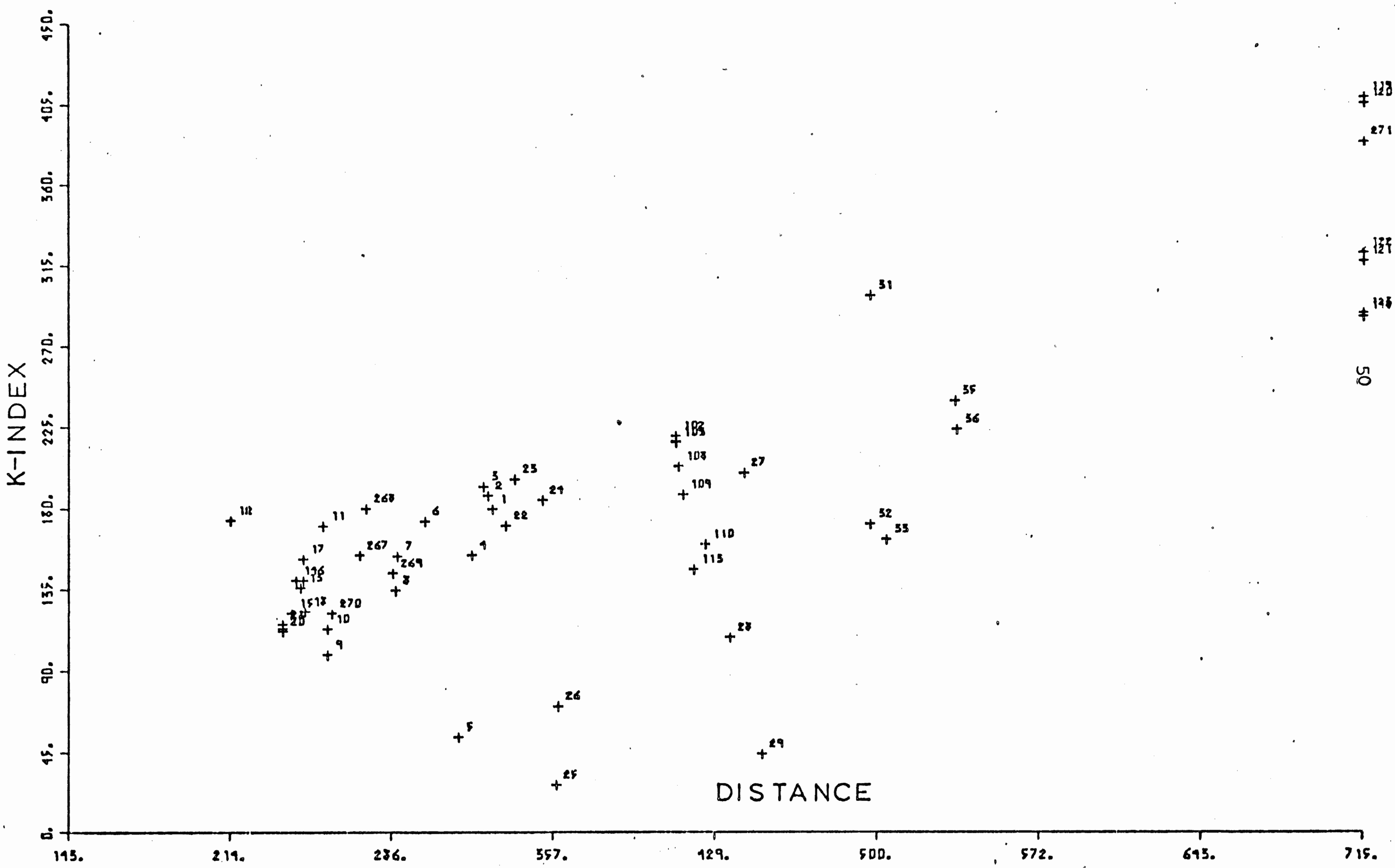
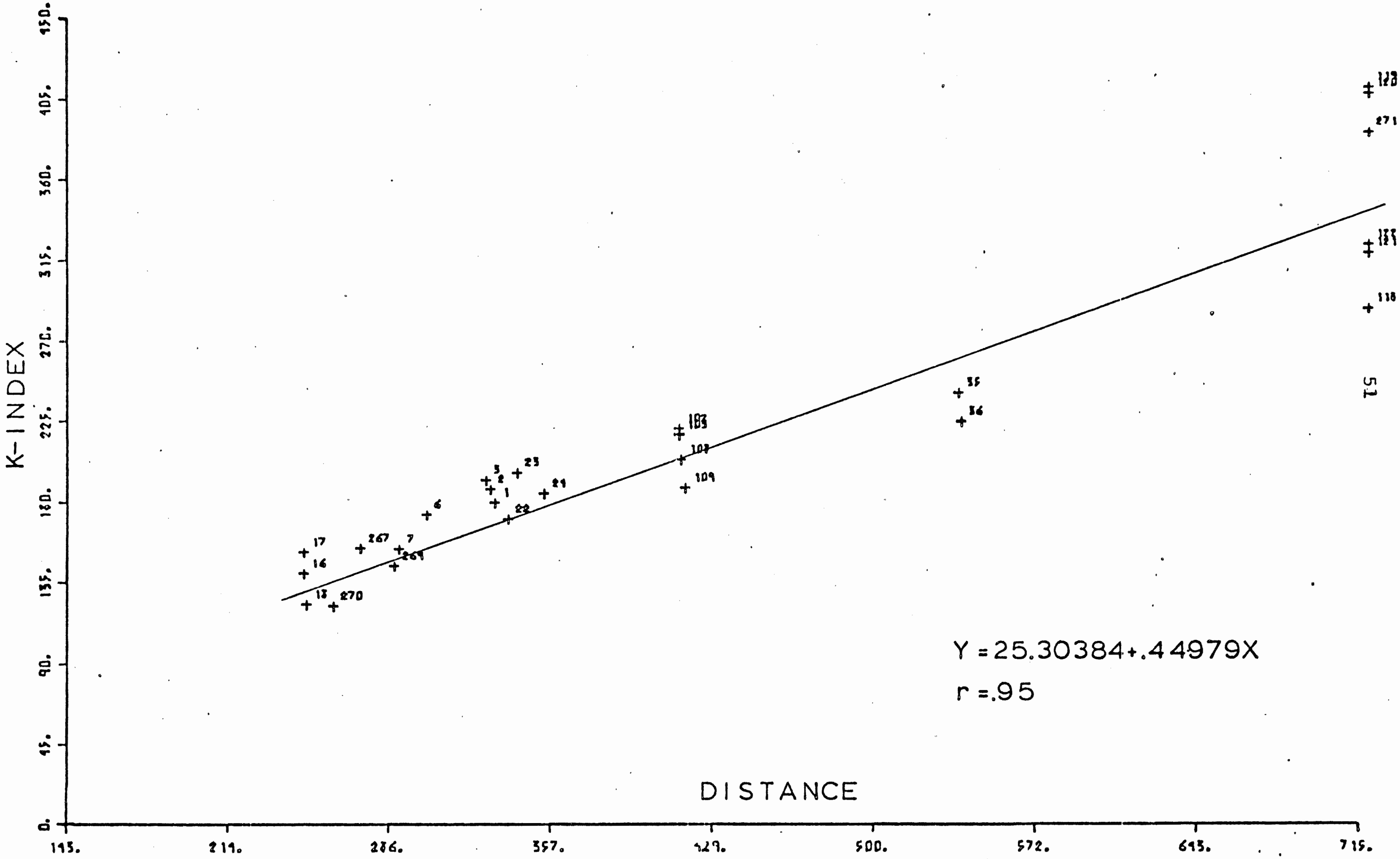


FIGURE 26: Plot of K-index versus distance for all the analyses of Region 2. The distance is in km. The code number appears beside each data point (NMBR).

Region 3, the K-index versus distance plot for all the rock types (Figure 27) shows a slight positive trend. The plots of K-index against distance for the dacites and rhyolites have a steplike shape similar to those shown for Regions 1 and 2. But for the andesites (Figure 28) and basalts the K-index shows a positive linear increase with increasing distance. Figure 28 indicates that the slight positive correlation shown in Figure 27 is controlled by the andesites, and that the potassium increases steadily with distance in the southern part of the Central Andes. On the other hand, in the middle and northern portions the potassium is invariant first and then it shows a dramatic increase in values.

In a geographical-position plot of the samples (Figure 29) have been divided each degree of latitude and longitude into four cells, and for each cell the average K-index was calculated. It was found that in order to show the zonation of potassium, such an approach was required. Figure 29 shows the area of the Central Andes under study divided into cells of 1/2° per 1/2°. Each cell is made up of a certain number of samples, for which an average K-index value has been computed (Table 7). This diagram applies to the andesites only, and it can be appreciated that the highest values appear further away from the trench, and that the lowest values fall closer. Owing to the relatively small density of the sample distribution there are many areas that are left blank. Before extrapolating, it would be valuable to find the K-index for several rocks in those areas, though.


K-INDEX
DISTANCE
0.
45.
90.
135.
180.
225.
270.
315.
360.
405.
450.
145.
715.


K-INDEX
DISTANCE
Y =25.30384+.44979X
r =.95

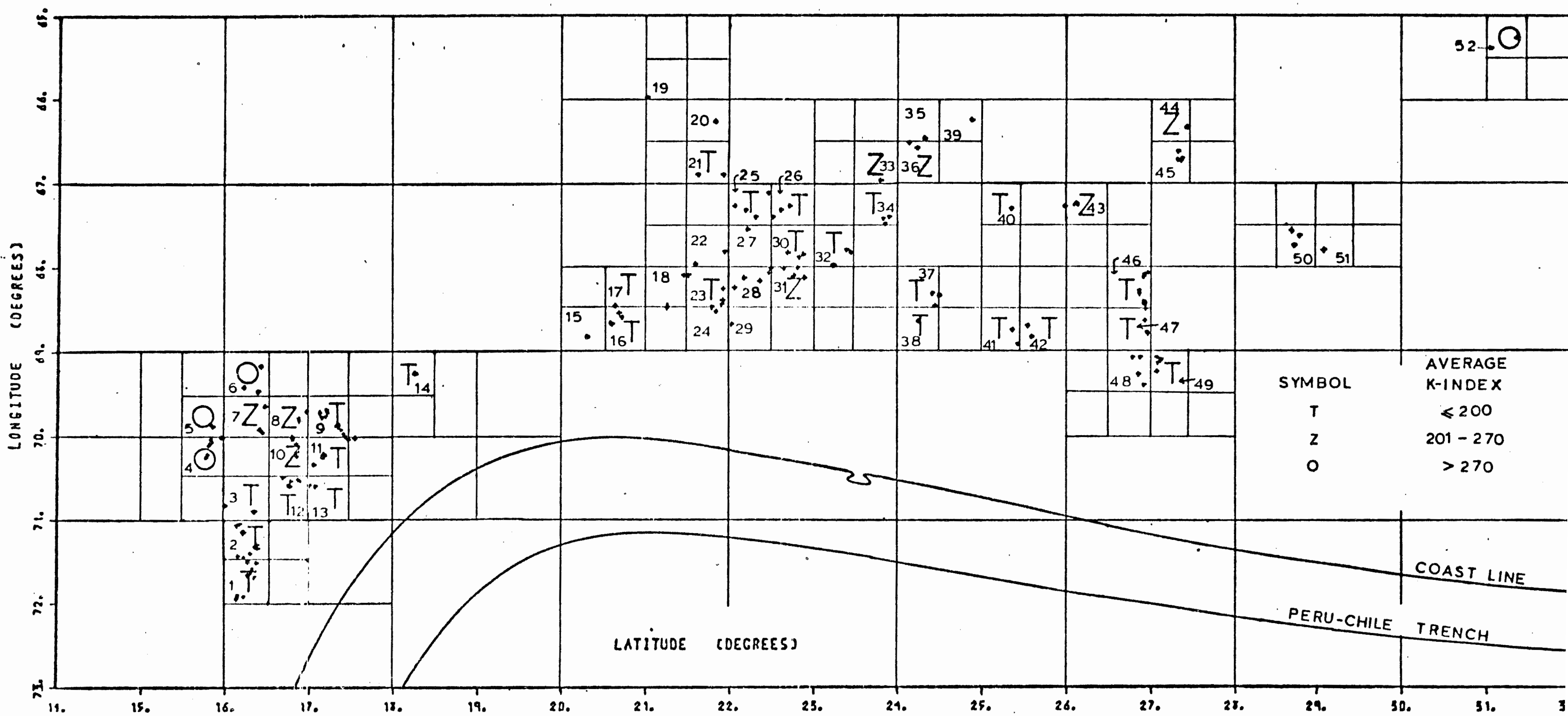

LONGITUDE (DEGREES)
LATITUDE (DEGREES)
SYMBOL
AVERAGE K-INDEX
T ≤ 200
Z 201 - 270
O > 270
COAST LINE
PERU-CHILE TRENCH

TABLE 7

Average K-index values for each cell (andesites only)

C_i = <u>ith</u> cell

K_i = <u>ith</u> K-index value

- = no andesites in this cell

(x) = number of samples in cell i (andesites)

Ci	K_i andesites (x)	Sample numbers (all rocks
1	192 (19)	125 to 136, 149 to 154, 161, 197 to 200
2	157 (11)	137 to 140, 155 to 160, 162 to 169
3	180 (2)	170, 171, 196
4	294 (9)	216 to 223, 230, 231
5	279 (1)	224, 225
6	333 (1)	226, 227, 228
7	200 (3)	183, 184, 185, 229
8	--	207, 208, 209
9	182 (8)	114, 145, 186, 187, 188, 201 to 206
10	214 (3)	146, 210 to 215
11	162 (9)	141 to 143, 173 to 180, 182, 189
12	--	147, 148, 190 to 195
13	148 (1)	172
14	185 (3)	58 to 65
15	--	251
16	162 (4)	252, 253, 255, 256
17	189 (1)	254
18	--	87, 86, 44
19	--	81
20	--	75

Table 7 (continued):

21	156 (1)	71, 76, 77, 90
22	--	67, 72, 79, 83
23	145 (11)	37 to 43, 45, 47 to 57, 249
24	--	238, 250
25	168 (1)	68, 69, 74, 78, 80, 82
26	156 (1)	66, 84
27	--	70
28	192 (1)	232, 233, 240, 241, 244, 248
29	--	----
30	127 (2)	85, 88, 89, 234
31	204 (1)	235, 236, 237, 239, 242, 243
32	122 (1)	245, 246, 247, 260, 261
33	215 (1)	99
34	193 (2)	257, 258, 259
35	416 (3)	96, 97, 98
36	213 (2)	111, 112
37	127 (3)	262 to 265
38	126 (1)	266
39	--	105, 106, 107
40	197 (2)	108, 109
41	138 (2)	267, 270
42	144 (1)	268, 269
43	216.5 (2)	100 to 104, 110, 113
44	232 (2)	35, 36
45	--	30 to 34
46	185 (6)	1 to 5, 22 to 26
47	164 (2)	6, 7, 8
48	--	9 to 12, 19, 20, 21
49	138 (3)	13 to 18
50	--	28, 29
51	--	27
52	353 (6)	114 to 124

Many of the trace elements do not show covariation with distance or SiO_2, but many of them show a good correlation among themselves. This correlation can either be linear (positive or negative) or parabolic (concave upwards or downwards). Data were available in Region 1 for only 5 trace elements: Ba, U, Li, Rb, and Sr. Data were available in Region 2 for 12 trace elements: Zn, Cu, V, Zr, Ni, Co, Y, Cr, Sc, Sr, Ba, and Rb. And data were available in Region 3 for 22 trace elements: Li, Ag, Sn, Ga, Pb, Zn, Cu, B, Be, Mo, V, Zr, Ni, Co, Y, Ce, Cr, Sc, Sr, Ba, Rb, and U. In Region 3, Li, Ga, Zn, Cu, Be, Mo, V, Ce, Cr, Sc, Sr, Ba, Rb, and U show no variation with either distance or SiO_2. Pb, Co and Ni vary with SiO_2 positively, negatively, and negatively respectively, but show no variation with distance; and Zr and Y vary with distance (negatively and positively respectively) but show no correlation with SiO_2. In Region 2, Zn, V, Ni, Y, and Co behave in a similar fashion as in Region 3. But Cu, Zr, Cr, Sc, Sr, Ba, and Rb behave differently. Cu and Zr vary negatively with distance and show no correlation with SiO_2. Figure 30 is a plot of copper versus distance. Note in this figure that most samples fall in either end of the fit line, but the few samples that fall in between follow the trend set by either end. Sr and Rb show a positive correlation with distance and no covariation with SiO_2. Cr and Sc show no covariation with distance but a positive correlation with SiO_2. Finally, Ba follows a negative trend with SiO_2 but shows no covariation with distance.

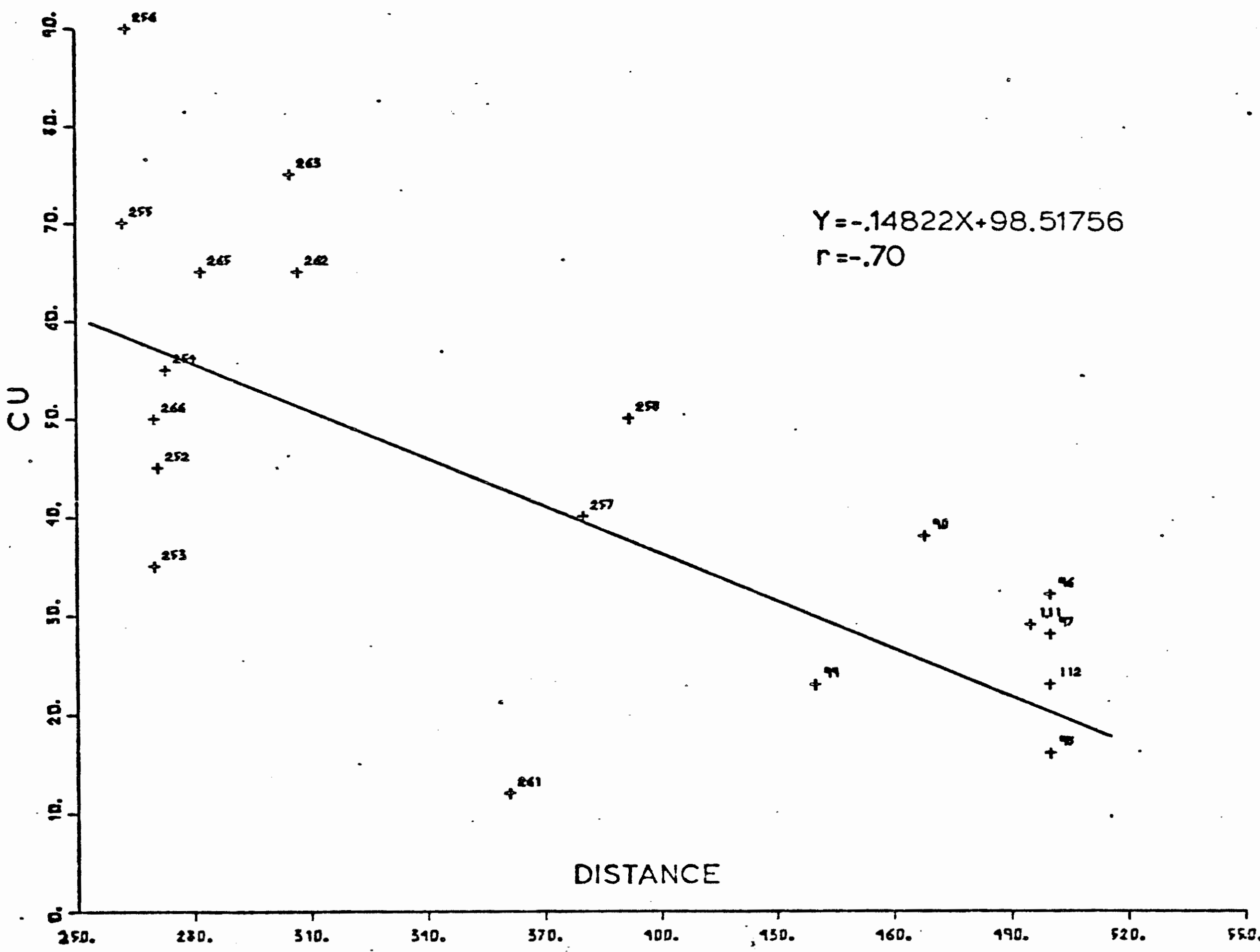


FIGURE 30: Copper (in ppm) versus distance from the Peru-Chile Trench (in km) diagram for the andesites of Region 2.

The trace elements in Region 1 shows two types of covariation with distance: Li, Rb, and U follow a parabolic concave downwards relation, Sr follows a parabolic concave upwards relation, and Ba follows a linear trend. With respect to SiO_2, none of these elements show correlation. Figures No. 31 and 32 are diagrams of lithium and uranium versus distance. Note that in both cases the andesites (unfilled circles) reach a maximum at approximately 320 km from the trench. Rb reaches a maximum at the same distance as U and Li, and Sr reaches a minimum at approximately 330 km from the trench. Since the continental crust in Region 1 reaches a maximum thickness at about 320 to 330 km from the trench, it is interesting to note that the point at which the tangent touching the maxima and minima in the plots of Li, U, Rb, and Sr versus distance, coincides roughly with the point of maximum continental thickness (Figure 33).

Finally the $^{87}Sr/^{86}Sr$ isotopic values (initial ratio) follow a negative linear relationship with distance (Figure 34) and no relation with SiO_2.

<u>Dacites</u>

The major elements of the dacites of Regions 1 to 3 do not show variation with distance, except TiO_2 and P_2O_5 in Region 1 where they show a slight positive increase with increasing distance, and Na_2O in Region 2 which follows a negative trend with distance (Figure 35). However, the covariation of the major elements with SiO_2 is better. In Region 1 TiO_2, K_2O, and P_2O_5 show a slight increase with increasing

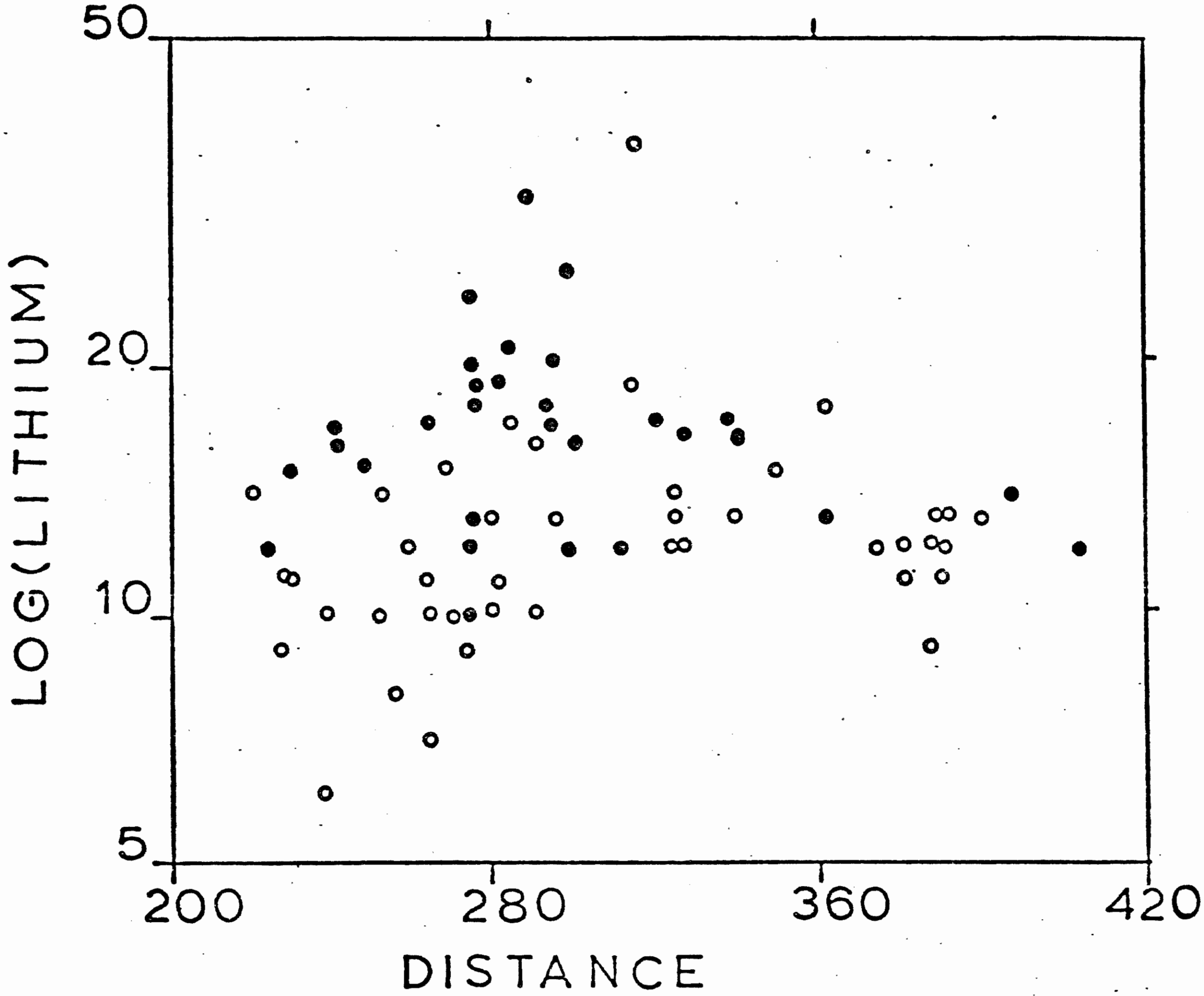
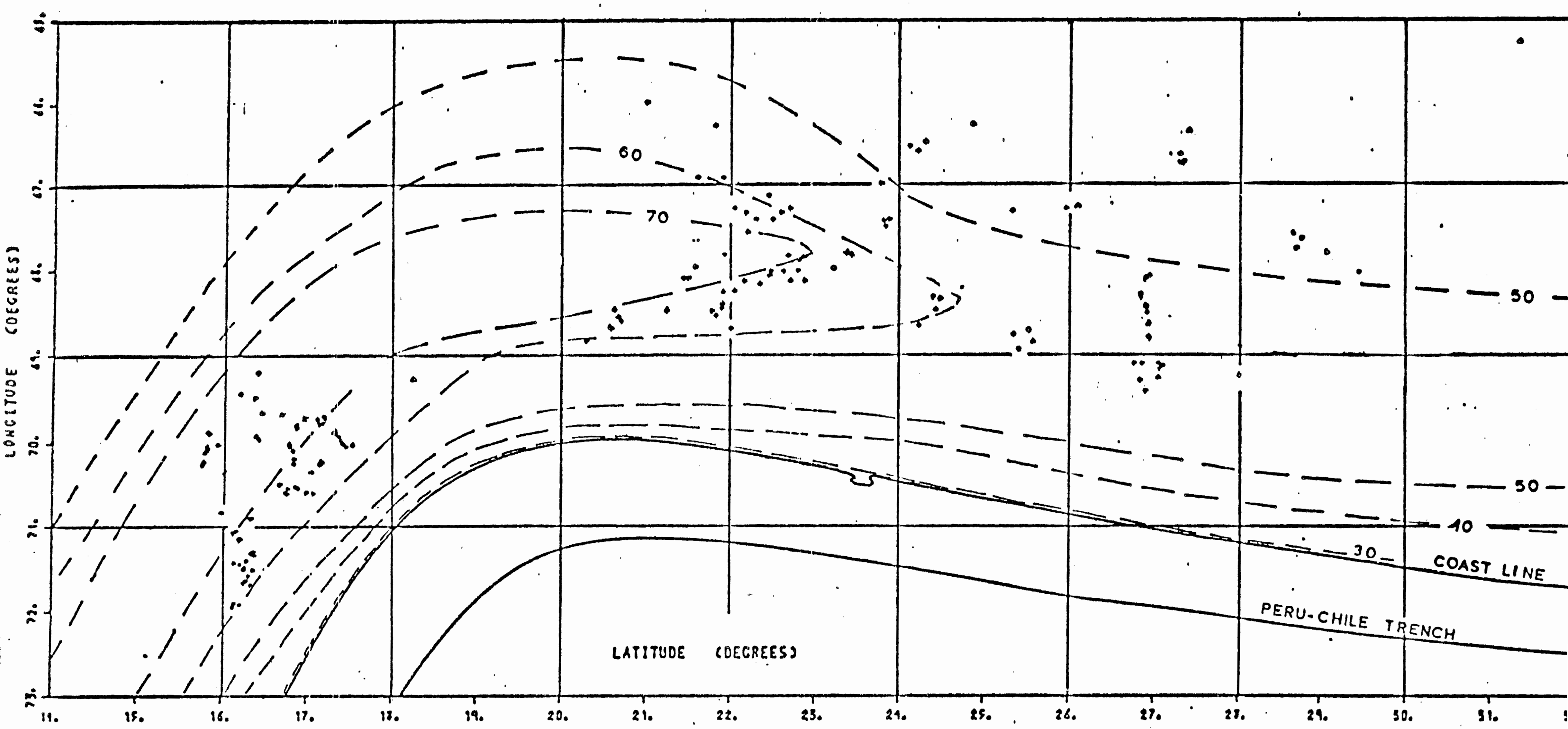


FIGURE 31: Log normal plot of Lithium (ppm) versus distance (km) for the andesites (circles) and dacites (dots) of Region 1.

Figure 33: This figure shows the contour lines of the Moho surface at the base of the Central Andean crust (James, 1971) in dashed lines. The numbers that appear in each of the Bouguer anomaly lines are the depth from the sea level to the base of the crust, and they are in kilometers.


LONGITUDE (DEGREES)
60
70
50
50
40
30
COAST LINE
PERU-CHILE TRENCH
LATITUDE (DEGREES)

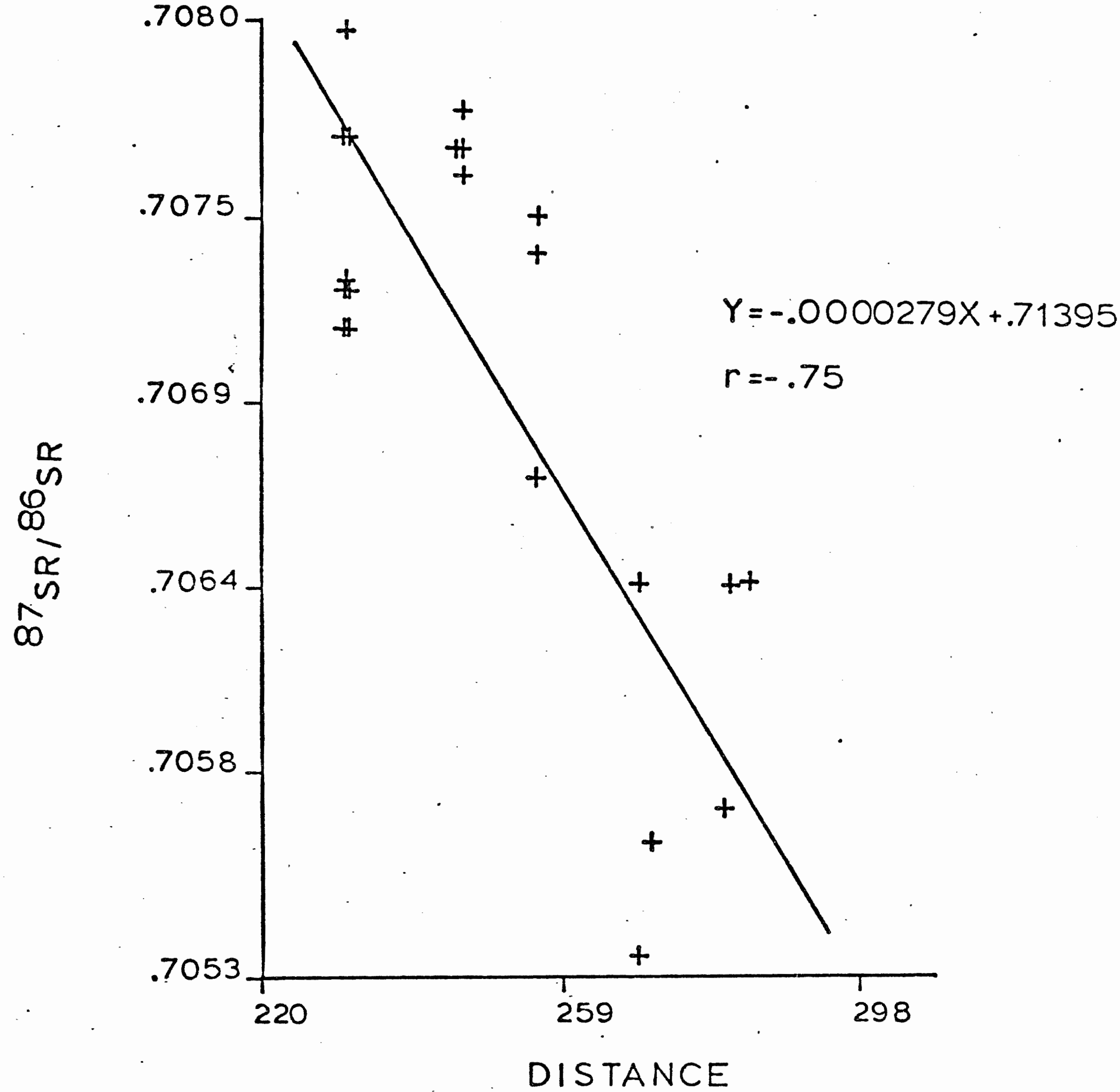


FIGURE 34: $^{87}Sr/^{86}Sr$ versus distance from the Peru-Chile Trench (in km) diagram for the andesites of Region 1.

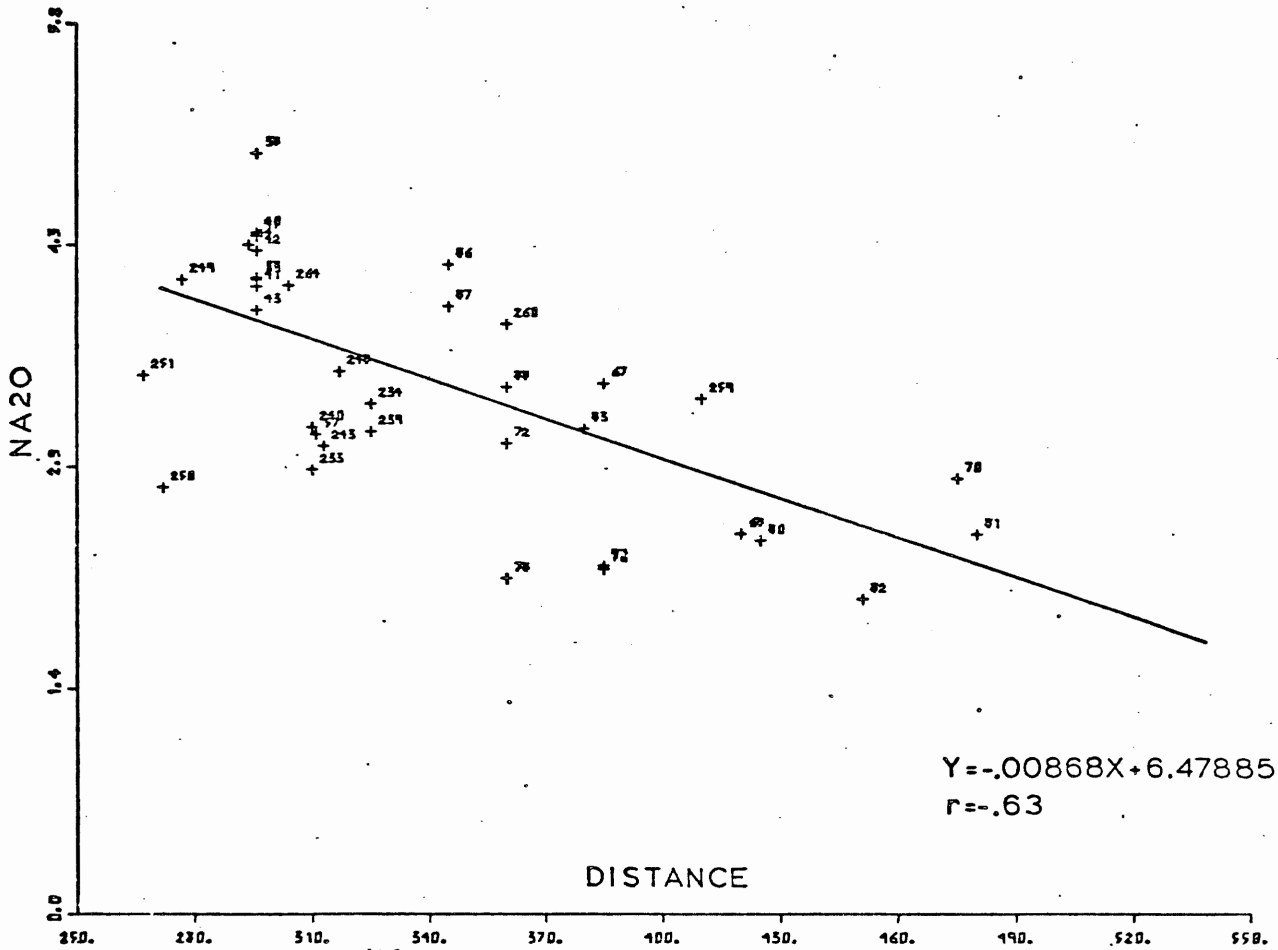


FIGURE 35: Na_2O versus distance from the Peru-Chile Trench diagram for the dacites of Region 2. The code number (NMBR) for each rock analysis appears beside each data point.

SiO_2, and MgO and CaO decrease linearly with increasing SiO_2. In Region 2 FeO, MgO, CaO, and Na_2O show a negative correlation with SiO_2, and K_2O shows a positive correlation as in Region 1. In Region 3 TiO_2, contrary as in Region 1, decreases linearly (negative correlation) with increasing SiO_2, but CaO, as in Region 1 and 2 has a negative correlation.

With respect to the trace elements, in Region 3, which has the most abundant data, Li, Ag, Ga, Pb, Cu, Be, Mo, Zr, Ni, Cr, Sc, Ba, Rb, and U show no variation with either distance or SiO_2. Sn, B, and Ce had less than 4 samples each (Table 6, Appendix A) and therefore it was not possible to detect a true relationship with SiO_2 or distance. However, Zn, Y, Sr, and Co show a good correlation with distance, and the latter together with V also vary (negatively) with SiO_2. Figure 36 is a plot of Sr versus distance for the dacites of Region 2; note in this diagram that the scatter is greatest in the center portion. In Region 1 Sr, and Ba do not show variation with either distance or SiO_2. But Rb shows a good correlation with SiO_2 although it shows no correlation with distance. The lithium and uranium behave like in the andesites. In Figure 31 and 32 the dacites appear as filled circles. Note in these two diagrams that the dacites generally have greater contents of Li and U than the andesites at any given distance. There was not enough isotopic data (< 4 samples) in any of the three regions to detect what kind of relationship it follows with distance or SiO_2.

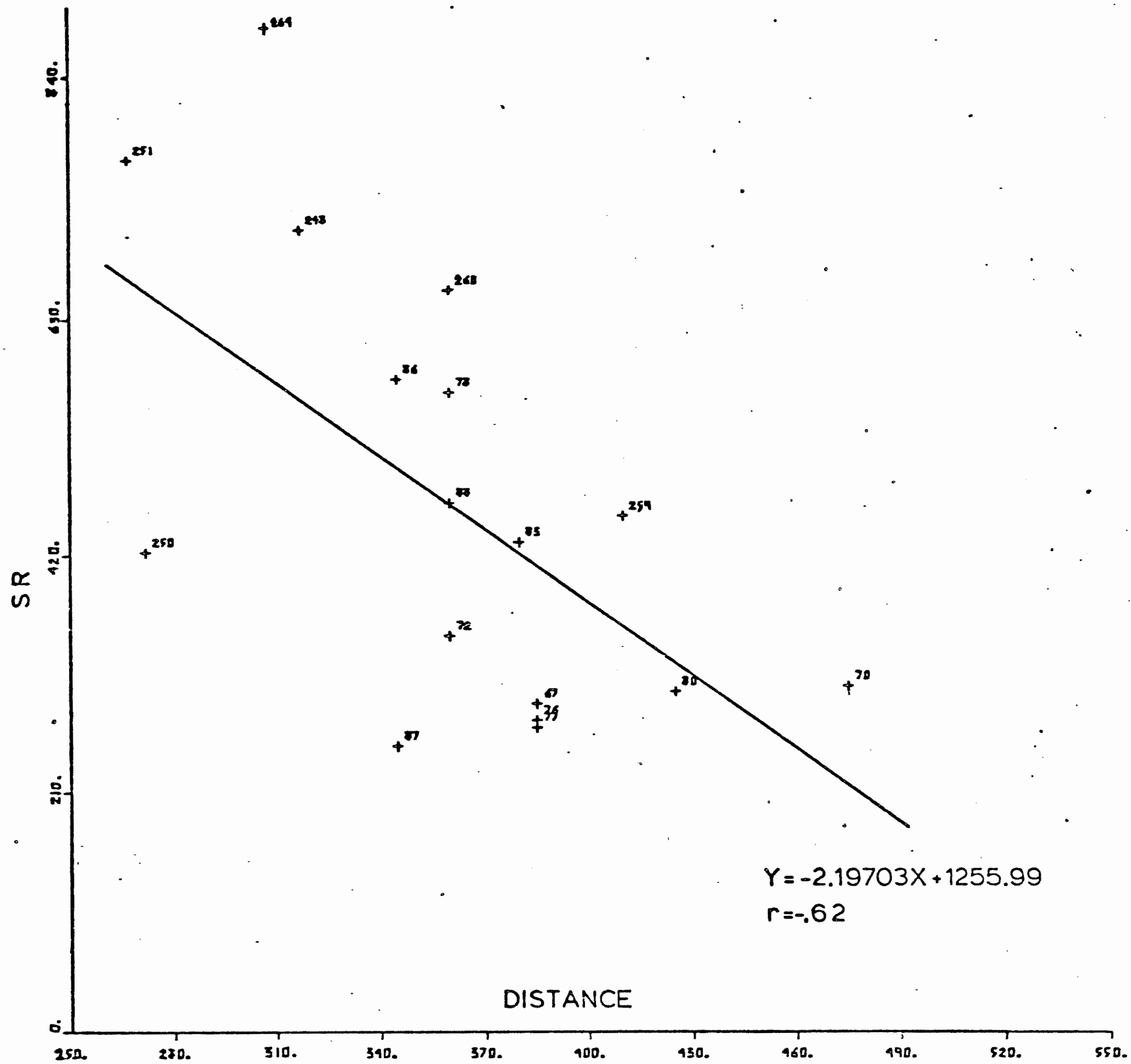


FIGURE 36: Sr (in ppm) versus distance (in km) plot for the dacites of Region 2.

With respect to the relative contents of each element in the dacites of the 3 regions, the following can be said: Al_2O_3, Fe_2O_3, MgO, Na_2O, and K_2O show comparable ranges in each region, but TiO_2, FeO, and CaO have the lowest values in Region 1. In particular CaO has on the average (Table 6, Appendix A) the highest values in Region 3. P_2O_5 has the lowest values in Region 2, and comparably higher values in Regions 1 and 3, thus making a saddle point in Region 2. The trace elements also show some longitudinal variation. Vanadium and nickel have higher values in Region 2 than in Region 1 or 3; Sr, on the average has higher values in Region 1 than in Regions 2 or 3; and Ba also shows the same relationship as Sr.

Rhyolites

None of the major elements in rhyolites of any of the three regions varies with distance, except K_2O of Region 1, which shows a slight increase with increasing distance. In Region 1, TiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, and P_2O_5 show very good (negative) correlation with SiO_2, but MnO, Na_2O, and K_2O show no correlation. In Region 2 Al_2O_3, Fe_2O_3, MgO, and CaO vary negatively with SiO_2, but K_2O vary positively. The other major elements in this region show no correlation with SiO_2. In Region 3 none of the major elements vary with SiO_2. With respect to the trace elements and the $^{87}Sr/^{86}Sr$ value, either there was no data or there were too few cases to detect any variation.

Figures 37 and 38 serve to compare the major and trace elements of the volcanic rocks of the Central Andes with equivalent rock types from other places of the circum-Pacific belt, such as the Tonga Islands (Ewart and Bryan, 1972), and East Papua, Fiji, and Solomon Islands (Jakes and White, 1972). Table 8 is a summary of Table 6 for the major elements. It shows the average composition of the different rock types with respect to their major element chemistry for the Central Andean volcanic rocks. It can be seen that in Figure 37 (andesites) there is an almost perfect correlation between the SiO_2, Al_2O_3, and CaO contents of the andesites of the 3 Central Andean regions with those from island arcs. However the Central Andean andesites have higher Sr, Ba, Rb, Ni, and K_2O values; and low V, Y and MgO values; than comparable rocks from island arcs. With respect to FeO, Region 1 has a lower value than island arcs, and with respect to Fe_2O_3, Region 2 has a lower value than island arcs. In Figure 38 (dacites), SiO_2 and Al_2O_3 show an almost perfect correlation between the Central Andean dacites and those from island arcs. But in the Central Andes they have higher FeO, CaO, Fe_2O_3, K_2O, U, Ni, Rb, V, and Zr values; and lower Y and Na_2O values than those from island arcs. Also, the Sr values are lower in the dacites of Region 1 and 3, but equal in Region 2 to those of island arcs.

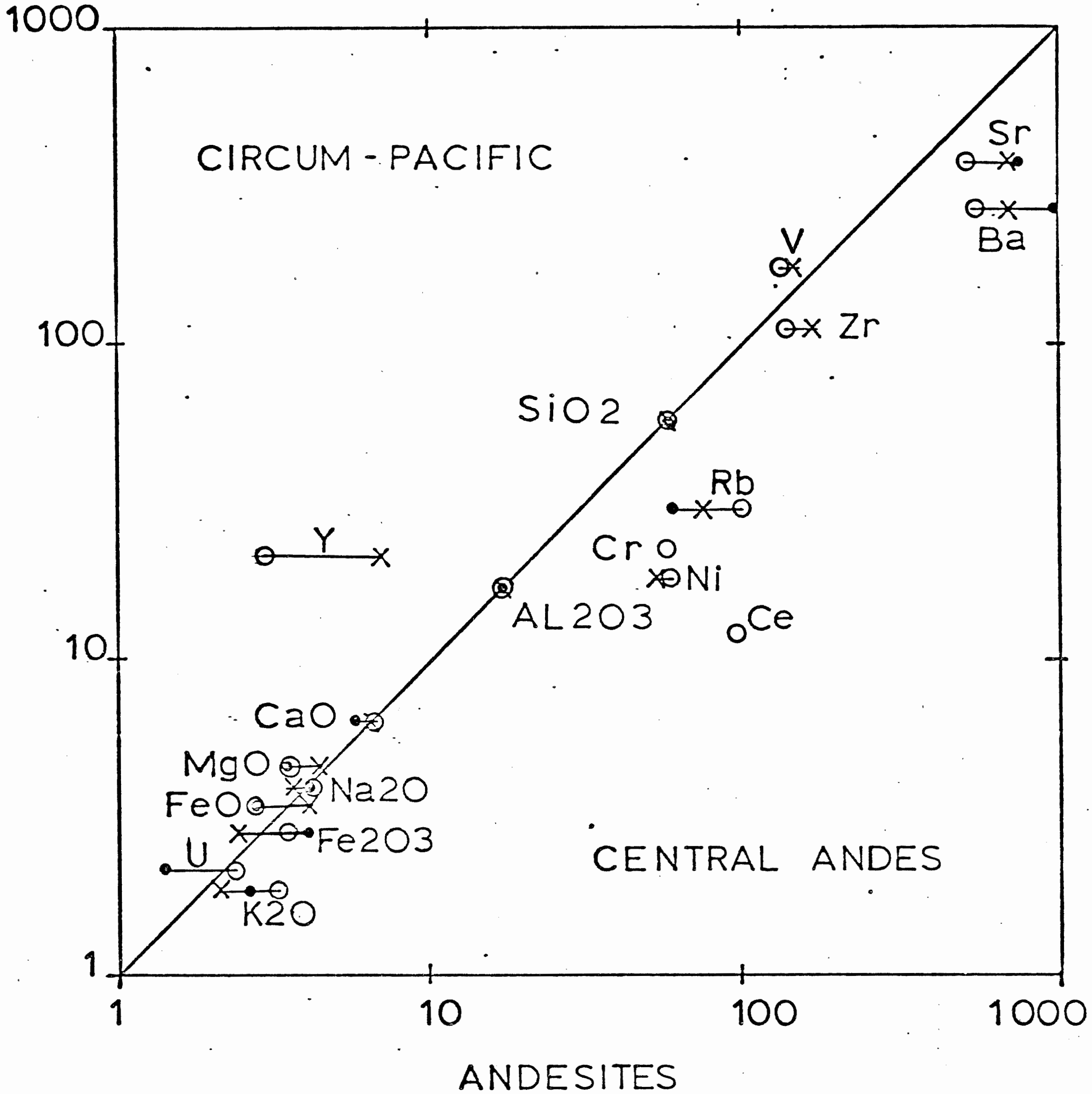


FIGURE 37: Log log plot of the average compositions of the Central Andean volcanic rocks for each region versus the Circum-Pacific averages. Dots are Region 1; crosses are Region 2; and circles are Region 3. (The Circum-Pacific data comes from Jakes and White, 1972, and Ewart and Bryant, 1972).

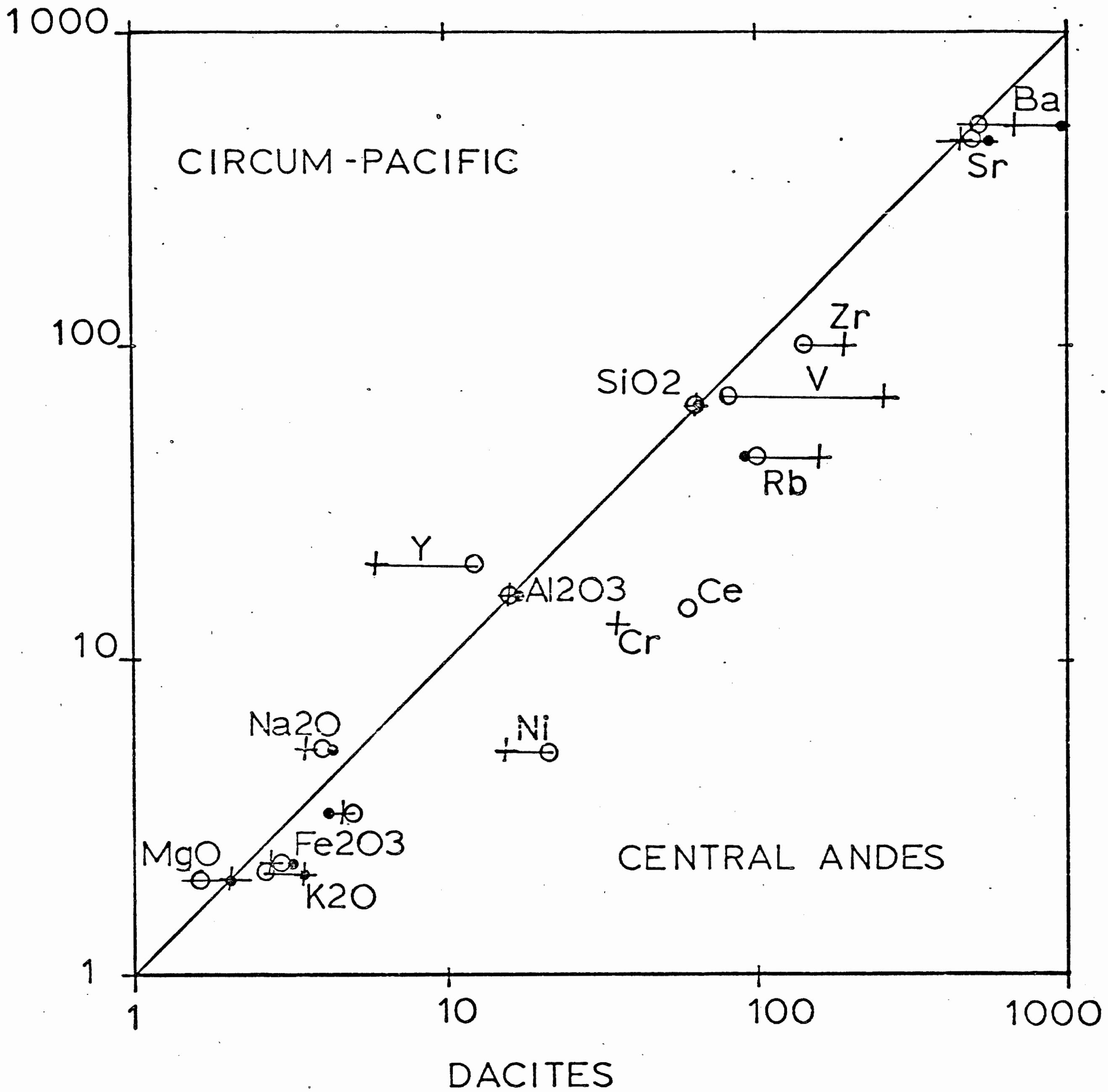


FIGURE 38: Log log plot of the average compositions of the Central Andean volcanic rocks for each region versus the Circum-Pacific averages. Crosses are Region 1; dots are Region 2; and circles are Region 3. (The Circum-Pacific data comes from Jakes and White, 1972, and Ewart and Bryant, 1972).

VARIABLE	CASES	MEAN	STD DEV
SIO2	135	58.4791	2.4606
TIO2	114	1.0516	.3896
AL203	114	16.7968	1.0282
FE203	114	3.3669	1.3590
FEO	114	3.1711	1.4646
MNO	114	.1136	.0390
MGO	114	3.7525	1.6144
CAO	114	6.2092	1.0253
NA2O	135	3.8631	.5954
K2O	135	2.6009	.6838
P205	114	.3622	.2304
LI	56	14.9643	7.1401
AG	3	.2067	.1701
SN	3	2.8667	1.5177
GA	11	16.0000	1.8974
PB	11	15.0000	7.0852
ZN	26	94.0769	42.5919
CU	42	36.5952	20.8409
B	3	14.0000	13.0000
BE	9	2.9444	3.4681
MO	7	5.1429	3.5790
V	30	137.7000	51.9775
ZR	42	193.1667	60.8569
NI	50	55.4000	50.9966
CO	38	23.3947	7.9781
Y	30	19.0333	20.2425
CE	3	99.3333	43.8786
CR	25	92.0400	111.0527
SC	26	31.1769	17.0335
SR	107	694.2991	190.5660
BA	74	907.4730	378.6674
RB	107	72.4393	37.4539
U	33	1.8000	1.4804
SRRATIO	22	.7069	.0007
DIST	135	335.8222	111.5775

DACITES

VARIABLE	CASES	MEAN	STD DEV
SIO2	86	64.1667	1.4695
TIO2	83	.7411	.1544
AL203	83	16.4804	.6244
FE203	83	2.8945	1.0310
FEO	82	1.7463	.9755
MNO	83	.0828	.0366
MGO	83	1.9635	.5620
CAO	83	4.4630	.7686
NA2O	86	3.8608	.7472
K2O	86	3.1472	.6045
P205	82	.2422	.0796
LI	38	21.7368	10.5720
AG	5	.1700	.1056
SN	3	7.3000	6.6836
GA	9	14.7778	2.5874
PB	9	19.2222	12.0600
ZN	23	90.8696	26.1643
CU	29	23.7241	19.7537
B	4	26.5000	9.1104
BE	8	1.1000	.3817
MO	7	7.1429	4.0999
V	18	95.8333	38.0483
ZR	30	167.3667	48.7729
NI	40	17.6750	21.2909
CO	27	11.4815	4.5266
Y	19	10.8947	7.2257
CE	3	59.6667	82.6458
CR	16	23.1250	19.4452
SC	16	13.8000	9.7284
SR	62	524.1935	151.6782
BA	48	912.1875	338.6091
RB	61	114.5902	54.4440
U	27	1.9004	1.2212
SRRATIO	7	.7066	.0008
DIST	86	322.1047	78.3347

CHAPTER 4

GENESIS OF THE INTERMEDIATE VOLCANIC ROCKS

The geochemical variations of the volcanic rocks of the Central Andes probably reflect the varying conditions of their genesis and paths of the magmas during their ascent and crystallization. Several models have been recently proposed to explain the genesis of intermediate volcanic rocks; these models have been reviewed by Thorpe et al. (1976) and Dostal et al. (1977). An attempt is made to see which model is most compatible with the data considered in the present thesis.

Anatexis of the Lower Crust

Pichler and Zeil (1969, 1972), and Fernandez et al. (1973) propose that the origin of the Andean andesites is the melting or partial melting of lower crustal rocks. To support this idea Fernandez et al. (1973) point out the high Al content of most samples, and the high Zn values of 3 samples (among 20 other with relatively lower value!). In addition Fernandez et al. (1973) and Pichler and Zeil (1969) argue other petrologic and isotopic criteria. Pichler and Zeil (1972) consider that the high initial $^{87}Sr/^{86}Sr$ values of the andesites (.7051-.7071) rule out a direct mantle derivation and that they support further a lower crustal origin. Thorpe et al. (1976) and Dostal et al. (1977) on the contrary do not consider the arguments presented above to be correct because:

a) the high initial $^{87}Sr/^{86}Sr$ isotopic data can be accounted for by the more-radiogenic character of the mantle in the Central Andes.

b) of the occurrence of similar andesitic rocks in island arcs that lack a pre-existing old continental crust.

c) of the fact that a crustal origin would not explain the geochemical variations noted across the Central Andes, which may be better correlated with depth to the Benioff Zone (albeit imprecisely and arbitrarily defined), such as the K_2O increase with depth to the Benioff Zone of Dickinson (1970).

Nevertheless, Dostal et al. (1977), Zentilli and Dostal (1977), and McNutt et al. (1975) recognize that the rising magmas may be contaminated by crustal material to a small degree. In view of the arguments presented above, this model will not be discussed further.

Amphibole-controlled Fractionation

Green and Ringwood (1968) proposed that the partial melting of the basaltic oceanic crust metamorphosed to amphibolite can produce an andesitic liquid. This model according to Dostal et al. (1977) could apply to their samples of low SiO_2 content occurring relatively close to the trench, but not to the more siliceous samples occurring farther away because the Benioff Zone under centers of volcanism far away from the trench is too deep to be in the amphibolite facies. This last statement is also shared by Thorpe et al. (1976). Thorpe et al. (1976) also find the high K_2O values of the dacites (over 3%) very difficult to account for by crystallization of a plausible proportion of amphibole. Furthermore, Dostal et al. (1977) and Thorpe et al. (1976) found that the rare earth data also created problems for this mechanism.

Eclogite-controlled Fractionation

Anatexis of eclogite would be capable of yielding a melt of intermediate composition according to Green and Ringwood (1968). According to Dostal et al. (1977) a simple eclogite model cannot account for the light rare earth elements enrichment in the Andean volcanic rocks if the source material has the composition of oceanridge tholeiite. In contrast, Thorpe et al. (1976) say that the alteration of ocean floor basalt would have the effect of enrichment in rare earth elements. Even though this model may account for the major elements composition, it does not account for the trace elements composition of the andesitic lavas. DeLong (1974) proposed that eclogite represented the extreme anhydrous high-pressure transformation that oceanic tholeiite is likely to undergo in a subduction zone, and that partial melting of such an assemblage showed a very large range of K enrichment for 1 to 50 percent melting, but that such an assemblage was deficient in Rb and Sr. The rocks of the Central Andes are invariably (except 1 or 2 samples) very enriched in these two elements. Also this model does not account for the high Ba values.

Partial Melting of Hydrous Upper Mantle

The experimental work of Kushiro et al. (1972), and Mysen and Boettcher (1975) suggests that andesite can be formed by less than

20 percent of partial melting of spinel- or garnet peridotite. However, Thorpe et al. (1976) noted that the experimental work of other workers indicate that andesite magmas are unlikely to be produced by partial melting of peridotite mantle at pressures greater than 10 kb (35 km). It is estimated that the pressure at the mantle in the Northern part of the Central Andes is twice that noted above (i.e. 70 km depth). Nevertheless, Thorpe et al. (1976) note that the rare eart data are consistent with such a mechanism of origin. Lopez-Escobar et al. (1977) indicate that if the andesites were produced by anatexis of peridotite, the Cr and Ni expected values of the andesites should be significantly higher (2200 and 1500 respectively) than they actually are; and that the expected Sr, Ba, and Rb contents should be significantly lower (20, 20, and 1 respectively) than they actually are. Also this model cannot explain the enrichment of light rare earth elements. But if very low degrees of melting are considered (i.e. < 5 percent) this model could explain the behaviour of Cr, Ni, Sr, Ba, Rb, and light rare earth elements (DeLong, 1974; Thorpe et al., 1976). Such a low degree of melting is, however, considered not likely (Thorpe et al., 1976).

None of the models reviewed above could explain fully the genesis of the Andean volcanic rocks. However, in order to account for the enrichment of some trace and rare earth elements in the Andean rocks, Thorpe et al. (1976) propose an enriched eclogite or extensive fractionation involving garnet and clinopyroxene. And Dostal et al. (1977) propose an enriched upper mantle overlying the Benioff Zone, which would partially melt (anatexis), due to the heat brought by felsic magmas rising diapirically, which have been produced by partial melting of eclogite. The combination of these two melts would produce calc-alkaline magmas. In addition, the progressive dehydration of the oceanic slab as it is subducted would cause a decrease in the degree of partial melting with increasing depth of magma generation (Dostal et al., 1977).

Most of the geochemical variations across the Central Andes can be accounted for by the models proposed by Thorpe et al. (1976) and by Dostal et al. (1977). However none of the models could explain the behaviour of Na_2O. As noted before Na_2O in the andesites follow a positive linear relationship with distance from the trench in Region 3, and a negative linear relationship in Region 2, therefore whichever process is invoked involving the subducted oceanic slab and upper mantle to produce the magmas it is clear that it would have opposite effects in two adjacent areas. A possible explanation may be that in Region 2 the oceanic slab (transformed to eclogite) and the upper mantle are relatively depleted in Na-bearing mineral phases and in Region 3 they are relatively enriched. This depletion or enrichment of certain mineral phases might be controlled by varying degrees of partial melting.

CHAPTER 5

GENESIS OF RHYOLITIC AND IGNIMBRITE ROCKS

Zeil and Pichler (1969) studied the geological relationships and the mineralogy and petrology of the rhyolites of the Central Andes, and put forward a hypothesis for the genesis of those rocks. The hypothesis was that the lavas of rhyolitic composition were produced by anatexis of the upper crust possibly at a depth of 7-8 km. There has been since 1950 a large amount of research bearing on the fusion and crystallization of crustal rocks and of relevant synthetic systems. Noticeable are the discussions by Winkler (1967), Presnall and Bateman (1973), and Willie (1977). Through this research, anatectic models using high H_2O pressures to simulate pressure conditions several kilometers deep into the earth have been created using the systems $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2-H_2O, $CaAl_2Si_2O_8$-$NaAlSi_3O_8$- K $AlSi_3O_8$-SiO_2-H_2O, and K_2O-Al_2O_3-SiO_2-H_2O. The latter serves to tell the influence of excess Al_2O_3, while the 2 former ones deal with common minerals such as plagioclase, orthoclase, and quartz, which are most abundant in granitic melts. The chemical analysis of 26 samples identified as rhyolites by the usage of Taylor (1969) (many of them have been classified as dacites, rhyolites and ignimbrites by their source of reference), indicate that all of them contain more than 85 percent normative Ab+An+OR+QZ and 90 percent of the rocks contain more than 80 percent normative Ab+OR+QZ. If the upper crust of the Central Andes is of granitic composition, the systems $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2-H_2O, and $CaAl_2Si_2O$ O_8-Na L Si_3O_8-

SiO_2-H_2O provide an excellent chemical model for testing a model of upper crust melting by anatexis to produce rhyolitic melts. Four assumptions are necessary before testing the model:

1) there is equilibrium between the different chemical phases in the samples under study
2) in the case of ignimbrites, the pressure of the volatile components was greater than the confining pressure at the moment of eruption
3) the composition plotted in the OR-Ab-QZ ternary diagram is at the liquidus surface
4) the composition of the upper crust is granitic.

Figure 39 is an Ab-OR-QZ ternary diagram in which the data on the "rhyolites" of the three regions have been plotted, and superimposed on it have been drawn on the projection of the isotherms and the cotectic line according to Winkler (1967) at 2000 bars of water pressure (note: this PH_2O = 2000 refer to the pressure used in the experiments to simulate buried conditions). This diagram shows that the samples from Region 1 and 2 plot without much scatter and close to the cotectic line, between the 675 and 750°C isotherms. But two samples fall outside this range falling between the 750 and the 800°C isotherm. The samples from Region 3 show a larger scatter and fall between a wider range of isotherms (750-950°C). This greater scatter shown by the samples of Region 3 may be a reflection of the wider range in values in Al_2O_3, K_2O, and Na_2) than in the other two regions. This in turn

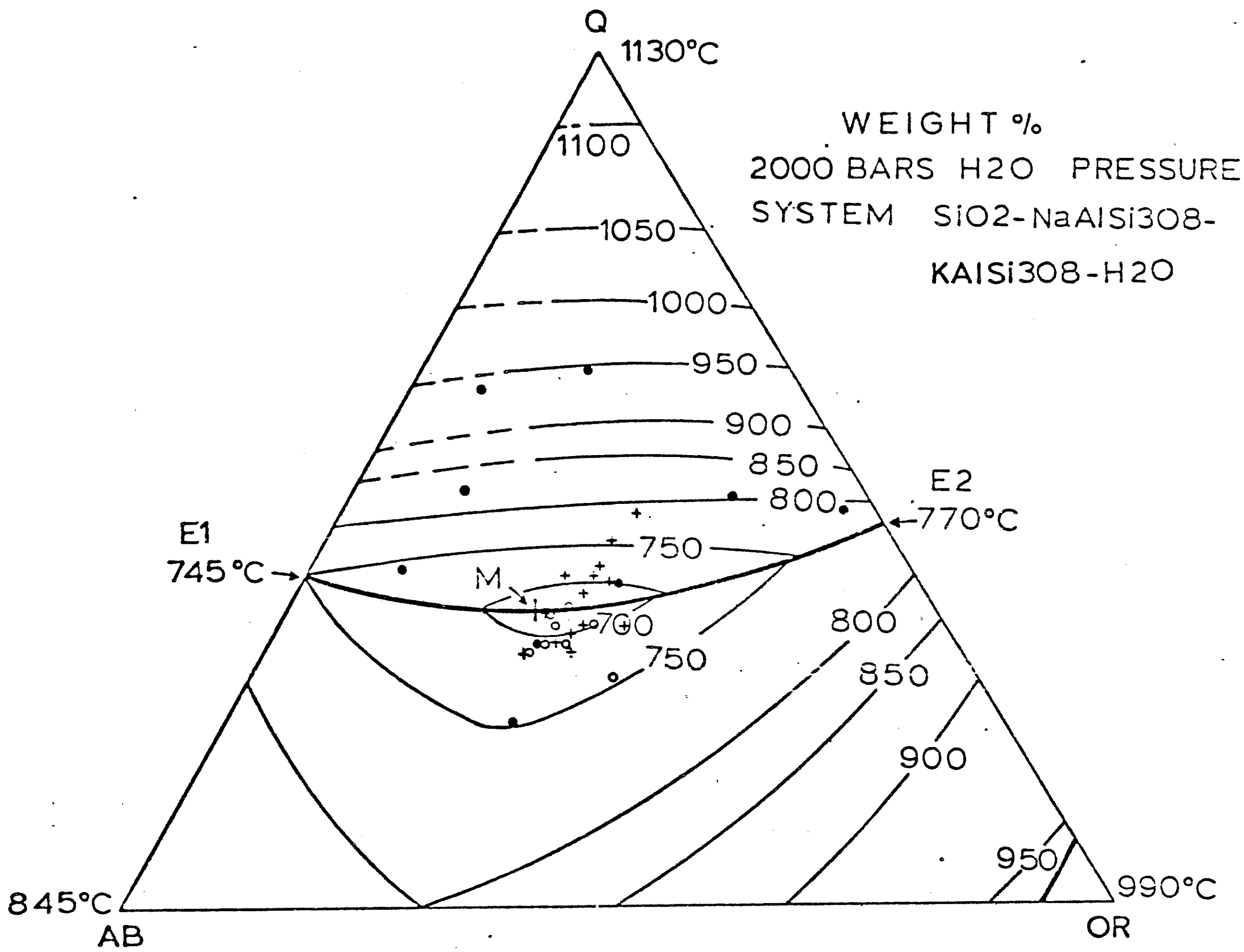


FIGURE 39: Ab-Or-Q-H_2O system at 2000 bars pressure (after Winkler, 1967). M = Ternary minimum. Dots represent the rocks of rhyolitic composition from Region 3. Crosses represent the rocks of rhyolitic composition from Region 2. Circles represent the rocks of rhyolitic composition from Region 1.

means that the upper crust in Region 3 may be less homogeneous than the upper crust in Regions 1 and 2. This argument may be supported by the experimental work of Winkler (1967), where he found that if at a given P H_2O ratio of albite to anorthite (Ab/An) increased, the cotectic line moves away from the quartz corner, and the ternary minimum (M) moves toward the Ab corner. Conversely, a decrease in Ab/An values cause the cotectic line to move towards the quartz corner and the ternary minimum (M) away from the Ab corner. Thus if all the assumptions stated, and the reasoning developed above are correct, then it appears reasonable to say that the rhyolites and ignimbrites of the Central Andes of Neogene-Quaternary age were produced by anatexis of the upper crust at a minimum depth of about 7 km (corresponding to 2000 bars). However, Zentilli (1974) pointed out that (in some rocks of Region 3) the mineralogy of the felsic rocks indicate lack of equilibrium. The heat necessary to melt the crust would come from the ascending, less felsic (Taylor, 1977), magmas. The range of Al_2O_3 in 85% of the rhyolitic rocks of the three regions is between 12 and 17 wt. percent; these high values of the alumina are interpreted as being an evidence of the anatectic origin of the rhyolitic magmas by Zeil and Pichler (1969).

CHAPTER 6

CONCLUSIONS

The present study shows that most of the Central Andean volcanic rocks of Neogene-Quaternary age are of a calc-alkaline character ($K_2O/Na_2O < .95$), but as the continent-ward distance from the trench to the sites of eruption is increased, these rocks gradually acquire a shoshonitic affinity ($K_2O/Na_2O > .95$). This transverse variation reflects the zonation of K_2O across the Central Andes (which has been documented in the present thesis by means of the K-index) and a variation of Na_2O. The Central Andean volcanic rocks under study can be considered mostly of intermediate composition (andesites and dacites) under the classifications of Taylor (1969) and Church (1975). Of these two types of rocks, the andesites display better the covariation with distance. The Central Andean volcanic rocks must be divided into groups or regions in order to determine best what geochemical variations are present.

Many elements vary from north to south as well as transversely away from the continental margin. The variation across the Central Andes of some elements can possibly be correlated with crustal thickness: U, Li, and Rb. Other elements may be correlated with depth to the Benioff Zone, such as the case of K_2O and other major elements, because it follows a linear trend with distance from the trench. The correlation with distance by most of the major elements may be accounted for by varying degrees of partial melting of the upper mantle or of the eclogite source. And the correlation with distance by many trace elements may be accounted for by the same process, but in many instances crustal contamination (as with Li, U, and Rb above) could be the responsible process. Finally the ignimbrites (classified as rhyolites) show no compositional variations across the Central Andes perhaps due to the fact that they cover very extensive areas on account of their explosive nature. It is suggested in this study that they may have formed a depth of about 7 km.

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APPENDIX A

NOTE FOR TABLE 1 a, b, c

REGION	SAMPLE
Region 1	58 to 65, 125 to 231
Region 2	1 to 36, 100 to 104, 108 to 110, 113 to 124, 267 to 270
Region 3	37 to 57, 66 to 99, 105 to 107, 111, 112, 232 to 266

Note also that in these tables a zero was printed where there was no data.

SOURCES OF THE DATA

Reference No.	Author
1	Zentilli, M. 1974
2	Caelles, J. 1978 (unpublished analyses)
3	Thorpe *et al.* 1976
4	Kussmaul, S. *et al.* 1977
5	Oyarzun and Villalobos 1969
6	Horman *et al.* 1973
7	Bernascony *et al.* 1969
8	James *et al.* 1976
9	Zentilli and Dostal 1977
10	Guest, J. E. 1969
12	Siegers *et al.* 1969

* Reference No. 11 does not exist

KEY TO NAME ABBREVIATIONS IN TABLE 1a, b, and c

a) Lat-Ande	Latite-Andesite
Ande-Lav	Andesite-lava
Rhyodaci	Rhyodacite
Qtz-Lat	Quartz latite
R-dacite	Rhyolitic dacite
Ignimb	Ignimbrite

b) Argnt	....	Argentina
Bol	....	Bolivia
	....	
c) Pleist	....	Pleistocene
M-Mio	....	Middle-Miocene
L-Mio	....	Lower Miocene
U-Mio	....	Upper Miocene
Quaternat	....	Quarternary
Plio-Quat	....	Pliocene-Quaternary
U-Plio	....	Upper pliocene

MODIFICATIONS TO THE DATA

1. The data for references No. 3, 4, 5, 6, 7, 9, 10 and 12 was adjusted volatile free
2. The $^{87}Sr/^{86}Sr$ ratios given in reference No. 8 have been recorded to 4 significant figures.
3. The K values reported in reference 8 were recalculated to K_2O
4. Na_2O for reference 8 was calculated according to the formula:

$$Na_2O = [(K_2O - K^*)/(K^*)] \times K_2O$$

where $K^* = K_2O/(K_2O - Na_2O)$

TABLE 1 A: Chemical data for the major elements. All values of the oxides are in weight percent.

In addition in this table appear a code number (NMBR); sample number as in the publication; the source of reference (Ref); and the latitude and the longitude of the geographical location of the sample.

NMBR	SAMPLE	REF.	LAT.	LONG.	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5
1	Z06	1	265300	682330	61.05	.87	16.83	2.35	3.20	.23	1.96	5.35	3.62	2.88	.23
2	Z07	1	265320	682500	61.95	.79	16.83	4.97	.43	.22	2.00	4.90	3.60	3.17	.24
3	Z08	1	265400	682600	60.35	.84	16.60	3.20	2.50	.22	2.45	5.27	3.47	2.95	.23
4	Z09	1	265430	682430	64.80	.75	16.45	1.39	2.89	.20	1.50	4.53	3.90	3.05	.22
5	Z011	1	265430	682850	71.75	.76	11.20	4.25	.20	.19	2.08	4.05	3.50	1.43	.17
6	Z01	1	265400	683730	57.60	1.08	16.75	1.55	4.70	.23	3.40	6.50	3.63	2.18	.35
7	Z04	1	265530	684530	60.35	.83	17.50	2.58	2.50	.22	2.32	5.55	3.64	2.36	.35
8	Z03	1	265600	684630	62.65	.80	17.30	4.92	.40	.05	.80	4.12	3.80	2.37	.22
9	Z0804	1	265100	690320	62.40	.68	16.70	3.99	.68	.07	2.50	6.00	3.94	1.72	.23
10	Z804B	1	265100	690320	62.20	.68	17.00	4.32	.34	.21	1.57	6.02	3.34	1.95	.22
11	Z809	1	264520	690320	70.80	.17	14.15	1.15	.05	.17	.25	1.00	5.53	4.40	.05
12	Z682	1	265330	692300	72.43	.14	13.20	.72	.34	.08	.41	1.00	3.07	4.75	.02
13	Z670	1	270600	690510	62.90	.64	17.05	1.64	2.05	.06	1.50	4.90	3.99	2.43	.22
14	Z671	1	270500	690600	62.10	.63	17.16	3.67	.46	.07	1.42	5.60	3.98	2.39	.31
15	Z673	1	270330	690710	66.15	.38	16.30	1.92	.32	.04	.80	3.48	4.32	2.58	.15
16	Z669	1	270500	690430	57.80	.87	17.70	3.06	2.15	.08	2.02	6.40	3.01	1.79	.24
17	Z668	1	270230	691330	58.60	.77	18.00	4.52	.27	.07	2.38	6.24	3.95	2.07	.32
18	Z667	1	270240	690330	59.50	.77	18.03	2.53	1.93	.07	2.00	6.10	4.62	1.78	.26
19	Z813	1	264940	691530	63.50	.64	17.50	3.77	1.08	.19	1.32	4.95	4.75	2.10	.34
20	Z814	1	264940	691530	65.05	.60	16.50	2.87	.33	.05	.75	4.42	3.86	2.25	.13
21	Z815	1	264940	691530	65.90	.60	16.60	2.15	.94	.04	1.32	4.37	4.26	2.42	.21
22	JC249	2	265000	681900	61.90	.84	16.81	2.06	3.38	.08	2.49	5.28	4.01	2.83	.25
23	JC250	2	265000	681500	58.46	.78	16.37	5.62	.95	.11	4.93	6.46	3.50	2.64	.13
24	JC251	2	265300	680600	60.89	.82	15.95	3.63	2.13	.09	3.46	5.97	3.89	2.93	.23
25	JC252	2	265400	680400	83.09	.31	10.07	.10	.89	.01	.62	.21	3.57	1.03	.10
26	JC254	2	265600	680300	83.92	.24	6.82	2.62	.74	.02	.50	.11	2.23	2.75	.05
27	JC6	2	290200	674500	75.16	.37	15.05	.82	.63	.01	.26	.32	1.33	6.02	.04
28	JC27	2	284100	674200	63.23	.57	17.92	1.33	2.72	.22	1.34	5.68	4.82	1.99	.13
29	JC158	2	284500	673500	70.56	.42	15.28	1.37	1.88	.06	1.12	3.52	4.54	1.12	.14
30	JC30	2	271900	664300	51.48	1.56	16.81	2.14	6.65	.19	4.15	9.98	4.26	2.34	.45
31	JC31A	2	271700	664200	68.42	.54	17.14	3.97	.44	.01	.93	1.13	.22	6.98	.21
32	JC41	2	271700	664200	63.06	.74	15.85	4.09	1.07	.17	2.23	7.14	2.26	3.09	.30
33	JC47B	2	271700	663600	63.63	.75	16.85	1.36	3.26	.17	2.51	5.34	2.85	3.03	.25
34	JC77A	2	272000	664100	50.87	1.38	17.47	6.37	3.54	.16	4.34	10.13	2.45	2.79	.50
35	JC193	2	272300	661900	61.24	.79	19.18	2.05	2.85	.23	.73	3.96	4.88	3.89	.20
36	JC194	2	272400	661900	61.11	.84	17.31	3.01	2.86	.19	1.59	4.47	4.63	3.60	.29
37	184A	3	215400	682300	63.80	.64	16.23	1.32	3.38	.07	2.58	4.67	4.28	2.87	.17
38	61A	3	215400	682300	64.42	.79	15.34	1.84	2.95	.07	2.46	4.25	5.12	2.50	.25
39	284A	3	215400	682300	63.92	.66	16.61	2.09	2.49	.07	2.22	4.53	4.27	2.97	.17
40	54A	3	215400	682300	65.51	.53	17.28	1.78	1.51	.05	1.68	3.96	4.59	2.88	.23
41	172A	3	215400	682300	64.03	.64	16.56	2.13	2.34	.07	2.37	4.51	4.22	2.94	.13
42	167C	3	215400	682300	64.56	.68	17.36	2.08	2.41	.08	.99	4.45	4.46	2.72	.21
43	166A	3	215400	682300	64.76	.66	16.11	1.91	2.53	.07	2.40	4.21	4.06	3.06	.22
44	146C	3	211400	682300	64.20	.74	14.77	2.30	2.89	.09	2.53	5.30	4.50	2.50	.13
45	168A	3	215400	682300	67.57	.47	16.38	1.39	1.72	.05	1.09	3.37	4.56	3.25	.15
47	194C	3	214600	682800	55.52	.67	18.39	4.36	3.83	.15	4.00	8.06	3.83	.98	.20
48	280A	3	215400	682300	56.64	.92	16.98	1.21	5.93	.12	5.71	7.02	3.60	1.67	.20
49	186A	3	215400	682300	57.07	.86	16.75	1.68	5.13	.11	5.84	7.09	3.63	1.65	.13
50	176A	3	215400	682300	58.48	.77	16.14	2.07	4.49	.11	5.74	6.43	3.70	1.89	.13
51	283A	3	215400	682300	58.72	.97	17.17	1.78	4.63	.09	3.97	6.58	3.78	2.06	.25
52	64B	3	215400	682300	58.53	.77	16.62	2.35	4.04	.10	4.99	6.43	3.75	2.32	.12
53	287A	3	215400	682300	59.14	.87	17.49	2.28	3.99	.09	3.62	6.30	3.80	2.17	.24
54	170A	3	215400	682300	59.56	.86	18.08	1.96	3.63	.08	2.72	6.13	4.40	2.36	.23
55	487A	3	215400	682300	61.65	.68	17.92	1.63	3.64	.09	2.20	5.22	4.37	2.39	.22
56	482C	3	215400	682300	61.66	.79	17.56	1.66	3.75	.12	1.97	4.61	4.90	2.61	.27
57	56A	3	215400	681430	62.61	.76	16.79	2.28	2.98	.08	2.73	5.42	3.22	2.95	.17

58	M71	5	181500	691500	59.66	.85	17.79	4.23	2.09	.14	2.40	6.79	3.88	2.27	.31
59	M73	5	181500	691500	62.85	.91	17.19	1.90	2.41	.13	2.53	4.68	4.10	2.98	.32
60	M207	5	181500	691500	59.78	1.07	17.86	1.99	3.56	.15	3.11	5.17	4.07	2.83	.41
61	M81	5	181500	691500	62.20	.87	16.59	2.37	2.70	.12	2.70	4.64	4.35	3.12	.33
62	M70	5	181500	691500	57.43	1.07	17.78	2.16	4.29	.20	3.43	6.52	4.14	2.58	.40
63	M200	5	181500	691500	71.16	.47	14.67	1.93	.66	.04	.76	1.81	4.25	4.07	.12
64	M74	5	181500	691500	71.49	.32	14.92	1.89	.58	.04	.65	1.57	4.02	4.04	.12
65	M76	5	181500	691500	73.80	.21	14.14	1.21	.26	.04	.40	1.01	3.85	4.97	.03
66	I7	4	224100	671500	74.46	.31	13.98	.96	.53	.05	.34	1.29	3.36	4.63	.03
67	I6	4	215500	674800	67.73	.59	15.77	3.35	.04	.07	1.19	3.12	3.57	4.43	.13
68	I5	4	222900	672300	67.64	.94	15.86	3.55	.36	.05	1.26	3.78	2.55	3.82	.17
69	I4	4	222600	670600	68.10	.64	16.08	2.00	1.11	.70	1.51	3.91	2.94	3.55	.11
70	I3	4	221100	673200	64.54	1.02	16.09	3.04	1.92	.10	2.12	4.92	2.92	3.18	.15
71	I1	4	215400	665300	70.85	.67	14.43	2.96	.79	.03	1.24	2.69	2.25	3.94	.16
72	I8	4	213400	675700	67.87	.72	15.24	2.75	.87	.06	1.58	3.07	3.16	4.54	.15
74	L2	4	221000	671800	61.29	1.13	16.21	1.55	4.43	.08	4.23	5.10	3.04	2.74	.21
75	L3	4	214800	661500	69.66	.45	16.18	.34	2.25	.03	.97	2.12	3.91	3.94	.13
76	L4	4	215400	665300	63.64	.98	17.13	4.34	1.52	.08	2.16	5.09	2.31	2.75	0.00
77	L5	4	215400	665300	65.85	.87	16.53	2.64	1.89	.05	1.66	3.92	2.33	4.63	.22
78	L6	4	220200	671500	65.06	1.33	15.84	1.44	3.70	.08	2.12	4.21	2.24	3.78	.20
79	L7	4	213400	675700	69.39	.59	15.25	.93	2.32	.05	.85	2.82	2.96	4.68	.14
80	L8	4	221700	672300	65.26	1.06	16.74	.92	3.27	.06	1.92	4.56	2.50	3.55	.15
81	L9	4	205900	655800	63.02	1.18	16.60	3.78	1.90	.08	1.95	5.17	2.54	3.51	.27
82	L10	4	222600	670600	64.06	.62	16.27	1.19	4.14	.09	2.53	5.05	2.10	3.25	.19
83	L11	4	215500	674800	64.33	.86	16.60	2.19	2.33	.08	1.87	4.58	3.26	3.75	.14
84	L12	4	223500	671800	61.11	1.21	17.54	1.62	4.62	.09	3.12	5.48	2.41	2.52	.23
85	L13	4	224000	674900	61.74	1.22	16.24	2.10	4.20	.10	2.12	5.87	2.95	2.30	.15
86	L14	4	212900	680500	63.91	.98	16.45	2.48	2.25	.07	1.79	4.47	4.37	3.05	.18
87	L15	4	212600	680500	64.57	.87	16.21	1.91	2.60	.07	2.12	4.31	4.09	3.09	.13
88	L16	4	224800	675200	64.48	.85	15.50	1.72	3.38	.09	2.86	5.25	3.54	2.24	.07
89	L17	4	225100	675000	57.29	1.40	18.58	2.56	4.63	.14	2.71	8.01	3.06	1.44	.12
90	L18	4	213600	665300	55.17	1.14	15.56	.79	7.57	.13	8.09	7.48	2.27	1.59	.12
96	4-27	6	241700	662700	54.58	1.76	14.06	1.87	5.75	.12	7.17	7.62	2.77	3.57	.72
97	4-28	6	241700	662700	53.27	1.82	14.98	2.09	6.15	.13	7.68	6.73	2.78	3.61	.75
98	4-29	6	241700	662700	54.37	1.64	14.74	2.58	4.87	.12	7.61	6.14	2.95	4.11	.87
99	4-37	6	234600	665700	56.84	1.46	15.92	2.75	4.65	.10	5.37	6.52	3.41	2.55	.42
100	4-49	6	260500	671300	52.78	1.45	16.14	1.85	6.63	.13	7.13	8.08	3.72	1.72	.47
101	4-50	6	260500	671300	52.79	1.42	15.98	1.87	6.69	.14	7.15	8.23	3.72	1.65	.37
102	4-57	6	260600	671400	54.36	1.43	16.35	2.08	5.82	.13	6.98	6.98	3.47	2.06	.32
103	4-58	6	260600	671400	54.52	1.41	16.14	2.05	5.80	.13	6.94	7.16	3.46	2.06	.32
104	4-59	6	260600	671400	54.40	1.45	16.40	2.02	5.84	.13	6.98	7.11	3.39	2.04	.33
105	4-68	6	245100	661400	51.87	1.52	15.05	3.72	4.47	.14	8.73	7.29	3.05	3.34	.82
106	4-69	6	245100	661400	51.61	1.51	15.81	3.81	4.36	.14	8.76	7.27	3.08	3.31	.82
107	4-70	6	245100	661400	50.88	1.40	15.00	5.83	2.58	.13	9.82	7.65	3.02	2.92	.73
108	4-46	6	251900	671700	55.15	1.24	15.78	6.87	.74	.13	6.27	8.23	3.28	2.06	.26
109	4-47	6	251900	671700	55.41	1.26	15.90	2.34	4.95	.12	6.66	7.92	3.17	1.95	.25
110	4-48	6	260400	671400	62.84	.88	15.47	2.03	3.51	.07	3.15	5.46	3.47	2.85	.25
111	4-30	6	241200	663400	60.17	1.07	15.37	1.96	4.18	.09	5.09	5.72	3.21	2.79	.34
112	4-66	6	240600	663000	58.30	1.35	15.83	2.08	4.29	.10	5.13	5.80	3.37	3.22	.52
113	4-60	6	255700	671500	69.58	.33	15.91	2.58	.21	.04	1.19	2.96	4.03	3.59	.14
114	1	7	311800	651400	48.24	1.39	17.10	6.63	2.71	.16	5.42	10.22	3.83	2.82	1.09
115	2	7	311800	651400	50.65	1.67	17.29	5.75	3.50	.04	3.88	8.81	4.28	4.05	.07
116	3	7	311800	651400	50.68	.72	18.44	8.34	.40	.10	4.01	8.68	4.93	3.50	.17
117	4	7	311800	651400	51.78	1.04	16.45	2.80	3.55	.15	5.06	8.41	4.33	3.89	2.44
271	5	7	311800	651400	53.06	1.86	17.63	7.15	.70	.11	4.22	7.03	3.33	3.09	1.73
118	6	7	311800	651400	55.78	.52	17.87	4.47	3.15	.07	2.70	7.54	4.60	3.08	.24
119	7	7	311800	651400	56.43	.42	16.85	3.48	2.32	.15	2.73	6.93	5.76	4.67	.20
120	8	7	311800	651400	56.43	.57	19.41	3.50	1.57	.12	1.85	6.29	5.58	4.63	.04
121	9	7	311800	651400	57.39	.60	19.84	2.34	2.34	.17	1.66	5.82	5.68	3.92	.22
122	10	7	311800	651400	60.10	.86	18.48	1.42	.85	.03	2.20	5.12	6.01	4.65	.07
123	11	7	311800	651400	62.67	.67	15.64	2.06	1.01	.10	1.86	4.17	6.24	5.08	.47
124	12	7	311800	651400	47.19	1.53	17.55	6.05	1.88	.17	3.65	14.02	4.81	1.55	1.16
125	PE23	8	161700	713900	57.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.27	2.73	0.00
126	PE24	8	161700	713900	58.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.93	2.51	0.00
127	PE25	8	161700	713900	58.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.69	2.67	0.00
128	PE26	8	161700	713900	56.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.07	2.37	0.00
129	PE27	8	161600	714000	56.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.16	2.24	0.00
130	PE28	8	161600	714000	56.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.21	2.17	0.00

131	PE29	8	161600	714000	56.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.07	2.19	0.00
132	PE30	8	161600	714000	56.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.14	2.43	0.00
133	PE46	8	161600	713100	58.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.11	3.10	0.00
134	PE47	8	161600	713100	59.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.35	2.78	0.00
135	PE48	8	161600	713100	58.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.44	2.84	0.00
136	PE49	8	161600	713100	59.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.35	2.78	0.00
137	PE80	8	162130	712000	61.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40	2.37	0.00
138	PE81	8	162100	711930	56.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.62	1.88	0.00
139	PE82	8	162100	711930	60.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.85	2.26	0.00
140	PE83	8	162100	711930	64.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.01	2.94	0.00
141	PE128	8	172600	700100	55.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.39	1.99	0.00
142	PE129	8	172600	700100	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.58	2.70	0.00
143	PE130	8	172500	700000	57.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.59	2.02	0.00
144	PE131	8	172400	695800	59.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.69	2.46	0.00
145	PE132	8	172200	695500	59.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.83	2.66	0.00
146	PE144	8	164100	702900	58.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.57	2.92	0.00
147	PE145	8	165200	703100	62.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.13	2.99	0.00
148	PE146	8	165400	703200	63.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.96	3.24	0.00
149	1	9	161900	713500	63.40	.78	16.02	3.23	1.76	.08	2.60	4.58	4.08	3.14	.32
150	3	9	161700	713800	59.85	.80	16.82	3.94	2.50	.11	3.33	6.07	3.76	2.58	.25
151	4	9	161700	713900	57.90	1.02	16.62	3.30	3.47	.09	4.37	6.48	4.06	2.35	.33
152	7	9	161730	713900	58.02	1.02	16.73	3.75	3.14	.09	4.05	6.40	4.25	2.19	.35
153	24	9	162015	714100	61.65	.89	16.39	2.75	2.99	.08	3.07	5.33	4.07	2.55	.33
154	26	9	161545	713015	56.70	1.07	17.53	3.77	3.44	.10	4.17	6.57	4.29	2.02	.34
155	27	9	161600	712900	62.36	.72	17.36	3.03	1.95	.08	2.24	4.57	4.27	3.13	.27
156	28	9	161600	712845	63.89	.62	17.32	1.79	2.53	.08	1.58	4.08	4.50	3.20	.30
157	32	9	161300	712700	62.47	.76	17.10	2.34	2.78	.08	1.91	4.63	4.27	3.34	.31
158	33	9	160900	712600	60.52	.92	16.49	3.50	2.58	.09	3.40	5.38	3.92	2.83	.35
159	34	9	162300	712030	60.70	.82	17.31	3.37	2.52	.10	2.77	5.54	4.27	2.33	.27
160	38	9	162230	711800	57.29	1.01	17.32	3.89	3.52	.12	3.86	6.85	3.95	1.89	.31
161	45	9	162200	713100	61.50	.84	16.21	3.54	2.52	.01	3.09	5.37	3.34	3.24	.25
162	M1	9	161730	712430	59.12	.90	17.50	3.65	2.65	.09	3.25	6.11	4.40	1.97	.35
163	47	9	161315	710900	61.86	.66	17.45	4.50	1.37	.12	1.30	5.21	4.37	2.32	.31
164	48	9	161300	710900	57.43	.93	18.09	5.14	2.46	.10	2.75	6.26	4.33	2.23	.37
165	49	9	161245	710845	56.48	.94	18.13	3.88	3.56	.12	3.49	7.13	3.98	1.96	.34
166	50	9	161230	710830	64.20	.51	17.37	3.41	.94	.11	1.46	4.21	4.81	2.67	.31
167	59	9	161230	711000	64.99	.55	17.14	3.21	1.14	.09	1.02	4.14	4.78	2.66	.29
168	61	9	161000	710330	64.25	.69	17.52	4.90	.70	.06	1.71	3.06	3.66	3.28	.17
169	62	9	160800	710430	56.72	1.16	17.23	4.62	2.87	.11	3.82	7.21	4.02	1.82	.42
170	U1	9	162000	705400	59.08	1.07	17.10	4.41	2.38	.11	3.07	5.76	3.99	2.57	.45
171	U1	9	162100	705400	60.27	.97	16.83	3.39	3.14	.11	2.80	5.27	4.08	2.71	.43
172	143	9	170400	703536	65.12	.56	16.41	3.22	1.01	.07	2.02	3.89	4.37	2.99	.24
173	167	9	170900	701430	64.98	.63	15.80	3.22	1.47	.09	2.05	4.21	3.87	3.35	.35
174	168	9	170930	701430	62.01	.80	16.72	4.61	1.44	.10	2.69	4.56	3.80	2.96	.31
175	169	9	171000	701400	60.90	.79	17.37	3.11	2.66	.09	2.49	5.64	4.06	2.57	.30
176	170	9	171015	701345	69.11	.36	15.59	3.15	.05	.09	.81	2.80	4.07	3.76	.21
177	172	9	171030	701330	59.73	.68	17.17	4.36	2.23	.12	2.71	5.53	4.10	2.05	.34
178	173	9	171030	701315	60.22	.65	17.62	3.68	2.56	.11	3.04	5.87	3.82	2.20	.24
179	174	9	171015	701230	61.52	.63	17.58	3.90	2.03	.09	2.38	5.23	4.22	2.08	.33
180	175	9	171000	701230	61.93	.86	16.39	3.21	2.45	.10	2.68	5.36	3.93	2.80	.29
181	205	9	173200	700100	60.54	.88	16.38	3.78	2.47	.09	3.36	5.53	3.78	2.90	.28
182	211	9	172730	700200	59.72	.97	16.19	3.84	3.22	.12	3.52	5.68	3.67	2.76	.30
183	230	9	162600	695700	60.51	.95	16.03	2.33	3.87	.09	3.82	5.49	3.60	2.97	.34
184	235	9	162430	695500	60.18	.93	16.37	3.03	3.42	.10	3.39	5.58	3.83	2.75	.34
185	236	9	162400	695500	63.45	.66	16.44	4.24	1.01	.07	1.93	4.67	3.94	3.24	.30
186	239	9	172000	695200	62.75	.74	16.86	4.30	1.45	.09	1.94	4.51	3.90	3.10	.35
187	240	9	171930	695130	60.63	.82	16.96	3.65	2.54	.10	2.89	5.51	3.75	2.87	.27
188	241	9	171900	695300	66.18	.68	15.52	2.70	1.41	.07	1.89	3.67	4.08	3.58	.22
189	297	9	170300	702000	63.88	.77	16.10	3.88	1.33	.07	2.12	4.12	3.69	3.52	.31
190	305	9	165930	703500	59.15	.80	17.95	2.95	3.16	.09	2.85	5.96	4.70	2.10	.31
191	309	9	164630	703200	67.08	.62	15.19	3.78	.05	.07	1.69	3.51	4.07	3.63	.33
192	312	9	164500	703500	65.66	.63	16.07	2.37	1.74	.06	1.66	3.67	4.41	3.39	.33
193	314	9	164600	703545	65.36	.64	16.23	2.38	1.69	.06	1.97	3.88	4.42	3.06	.31
194	315	9	164600	703545	65.26	.71	16.32	2.00	2.11	.06	1.83	3.72	4.47	3.28	.23
195	316	9	164600	703545	65.64	.75	16.18	2.10	1.87	.06	1.67	3.59	4.35	3.53	.23
196	75	9	160000	705000	62.64	.64	16.00	4.41	.77	.05	2.84	4.99	4.01	3.34	.31
197	112	9	160800	715700	64.63	.69	16.20	3.20	1.34	.07	2.04	4.21	3.51	3.84	.27
198	113	9	160830	715530	64.06	.72	16.02	3.53	1.58	.06	2.13	4.01	3.81	3.66	.21

199	114	9	160900	715400	59.62	.88	17.06	3.49	2.77	.09	3.38	5.85	3.81	2.78	.27
200	117	9	161300	715500	65.54	.63	17.08	3.33	.48	.07	1.15	3.21	4.00	4.28	.24
201	242	9	171130	694530	61.22	.79	16.93	4.14	1.64	.09	2.34	5.08	4.15	3.26	.35
202	243	9	171130	694100	61.17	.85	16.77	3.63	2.09	.12	2.47	5.14	4.30	3.11	.34
203	244	9	171230	694300	60.00	.89	16.87	3.89	2.53	.10	2.98	5.56	3.97	2.89	.31
204	245	9	170900	694630	61.91	.69	16.56	3.94	1.44	.09	2.35	5.01	4.12	3.53	.35
205	246	9	170800	694600	59.90	1.40	15.63	2.90	3.53	.10	3.50	5.41	4.14	2.97	.50
206	247	9	170715	694300	62.12	.81	17.37	3.67	1.65	.10	2.04	4.74	3.92	3.21	.35
207	250	9	165730	694200	72.87	.22	15.02	1.44	.05	.03	.14	1.43	4.23	4.51	.05
208	254	9	165200	694700	63.23	.74	16.24	3.74	1.19	.06	2.23	4.45	4.05	3.77	.27
209	255	9	165230	694900	69.24	.41	15.41	2.37	.70	.05	.52	2.12	3.62	5.29	.27
210	289	9	164730	700100	60.39	.75	16.29	5.40	.88	.11	3.55	5.37	3.39	3.53	.33
211	290	9	164800	700200	60.62	.74	15.50	3.95	2.01	.12	3.97	6.19	3.54	3.12	.23
212	292	9	165000	700500	76.95	.05	13.08	.59	.05	.01	.04	.23	4.32	4.59	0.00
213	293	9	165000	700500	76.81	.01	13.08	.56	.05	.12	.07	.35	4.45	4.50	0.00
214	294	9	165100	701100	62.00	.71	16.75	2.83	2.73	.09	2.52	5.17	3.56	3.32	.32
215	295	9	165030	701400	63.82	.52	16.61	2.17	2.65	.09	2.05	4.46	3.74	3.60	.29
216	94	9	154930	700200	55.60	2.55	14.76	5.05	4.20	.13	3.82	6.42	3.80	3.06	.50
217	95	9	155000	700400	54.44	2.53	14.65	4.25	4.02	.13	4.52	6.76	3.69	3.03	1.17
218	96	9	154930	700500	58.48	1.47	16.90	6.50	.82	.11	3.22	4.09	4.06	3.68	.69
219	97	9	154915	700500	54.26	1.88	15.69	6.47	2.06	.14	4.83	6.78	3.86	3.18	.95
220	98	9	154900	700530	53.79	1.89	15.24	6.58	2.00	.14	5.53	7.04	3.79	3.11	.30
221	99	9	154800	700630	58.58	1.44	15.77	5.27	1.19	.13	3.24	5.26	4.61	3.83	.50
222	102	9	154700	701300	56.58	2.18	15.29	5.71	2.34	.13	3.20	5.90	3.98	3.62	1.05
223	103	9	154600	701500	59.87	1.43	15.74	5.06	1.33	.07	3.05	4.88	4.24	3.69	.54
224	257	9	155100	695300	54.93	1.41	15.26	3.41	4.65	.14	6.78	6.67	3.39	2.77	.53
225	258	9	155000	695200	64.99	1.04	16.07	3.40	1.08	.04	1.43	2.80	4.41	4.30	.43
226	265	9	161300	692500	54.29	1.63	15.91	5.96	2.81	.13	6.23	5.99	3.33	3.09	.53
227	271	9	162500	691000	63.80	.92	16.15	4.09	1.02	.06	1.96	3.40	4.04	4.10	.45
228	277	9	162300	692800	51.54	1.97	14.83	4.26	4.92	.13	8.22	7.49	3.22	2.73	.70
229	279	9	162800	693830	59.68	.97	16.05	5.08	.98	.18	2.09	6.67	4.49	3.35	.49
230	328	9	155700	700100	62.07	.88	17.03	3.87	1.91	.09	2.43	4.59	5.55	3.29	.30
231	332	9	155730	700100	57.73	1.02	14.54	2.74	4.12	.12	7.16	6.00	3.33	2.83	.42
232	83	10	220850	680700	61.80	.99	16.99	5.36	.81	.10	1.81	5.33	3.39	3.23	.17
233	84	10	220850	680700	62.31	.90	16.57	4.09	1.43	.09	2.63	5.03	2.98	3.07	.17
234	11	10	224710	675940	65.82	.70	16.33	3.87	.32	.14	1.21	4.22	3.43	3.45	.15
235	94	10	225200	680700	68.61	.56	15.37	2.86	.43	.04	1.03	3.53	3.46	3.96	.10
236	CR120	10	224200	680700	69.54	.30	15.87	2.05	.58	.06	1.02	2.90	3.30	4.22	.19
237	RH1	10	224200	680700	70.81	.40	15.38	2.59	.09	.03	.50	2.09	3.88	4.53	.07
238	42	10	220000	684000	73.33	.25	14.59	1.35	.04	.08	.45	1.06	4.84	3.97	.05
239	35	10	223700	680000	64.97	.71	17.29	3.49	.98	.08	1.86	4.03	3.24	3.22	.14
240	268	10	222000	680900	65.69	.72	16.96	4.12	.12	.06	1.41	3.77	3.27	3.75	.14
241	227	10	222800	680000	68.42	.63	16.44	4.44	.05	.04	.46	2.77	3.15	3.49	.12
242	RH2B	10	224200	680700	61.52	.82	16.38	4.10	.76	.13	1.54	7.99	2.94	3.37	.15
243	RH2A	10	224200	680700	67.17	.64	15.79	2.56	1.71	.06	1.73	3.40	3.14	3.67	.12
244	254	10	220200	681400	68.72	.58	14.87	2.50	1.01	.08	1.59	3.61	3.01	3.92	.10
245	352	10	231300	675800	75.14	.14	12.69	.73	.05	.06	.60	1.98	3.04	4.42	1.15
246	5A	10	231300	675800	76.78	.39	12.08	.68	.03	.09	.11	1.16	3.40	4.59	.03
247	5	10	231200	675800	76.32	.28	13.09	.81	.09	.08	.13	1.15	3.47	4.57	.02
248	1	12	222700	680300	63.36	.71	16.93	2.13	2.43	.07	2.53	5.37	3.65	2.64	.17
249	2	12	215300	682600	59.28	.92	19.01	2.24	3.25	.09	2.24	6.41	4.27	2.03	.25
250	3	12	214900	683100	62.71	.82	16.42	2.25	2.75	.09	3.57	5.30	2.86	2.75	.13
251	4	12	201700	684900	64.92	.72	16.57	5.18	.31	.04	1.55	3.73	3.62	3.11	.25
252	5	12	204200	683500	61.31	.91	16.81	5.34	.40	.08	2.92	5.24	4.13	2.62	.25
253	6	12	204000	683200	60.89	1.11	16.68	2.71	3.01	.08	2.81	5.22	4.32	2.81	.35
254	7	12	203700	682700	60.53	1.21	16.85	2.52	3.13	.08	2.82	5.35	4.24	2.93	.35
255	8	12	203500	684000	55.66	1.11	17.20	3.54	4.15	.11	4.96	7.39	4.05	1.62	.30
256	9	12	203400	683900	55.92	1.11	17.02	2.53	5.07	.11	5.07	7.29	3.85	1.72	.30
257	10	12	234900	672800	53.59	1.43	16.44	2.55	5.82	.01	6.12	8.98	3.16	1.53	.35
258	11	12	234800	672400	53.26	1.41	16.47	2.02	6.27	.14	6.27	8.59	3.44	1.72	.40
259	12	12	235200	672300	64.10	.81	15.87	2.44	2.65	.08	2.44	4.78	3.46	3.15	.21
260	13	12	232500	674900	62.68	.71	17.33	3.67	1.63	.09	2.34	5.40	3.97	1.94	.23
261	14	12	232200	674700	61.52	.08	18.05	2.62	2.62	.10	2.32	5.75	3.93	2.02	.25
262	15	12	242300	681800	57.81	1.21	16.78	2.63	4.24	.10	4.35	6.87	3.84	1.82	.35
263	16	12	242800	681900	59.12	1.21	16.98	3.13	3.44	.09	3.74	6.37	3.94	1.82	.35
264	17	12	242800	682000	64.82	.91	15.80	4.43	0.00	.07	2.32	4.63	4.23	2.52	.23
265	18	12	242500	682700	55.19	.81	16.04	2.42	4.94	.12	7.47	8.58	3.13	1.11	.20
266	19	12	241300	683800	59.34	1.31	16.70	2.62	3.72	.07	3.32	6.14	4.53	1.81	.45
267	20	12	252000	684400	58.81	1.01	16.83	3.35	3.75	.10	3.45	7.20	3.14	2.13	.22
268	21	12	253400	684900	62.49	.81	16.49	2.85	2.54	.08	2.54	5.80	3.05	3.15	.13
269	22	12	253100	684100	61.16	.71	15.59	2.53	3.14	.09	4.96	6.38	2.94	2.33	.15
270	23	12	252400	685400	59.92	.91	17.31	2.43	3.34	.09	3.85	6.85	3.54	1.82	.21

TABLE 1 B: Chemical data for the trace elements. All values are in ppm. In the first column appears the the code number, as in table 1 A.

NMBR	Li	Ag	Sn	Ga	Pb	Zn	Cu	B	Be	Mo	V	Zr	Ni	Co	Y	Ce	Cr	Sc	Sr
1	26.0	0.00	0.00	16	13	85	27	0	9.0	4	123	134	13	13	26	0	10	14.00	490
	31.0	.14	0.00	18	22	81	27	7	1.0	1	108	213	10	11	31	114	9	13.00	471
	38.0	.08	1.50	15	18	79	27	6	1.0	9	135	255	11	13	32	134	13	17.00	433
	31.0	.05	15.00	16	15	74	19	0	0.0	0	56	181	9	10	14	0	46	12.00	399
5	0.0	0.00	0.00	14	8	25	11	0	.4	0	96	137	7	9	12	0	8	8.00	338
	19.0	0.00	0.00	14	10	94	30	0	1.0	0	164	291	15	17	21	0	69	16.00	500
	30.0	0.00	0.00	16	12	93	14	0	9.0	8	139	171	11	13	22	0	28	13.00	522
	48.0	0.00	0.00	0	0	51	10	0	0.0	0	88	151	4	0	25	0	0	0.00	537
	28.0	0.00	0.00	10	7	73	28	0	1.0	0	101	123	60	7	12	0	13	7.00	429
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	13	0	0	0.00	0
10	35.0	0.00	0.00	15	23	57	6	0	.4	0	1	52	15	0	5	0	0	0.00	71
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	38.0	0.00	0.00	17	14	61	11	32	1.0	0	73	97	6	0	5	0	3	2.00	609
15	32.0	0.00	0.00	0	0	55	10	0	0.0	0	21	169	12	0	9	0	0	0.00	819
	19.0	0.00	0.00	15	7	76	10	29	1.0	6	126	177	16	11	4	50	11	15.00	695
	14.0	0.00	0.00	0	0	61	24	0	0.0	0	124	219	0	0	15	0	0	0.00	887
	21.0	0.00	0.00	0	0	95	6	0	0.0	0	113	232	12	0	15	0	0	0.00	929
20	14.0	.33	3.00	16	7	96	31	29	1.0	10	86	157	18	8	8	154	12	6.00	494
	0.0	0.00	0.00	19	15	27	6	32	1.0	5	75	109	5	4	4	25	13	4.00	631
	56.0	0.00	0.00	14	22	113	14	13	1.0	6	77	108	10	5	3	0	14	4.00	360
	26.0	0.00	0.00	0	0	69	23	0	0.0	0	125	253	11	0	27	0	0	0.00	521
	0.0	0.00	0.00	15	15	49	9	0	2.0	0	87	94	51	20	29	0	84	19.50	332
25	0.0	0.00	0.00	18	18	39	10	0	2.0	0	80	139	20	18	26	0	45	16.50	261
	0.0	0.00	0.00	11	2	12	0	0	0.0	0	0	67	0	0	22	0	15	0.00	55
	15.0	.09	8.60	14	12	90	15	0	0.0	0	236	443	74	0	91	0	0	0.00	7
	0.0	0.00	0.00	14	21	287	168	0	.5	0	69	114	0	3	10	0	15	5.10	261
	0.0	.11	0.00	14	16	87	11	0	1.7	8	110	138	3	9	23	0	7	7.60	418
	0.0	0.00	0.00	17	2	17	0	0	0.0	0	49	102	0	0	22	0	0	10.50	145
30	92.0	0.00	2.60	11	19	87	61	0	.8	15	259	124	34	28	32	0	54	28.90	291
	12.0	1.62	5.10	19	25	37	108	0	.8	0	58	88	7	0	21	0	15	8.80	54
	37.0	.16	3.90	13	34	118	80	0	.5	8	84	100	43	14	24	0	19	10.90	193
	26.0	.20	0.00	14	43	112	57	0	1.6	13	104	137	6	11	21	0	22	10.30	452
35	23.0	0.00	2.60	14	2	48	56	0	0.0	8	360	151	205	27	63	0	72	29.40	350
	19.0	.40	4.50	20	25	280	37	0	0.0	0	121	135	31	0	102	0	0	0.00	444
	41.0	0.00	0.00	15	23	118	4	0	.5	0	61	97	10	12	29	0	0	9.20	402
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	43	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	16	0	0	0	0	0.00	0
40	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	9	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	9	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	7	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	6	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	21	0	0	0	0	0.00	0
45	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	13	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	9	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	21	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	45	0	0	0	0	0.00	0
50	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	71	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	91	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	37	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	79	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	27	0	0	0	0	0.00	0
55	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	17	0	0	0	0	0.00	0

	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	2	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	15	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
60	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
65	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	60	11	0	0.0	0	0	126	2	2	0	0	0	0	0.00	135
	0.0	0.00	0.00	0	0	66	14	0	0.0	0	0	127	3	6	0	0	0	0	0.00	292
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
70	0.0	0.00	0.00	0	0	76	5	0	0.0	0	0	133	5	8	0	0	0	0	0.00	304
	0.0	0.00	0.00	0	0	103	12	0	0.0	0	0	175	10	11	0	0	0	0	0.00	327
	0.0	0.00	0.00	0	0	75	7	0	0.0	0	0	163	16	7	0	0	0	0	0.00	424
	0.0	0.00	0.00	0	0	107	19	0	0.0	0	0	29	7	12	0	0	0	0	0.00	349
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
75	0.0	0.00	0.00	0	0	93	21	0	0.0	0	0	182	5	7	0	0	0	0	0.00	330
	0.0	0.00	0.00	0	0	99	26	0	0.0	0	0	221	7	13	0	0	0	0	0.00	279
	0.0	0.00	0.00	0	0	75	0	0	0.0	0	0	171	12	7	0	0	0	0	0.00	272
	0.0	0.00	0.00	0	0	126	4	0	0.0	0	0	235	5	9	0	0	0	0	0.00	552
	0.0	0.00	0.00	0	0	88	25	0	0.0	0	0	197	7	7	0	0	0	0	0.00	259
80	0.0	0.00	0.00	0	0	113	12	0	0.0	0	0	234	3	6	0	0	0	0	0.00	302
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	99	11	0	0.0	0	0	171	2	8	0	0	0	0	0.00	428
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
85	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	125	23	0	0.0	0	0	222	7	9	0	0	0	0	0.00	564
	0.0	0.00	0.00	0	0	108	19	0	0.0	0	0	212	7	13	0	0	0	0	0.00	257
	0.0	0.00	0.00	0	0	94	11	0	0.0	0	0	217	24	16	0	0	0	0	0.00	461
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
90	0.0	0.00	0.00	0	0	94	38	0	0.0	0	0	153	123	33	0	0	0	0	0.00	420
	0.0	0.00	0.00	0	0	99	32	0	0.0	0	0	281	51	24	0	0	0	0	0.00	759
	0.0	0.00	0.00	0	0	105	28	0	0.0	0	0	311	59	32	0	0	0	0	0.00	803
	0.0	0.00	0.00	0	0	104	16	0	0.0	0	0	347	117	30	0	0	0	0	0.00	749
	0.0	0.00	0.00	0	0	101	23	0	0.0	0	0	185	48	27	0	0	0	0	0.00	560
100	0.0	0.00	0.00	0	0	92	44	0	0.0	0	0	121	66	35	0	0	0	0	0.00	692
	0.0	0.00	0.00	0	0	92	45	0	0.0	0	0	161	68	35	0	0	0	0	0.00	693
	0.0	0.00	0.00	0	0	96	41	0	0.0	0	0	142	125	31	0	0	0	0	0.00	534
	0.0	0.00	0.00	0	0	97	44	0	0.0	0	0	178	120	31	0	0	0	0	0.00	535
	0.0	0.00	0.00	0	0	100	51	0	0.0	0	0	158	90	29	0	0	0	0	0.00	572
105	0.0	0.00	0.00	0	0	108	33	0	0.0	0	0	272	123	34	0	0	0	0	0.00	994
	0.0	0.00	0.00	0	0	106	33	0	0.0	0	0	229	121	35	0	0	0	0	0.00	936
	0.0	0.00	0.00	0	0	103	24	0	0.0	0	0	223	165	23	0	0	0	0	0.00	985
	0.0	0.00	0.00	0	0	91	22	0	0.0	0	0	76	109	28	0	0	0	0	0.00	474
	0.0	0.00	0.00	0	0	93	24	0	0.0	0	0	77	81	29	0	0	0	0	0.00	517
110	0.0	0.00	0.00	0	0	108	20	0	0.0	0	0	157	45	17	0	0	0	0	0.00	332
	0.0	0.00	0.00	0	0	93	29	0	0.0	0	0	127	50	24	0	0	0	0	0.00	509
	0.0	0.00	0.00	0	0	106	23	0	0.0	0	0	157	68	21	0	0	0	0	0.00	647
	0.0	0.00	0.00	0	0	63	7	0	0.0	0	0	69	13	10	0	0	0	0	0.00	323
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
115	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
27]	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
120	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	0
125	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0.00	806

	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	639
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	657
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	849
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	848
130	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	840
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	856
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	849
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	824
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	795
135	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	816
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	804
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	753
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	729
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	753
140	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	730
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	675
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	614
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	653
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	600
145	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	573
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	590
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	502
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	532
	15.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	670
150	11.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	576
	9.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	761
	11.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	718
	14.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	700
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	760
155	16.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	600
	17.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	600
	15.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	640
	14.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	720
	8.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	686
160	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	600
	6.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	520
	7.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	780
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	657
	9.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	766
165	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	660
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	653
	32.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	392
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	810
170	11.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	676
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	700
	17.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	542
	21.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	505
	19.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	550
175	17.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	655
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	533
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	549
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	536
180	19.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	623
	11.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	557
	15.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	530
	15.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	574
	18.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	590
185	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	523
	17.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	493
	16.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	533
	26.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	520
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	481
190	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	718

	24.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	508
	19.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	608
	18.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	470
	20.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	626
195	20.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	625
	37.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	405
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	478
	20.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	435
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	600
200	18.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	415
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	742
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	820
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	816
	19.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	492
205	14.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	724
	17.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	642
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	223
	16.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	563
	17.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	301
210	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	503
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	511
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	16.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	477
215	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	444
	9.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	1040
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	993
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	942
	11.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	1025
220	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	1066
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	1243
	11.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	1115
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	1052
	13.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	722
225	14.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	823
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	10.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	871
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	12.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	1070
230	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
235	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
240	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
245	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0.00	0
	0.0	0.00	0.00	0	0	0	5	0	0.0	0	100	200	7	12	7	0	30	35.00	600
	0.0	0.00	0.00	0	0	0	45	0	0.0	0	145	200	6	20	18	0	17	45.00	750
250	0.0	0.00	0.00	0	0	0	20	0	0.0	0	215	180	30	20	7	0	85	25.00	420

	0.0	0.00	0.00	0	0	0	80	0	0.0	0	100	190	6	20	6	0	20	15.00	750
	0.0	0.00	0.00	0	0	0	45	0	0.0	0	110	220	45	16	5	0	40	25.00	790
	0.0	0.00	0.00	0	0	0	35	0	0.0	0	95	250	14	14	8	0	30	30.00	960
	0.0	0.00	0.00	0	0	0	55	0	0.0	0	160	260	50	25	3	0	30	20.00	990
255	0.0	0.00	0.00	0	0	0	70	0	0.0	0	135	190	40	25	8	0	130	60.00	770
	0.0	0.00	0.00	0	0	0	90	0	0.0	0	210	210	80	40	8	0	150	50.00	1000
	0.0	0.00	0.00	0	0	0	40	0	0.0	0	135	190	18	25	10	0	210	50.00	520
	0.0	0.00	0.00	0	0	0	50	0	0.0	0	145	180	30	40	8	0	250	50.00	620
	0.0	0.00	0.00	0	0	0	40	0	0.0	0	120	220	8	16	6	0	25	20.00	450
260	0.0	0.00	0.00	0	0	0	20	0	0.0	0	120	190	25	18	5	0	15	20.00	640
	0.0	0.00	0.00	0	0	0	12	0	0.0	0	100	200	70	12	8	0	18	25.00	520
	0.0	0.00	0.00	0	0	0	65	0	0.0	0	130	230	45	25	5	0	145	30.00	950
	0.0	0.00	0.00	0	0	0	75	0	0.0	0	170	230	50	25	7	0	60	30.00	820
	0.0	0.00	0.00	0	0	0	45	0	0.0	0	105	220	105	15	5	0	30	12.00	860
265	0.0	0.00	0.00	0	0	0	65	0	0.0	0	160	170	195	35	5	0	500	60.00	500
	0.0	0.00	0.00	0	0	0	50	0	0.0	0	110	260	10	18	5	0	35	17.00	1050
	0.0	0.00	0.00	0	0	0	30	0	0.0	0	155	180	10	25	12	0	25	55.00	500
	0.0	0.00	0.00	0	0	0	30	0	0.0	0	90	180	70	14	10	0	16	30.00	500
	0.0	0.00	0.00	0	0	0	65	0	0.0	0	175	200	210	30	12	0	230	60.00	400
270	0.0	0.00	0.00	0	0	0	70	0	0.0	0	130	190	50	20	7	0	90	40.00	590

TABLE 1 C: Chemical data for some trace elements (Ba, Rb, and U. Values in ppm), and isotopic value (Sr ratio), plus the distance from the Peru-Chile Trench in km., the type of rock as reported by each author, the age , the country where the sample comes from, and some miscellaneous information.

NMBR	Ba	Rb	U	$^{87}Sr/^{86}Sr$	Dist	Rock type	Age	Country	Miscellaneous information.
1	445	115	3.01	.0000	331	ANDESITE	PLEIST	CHILE	PASO SAN FRANCISCO
	528	125	2.83	.0000	329	ANDESITE	PLEIST	CHILE	PASO SAN FRANCISCO
	468	114	3.51	.0000	327	ANDESITE	PLEIST	CHILE	PASO SAN FRANCISCO
	474	98	3.51	.7077	322	ANDESITE	MIOCENE	CHILE	LAGUNA VERDE
5	330	69	15.31	.0000	316	RHYOLITE	MIOCENE	CHILE	LAGUNA VERDE
	506	58	1.15	.0000	301	ANDESITE	MIOCENE	CHILE	PAMPA DE BARRANCAS BLANCAS
	512	94	1.27	.0000	289	ANDESITE	MIOCENE	CHILE	N. NEVADO TRES CRUCES
	660	100	2.27	.0000	288	DACITE	MIOCENE	CHILE	N. NEVADO TRES CRUCES
	416	65	1.56	.0000	258	DACITE	MIOCENE	CHILE	SALAR DE MERICUNGA
10	0	0	1.56	.0000	258	DACITE	MIOCENE	CHILE	SALAR DE MERICUNGA
	534	181	3.05	.0000	256	RHYOLITE	MIOCENE	CHILE	CERRO LOS CORRALES
	0	0	0.00	.0000	215	RHYOLITE	MIOCENE	CHILE	QUEBRADA DE SAN ANDRES
	799	0	1.43	.0000	246	DACITE	M-MIO	CHILE	VOLCANO OJO DE MERICUNGA
	490	86	1.70	.0000	244	DACITE	M-MIO	CHILE	W. OF PORTEZUELO SANTA ROSA
15	693	86	1.31	.0000	242	DACITE	M-MIO	CHILE	QUEBRADA PAIPOTE
	436	60	1.00	.0000	247	ANDESITE	L-MIO	CHILE	VOLCANO OJO DE MARICUNGA
	1100	70	.92	.0000	247	ANDESITE	L-MIO	CHILE	VOLCANO OJO DE MARICUNGA
	714	69	.86	.0000	248	ANDESITE	L-MIO	CHILE	VOLCANO OJO DE MARICUNGA
	263	58	.62	.7052	238	DACITE	L-MIO	CHILE	MINA LA COIPA
20	474	0	1.31	.0000	238	DACITE	L-MIO	CHILE	MINA LA COIPA
	544	89	1.07	.7061	238	DACITE	L-MIO	CHILE	MINA LA COIPA
	585	110	4.38	.0000	337		U-PLIO	ARGNT	PASO SAN FRANCISCO
	308	150	7.60	.0000	341		U-PLIO	ARGNT	
	291	146	0.00	.0000	353		U-PLIO	ARGNT	
25	168	36	1.07	.0000	359		U-PLIO	ARGNT	
	56	96	3.52	.0000	360		U-PLIO	ARGNT	
	423	128	1.47	.0000	442		L-PLIO	ARGNT	FAMATINA
	593	94	.87	.7067	436	LAT-ANDE	L-PLIO	ARGNT	FAMATINA
	336	65	0.00	.0000	450		L-PLIO	ARGNT	FAMATINA
30	346	129	.71	.0000	497		L-PLIO	ARGNT	FARALLON NEGRO
	1372	365	3.33	.0000	498		U-MIO	ARGNT	
	318	156	2.91	.0000	498		U-MIO	ARGNT	
	966	90	2.36	.0000	505		U-MIO	ARGNT	
	491	91	1.36	.7060	500	ANDESITE	U-MIO	ARGNT	
35	868	244	.87	.0000	535			ARGNT	MI VIDA
	576	147	2.10	.0000	536			ARGNT	MI VIDA
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
40	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDESITE		CHILE	SAN PEDRO VOLCANO
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	294	ANDESITE		CHILE	AUCANQUILCHA VOLCANO
45	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	288	ANDESITE		CHILE	AGUA LA TURBEPA S. SLOPE OF POLAPI
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
50	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
55	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS

	0	0	0.00	.0000	296	ANDE-LAV		CHILE	SAN PEDRO SAN PABLO VOLCANOS
	0	0	0.00	.0000	311	ANDESITE		CHILE	15 KM E. SAN PABLO VOLCANO
	0	0	0.00	.0000	304	ANDESITE	QUATERNAR	CHILE	NEVADOS PAYACHATA PRV. TARAPACA
	0	0	0.00	.0000	304	ANDESITE	QUATERNAR	CHILE	NEVADOS PAYACHATA PRV. TARAPACA
	0	0	0.00	.0000	304	ANDESITE	QUATERNAR	CHILE	NEVADOS PAYACHATA PRV. TARAPACA
	0	0	0.00	.0000	304	ANDESITE	QUATERNAR	CHILE	NEVADOS DE PAYACHATA PRV. TARAPACA
	0	0	0.00	.0000	304	ANDESITE	QUATERNAR	CHILE	NEVADOS DE PAYACHATA PRV. TARAPACA
	0	0	0.00	.0000	304		QUATERNAR	CHILE	NEVADOS DE PAYACHATA PRV. TARAPACA
	0	0	0.00	.0000	304		PLIOCENE	CHILE	NEVADOS DE PAYACHATA PRV. TARAPACA
	0	0	0.00	.0000	304		PLIOCENE	CHILE	NEVADOS DE PAYACHATA PRV. TARAPACA
	0	273	0.00	.0000	440	RHYOLITE	PLIOCENE	BOL	IGNIMBRITE FORMATION.
	0	281	0.00	.0000	385	RHYODACI	PLIOCENE	BOL	IGNIMBRITE FORMATION.
	0	0	0.00	.0000	420	RHYODACI	PLIOCENE	BOL	IGNIMBRITE FORMATION.
	0	245	0.00	.0000	451	DACITE	PLIOCENE	BOL	IGNIMBRITE FORMATION.
	0	193	0.00	.0000	475	RHYODACI	PLIOCENE	BOL	IGNIMBRITE FORMATION.
	0	253	0.00	.0000	385	RHYODACI	MIOCENE	BOL	UPPER QUEHUA FORMATION.
	0	260	0.00	.0000	360	RHYODACI	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	0	0.00	.0000	480	LAT-ANDE	MIOCENE	BOL	BONETE LAVAS.
	0	251	0.00	.0000	472	RHYODACI	MIOCENE	BOL	UPPER QUEHUA FORMATION.
	0	168	0.00	.0000	385	DACITE	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	230	0.00	.0000	385	RHYODACI	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	113	0.00	.0000	360	RHYODACI	QUATERNAR	BOL	STRATO-VOLC. FF. SONIQUERA VOLC.
	0	279	0.00	.0000	365	RHYODACI	QUATERNAR	BOL	STRATO-VOLC. FM. CORINA VOLC.
	0	173	0.00	.0000	425	RHYODACI	QUATERNAR	BOL	STRATO-VOLC FM. QUETENA VOLC.
	0	0	0.00	.0000	480	RHYODACI	QUATERNAR	BOL	STRATO-VOLC FM. GALERA VOLC.
	0	0	0.00	.0000	451	RHYODACI	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	145	0.00	.0000	380	RHYODACI	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	0	0.00	.0000	430	DACITE	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	0	0.00	.0000	370	DACITE	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	146	0.00	.0000	345	LAT-ANDE	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	311	0.00	.0000	345	QTZ-LAT	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	130	0.00	.0000	360	DACITE	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	0	0.00	.0000	480	ANDESITE	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	95	0.00	.0000	468	LAT-ANDE	QUATERNAR	BOL	STRATO-VOLCANO FORMATION.
	0	147	0.00	.0000	500	LATITE	QUATERNAR	ARGNT	CERRO NEGRO DE CHORRILLOS
	0	106	0.00	.0000	500	LATITE	QUATERNAR	ARGNT	CERRO NEGRO DE CHORRILLOS
	0	166	0.00	.0000	500	LATITE	QUATERNAR	ARGNT	CERRO NEGRO DE CHORRILLOS
	0	95	0.00	.0000	440	LAT-ANDE	QUATERNAR	ARGNT	CERROS BAYOS
	0	37	0.00	.0000	413	LAT-ANDE	QUATERNAR	ARGNT	VOLCANO CARACHIPAMPA
	0	38	0.00	.0000	413	LAT-ANDE	QUATERNAR	ARGNT	VOLCANO CARACHIPAMPA
	0	60	0.00	.0000	412	LAT-ANDE	QUATERNAR	ARGNT	VOLCANO ANTOFAGASTA DE LA SIERRA
	0	58	0.00	.0000	412	LAT-ANDE	QUATERNAR	ARGNT	VOLCANO ANTOFAGASTA DE LA SIERRA
	0	56	0.00	.0000	412	LAT-ANDE	QUATERNAR	ARGNT	VOLCANO ANTOFAGASTA DE LA SIERRA
	0	104	0.00	.0000	520	LATITE	QUATERNAR	ARGNT	SAMPLES 4/68-69-70. E. FLANK OF
	0	104	0.00	.0000	520	LATITE	QUATERNAR	ARGNT	THE FAULT NEAR LA POMA BETWEEN SAN
	0	73	0.00	.0000	520	LATITE	QUATERNAR	ARGNT	ANTONIO DE LOS COBRES AND CACHI.
	0	57	0.00	.0000	413	LAT-ANDE	QUATERNAR	ARGNT	N. EDGE OF SALAR DE HOMBRE MUERTO
	0	74	0.00	.0000	415	LAT-ANDE	QUATERNAR	ARGNT	N. EDGE OF SALAR DE HOMBRE MUERTO
	0	118	0.00	.0000	425	R-DACITE	QUATERNAR	ARGNT	S. ANTOFAGASTA DE LA SIERRA
	0	114	0.00	.0000	495	LAT-ANDE	QUATERNAR	ARGNT	ESQUINA AZUL, 4120 M. ALTITUDE.
	0	211	0.00	.0000	500	LATITE	QUATERNAR	ARGNT	VOLCANO TUZGLE
	0	254	0.00	.0000	420	R-DACITE	QUATERNAR	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
271	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	0	0.00	.0000	715		NEOGENE	ARGNT	PUNTAS GORDAS, 4200 M. ALT.
	0	60	0.00	.7076	230	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS

0	57	0.00	.7079	230	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS
0	61	0.00	.7076	230	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS
0	46	0.00	.7072	230	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS
0	46	0.00	.7071	229	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS
0	46	0.00	.7072	229	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	47	0.00	.7071	229	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	47	0.00	.7072	229	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	71	0.00	.7077	245	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	67	0.00	.7076	245	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	69	0.00	.7075	245	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	69	0.00	.7076	245	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	50	0.00	.7074	255	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	39	0.00	.7067	256	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	51	0.00	.7073	256	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	63	0.00	.7073	256	ANDESITE	PLIO-QUAT	PERU	S. PERU, AREQUIPA VOLCANICS.
0	48	0.00	.7054	268		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
0	79	0.00	.7064	268		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
0	53	0.00	.7057	270		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
0	78	0.00	.7058	280		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
0	97	0.00	.7064	280		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
0	84	0.00	.7064	282		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
0	86	0.00	.7065	273		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
0	96	0.00	.7068	268		PLIO-QUAT	PERU	BARROSO VOLCS. ANDESITES& DACITES
985	64	.87	.0000	229	DACITE	PLIO-QUAT	PERU	SERIE CALC-ALK. SENAL CORTADRERAS
890	53	.72	.0000	227	ANDESITE	PLIO-QUAT	PERU	SERIE CALC-ALKCHACHANI VOLCANO
825	42	.69	.0000	226	ANDESITE	PLIO-QUAT	PERU	SERIE CALC-ALKCHACHANI VOLCANO
885	41	.64	.0000	225	ANDESITE	PLIO-QUAT	PERU	SERIE CALC-ALKCHACHANI VOLCANO
925	47	.66	.0000	220	ANDESITE	PLIO-QUAT	PERU	SERIE CALC-ALKCHACHANI VOLCANO
955	28	.35	.0000	239	ANDESITE		PERU	SERIE CALC-ALK. CHACHANI VOLCANO
1215	68	.99	.0000	241	ANDESITE		PERU	SERIE CALC-ALK. CHACHANI VOLCANO
1140	75	.63	.0000	241	DACITE		PERU	SERIE CALC-ALK. CHACHANI VOLCANO
1125	73	.72	.0000	247	ANDESITE		PERU	SERIE CALC-ALK. CHACHANI VOLCANO
1000	49	.78	.0000	253	ANDESITE		PERU	SERIE CALC-ALK. CHACHANI VOLCANO
1045	46	0.00	.0000	255	ANDESITE		PERU	SERIE CALC-ALK. PICHU-PICHU
760	33	0.00	.0000	257	ANDESITE		PERU	SERIE CALC-ALK. PICHU-PICHU
960	78	0.00	.0000	237	ANDESITE		PERU	SERIE CALC-ALK.MISTI VOLCANO
925	31	0.00	.0000	263	ANDESITE		PERU	SERIE CALC-ALK. MISTI VOLCANO
935	48	.82	.0000	272	ANDESITE		PERU	SERIE CALC-ALK. SENAL CONDORI
1000	37	.75	.0000	274	ANDESITE		PERU	SERIE CALC-ALK. SENAL CONDORI
0	0	.63	.0000	275	ANDESITE		PERU	SERIE CALC-ALK. SENAL CONDORI
1100	52	.73	.0000	274	DACITE		PERU	SERIE CALC-ALK. SENAL CONDORI
1200	58	.86	.0000	272	DACITE		PERU	SERIE CALC-ALK. SENAL CONDORI
930	104	0.00	.0000	290	DACITE		PERU	SERIE CALC-ALK. CERRO HUAYNANATO
690	32	0.00	.0000	290	ANDESITE		PERU	SERIE CALC-ALK. CERRO HUAYNANATO
955	58	0.00	.0000	280	ANDESITE		PERU	SERIE CALC-ALK. N. SLP UBINAS VOLC
1090	64	0.00	.0000	279	ANDESITE		PERU	SERIE CALC-ALK. SUMMIT UBINAS VOLC
1055	63	0.00	.0000	265	DACITE		PERU	SERIE CALC-ALK. NEVADO ARUNDANE
1065	93	3.31	.0000	283	DACITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
960	82	3.03	.0000	282	ANDESITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
960	64	2.35	.0000	283	ANDESITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
0	0	2.25	.0000	283	RHYOLITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
900	43	0.00	.0000	265	ANDESITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
840	39	C.00	.0000	280	ANDESITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
860	41	0.00	.0000	281	ANDESITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
960	78	0.00	.0000	281	ANDESITE		PERU	SERIE CALC-ALK. CERROS CALIENTES
1075	76	0.00	.0000	263	ANDESITE		PERU	SERIE CALC-ALK. CORDILLERA BARROSO
840	75	0.00	.0000	267	ANDESITE		PERU	SERIE CALC-ALK.
925	71	0.00	.0000	350	ANDESITE		PERU	SERIE CALC-ALK. CERRO ISCA ANAQUE
875	77	0.00	.0000	362	ANDESITE		PERU	SERIE CALC-ALK. CERRO ISCA ANAQUE
1035	102	0.00	.0000	362	DACITE		PERU	SERIE CALC-ALK. CERRO PUTINA

845	106	0.00	.0000	295	DACITE	PERU	SERIE	CALC-ALK.	CERRO AZUFRE
935	87	0.00	.0000	290	ANDESITE	PERU	SERIE	CALC-ALK.	CERRO ANTAJAVE
1100	110	0.00	.0000	298	DACITE	PERU	SERIE	CALC-ALK.	CERRO PURUPURUNI
1175	93	0.00	.0000	277	DACITE	PERU	SERIE	CALC-ALK.	TUTUPACA VOLCANO
990	35	0.00	.0000	252	ANDESITE	PERU	SERIE	CALC-ALK.	CERRO ARUNDAYA
880	117	0.00	.0000	275	DACITE	PERU	SERIE	CALC-ALK.	CERRO TORO BRAVO
1390	75	0.00	.0000	273	DACITE	PERU	SERIE	CALC-ALK.	TICSANI VOLCANO
1075	71	0.00	.0000	273	DACITE	PERU	SERIE	CALC-ALK.	TICSANI VOLCANO
1425	69	0.00	.0000	273	DACITE	PERU	SERIE	CALC-ALK.	TICSANI VOLCANO
1310	78	0.00	.0000	273	DACITE	PERU	SERIE	CALC-ALK.	TICSANI VOLCANO
845	125	2.30	.0000	314	ANDESITE	PERU	SERIE	CALC-ALK.	CERRO CAOCAYCO
930	133	0.00	.0000	225	DACITE	PERU	SERIE	CALC-ALK.	CERRO CHULLUNQUIAN
835	154	4.98	.0000	295	DACITE	PERU	SERIE	CALC-ALK.	CERRO CHULLUNQUIAN
790	91	2.83	.0000	297	ANDESITE	PERU	SERIE	CALC-ALK.	CERRO CHULLUNQUIAN
1010	170	5.05	.0000	294	DACITE	PERU	SERIE	CALC-ALK.	CERRO CHULLUNQUIAN
1335	72	0.00	.0000	312	ANDESITE	PERU	SERIE	CALC-ALK.	CERRO CAPACA
1150	70	1.55	.0000	327	ANDESITE	PERU	SERIE	CALC-ALK.	CHILA VOLCANO
1300	69	0.00	.0000	325	ANDESITE	PERU	SERIE	CALC-ALK.	CHILA VOLCANO
980	108	0.00	.0000	313	ANDESITE	PERU	SERIE	CALC-ALK.	W. OF CHILA VOLC.
1190	76	2.52	.0000	324	ANDESITE	PERU	SERIE	CALC-ALK.	W. OF CHILA VOLC.
1080	72	0.00	.0000	320	ANDESITE	PERU	SERIE	CALC-ALK.	W. OF CHILA VOLC.
1175	130	4.22	.0000	340	RHYOLITE	PERU	SERIE	CALC-ALK.	
1335	113	1.68	.0000	341	DACITE	PERU	SERIE	CALC-ALK.	
1000	192	5.04	.0000	338	RHYOLITE	PERU	SERIE	CALC-ALK.	
990	101	0.00	.0000	315	ANDESITE	PERU	SERIE	CALC-ALK.	
785	104	4.23	.0000	324	ANDESITE	PERU	SERIE	CALC-ALK.	
0	0	0.00	.0000	305	RHYOLITE	PERU	SERIE	CALC-ALK.	LAGUNA LORISCOTA
0	0	0.00	.0000	305	RHYOLITE	PERU	SERIE	CALC-ALK	
810	96	0.00	.0000	302	ANDESITE	PERU	SERIE	CALC-ALK	
920	99	0.00	.0000	298	DACITE	PERU	SERIE	CALC-ALK	
1570	50	0.00	.0000	387	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1400	54	1.88	.0000	390	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1670	77	0.00	.0000	387	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1565	61	1.41	.0000	390	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1580	61	0.00	.0000	387	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1925	74	1.44	.0000	389	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1950	68	1.55	.0000	380	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1625	74	1.53	.0000	379	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1095	61	0.00	.0000	400	ANDESITE	PERU	SERIE	SHOSHONITIC.	
1815	102	1.80	.0000	407	DACITE	PERU	SERIE	SHOSHONITIC.	
0	0	1.21	.0000	415	BASALT	PERU	SERIE	SHOSHONITIC.	PUCARA VOLC.
1745	83	1.88	.0000	422	DACITE	PERU	SERIE	SHOSHONITIC.	S.E. OF JULI
0	0	0.00	.0000	395	BASALT	PERU	SERIE	SHOSHONITIC.	
1535	60	0.00	.0000	375	ANDESITE	PERU	SERIE	SHOSHONITIC.	HUENQUE RIVER
0	0	0.00	.0000	387	ANDESITE	PERU	SERIE	SHOSHONITIC.	HUENQUE RIVER

0	0	0.00	.0000	386	ANDESITE		PERU	SERIE SHOSHONITIC. HUENQUE RIVER
0	0	0.00	.0000	310	IGNIMB	U-PLIO	CHILE	TOCONCE (BELOW SIFON IGNIMB).
0	0	0.00	.0000	310	IGNIMB	U-PLIO	CHILE	TOCONCE (LOWEST UNIT).
0	0	0.00	.0000	325	IGNIMB	U-PLIO	CHILE	CHAXAS IGNIMB.
0	0	0.00	.0000	315	IGNIMB	U-PLIO	CHILE	VILAMA IGNIMB.
0	0	0.00	.0000	310	IGNIMB	U-PLIO	CHILE	SAN BARTOLO FORMATION.
0	0	0.00	.0000	310	IGNIMB	U-PLIO	CHILE	SAN BARTOLO FORMATION.
0	0	0.00	.0000	243	IGNIMB	U-PLIO	CHILE	CORDILLERA MEDIA, LOC. BEST ESTMTD
0	0	0.00	.0000	325	IGNIMB	U-PLIO	CHILE	PURICAR IGNIMB.
0	0	0.00	.0000	310	IGNIMB	U-PLIO	CHILE	PURICAR IGNIMB.
0	0	0.00	.0000	325	IGNIMB	U-PLIO	CHILE	PURICAR IGNIMB.
0	0	0.00	.0000	313	IGNIMB	U-PLIO	CHILE	SIFON IGNIMB.
0	0	0.00	.0000	313	IGNIMB	U-PLIO	CHILE	SIFON IGNIMB.
0	0	0.00	.0000	295	IGNIMB	U-PLIO	CHILE	SIFON IGNIMB.
0	0	0.00	.0000	335	IGNIMB	U-PLIO	CHILE	TOCONAO IGNIMB.
0	0	0.00	.0000	335	IGNIMB	U-PLIO	CHILE	TOCONAO IGNIMB.
0	0	0.00	.0000	334	IGNIMB	U-PLIO	CHILE	TOCONAO IGNIMB.
920	100	0.00	.0000	317	LAT-ANDE	QUATERNAR	CHILE	S. TATIO VOLCANO
710	45	0.00	.0000	277	LAT-ANDE	QUATERNAR	CHILE	SAN PEDRO VOLCANO
720	135	0.00	.0000	272	DACITE	QUATERNAR	CHILE	EL VOLCAN
870	115	0.00	.0000	267	R-DACITE	QUATERNAR	CHILE	N.E. OF SALAR DE HUASCO
1000	80	0.00	.0000	271	LAT-ANDE	QUATERNAR	CHILE	N.W. IRRUPUTUNCO VOLCANO
1400	90	0.00	.0000	270	LAT-ANDE	QUATERNAR	CHILE	W. CHELA VOLCANO
1110	70	0.00	.0000	273	LAT-ANDE	QUATERNAR	CHILE	W. OCANA MINE
350	35	0.00	.0000	262	LAT-ANDE	QUATERNAR	CHILE	N. SALAR DE CEPOSA
600	35	0.00	.0000	263	LAT-ANDE	QUATERNAR	CHILE	N. SALAR DE CEPOSA
580	20	0.00	.0000	380	LAT-ANDE	QUATERNAR	CHILE	PIEDRAS NEGRAS VOLCANO
560	45	0.00	.0000	392	LAT-ANDE	QUATERNAR	CHILE	N. SALAR DE LACO
490	185	0.00	.0000	410	R-DACITE	QUATERNAR	CHILE	E. SALAR DE LACO
580	70	0.00	.0000	360	LAT-ANDE	QUATERNAR	CHILE	N. TUMISA VOLCANO
490	80	0.00	.0000	361	LAT-ANDE	QUATERNAR	CHILE	W. LASCAR VOLCANO
600	35	0.00	.0000	307	LAT-ANDE	QUATERNAR	CHILE	S.W. SOCOMPA VOLCANO
680	35	0.00	.0000	305	LAT-ANDE	QUATERNAR	CHILE	W. SOCOMPA VOLCANO
590	80	0.00	.0000	304	DACITE	QUATERNAR	CHILE	W. SOCOMPA VOLCANO
300	20	0.00	.0000	282	ANDESITE	QUATERNAR	CHILE	S. MONTURAQUI
800	20	0.00	.0000	270	LAT-ANDE	QUATERNAR	CHILE	BET. MONTURAQUI AND IMILAC
530	115	0.00	.0000	272	LAT-ANDE	QUATERNAR	CHILE	S. SALAR PLATO DE SOPA
590	170	0.00	.0000	275	LATITE	QUATERNAR	CHILE	E. SALAR DE AGUA AMARGA
490	155	0.00	.0000	287	LAT-ANDE	QUATERNAR	CHILE	S.E. CERRO AZUFRE
580	70	0.00	.0000	260	LAT-ANDE	QUATERNAR	CHILE	W. SALAR AGUAS CALIENTES

TABLE 2

Analysis of South-Central Andean volcanic rocks. These samples represent localities from 242 to 536 km from the Peru-Chile trench. All values in ppm. In brackets, for comparison are the values reported by Zentilli (1974) for the same samples.

Sample No.	V	Ni	Li	Cu	Zn
1	123 (107)	13 (11)	26	27 (31)	85 (24)
2	108 (119)	10 (9)	31	27 (20)	81 (43)
3	135 (100)	11 (25)	38	27 (16)	79 (48)
4	56	9	31	19	74
6	164 (185)	15 (26)	19	30 (32)	94 (68)
7	139 (122)	11 (11)	30	14 (21)	93 (33)
8	88	4	48	10	57
9	101	60	28	28	73
11	1	15	35	6	57 (72)
14	73 (45)	6	38	11 (1)	61 (30)
15	21	12	32	10	55
16	126 (145)	16 (9)	19	10 (10)	76 (24)
17	124	not detected	14	24	61
18	113	12	21	6	95
19	86 (152)	18 (13)	14	31 (36)	96 (25)
21	77 (85)	10 (5)	56	14 (7)	113 (107)
22	125	11	26	23	69
26	236	74	15	15	90
30	259	34	92	61	87
31	58	7	12	108	37
32	84	43	31	80	118
33	104	6	26	57	112
34	360	205	23	56	48
35	121	31	19	37	280

TABLE 4: Useful calculations. SUMALK= Sum of the alkalines= Na_2O+K_2O. FE.5MGCA= FeO total + 1/2(MgO + CaO). AL/SI = Al_2O_3/SiO_2. K/Na = K_2O / Na_2O. FE/MG = FeO total/MgO. All values for the major oxides are in weight percent. The values of distance are in km.

NMBR	CaO	SUMALK	SiO2	FE.5MgCa	Al/Si	K/Na	Fe/Mg	Fe(tot)	*Fe*	*Alk*	*Mg*	K-index	Dist.
1	1.96	6.50	61.05	9.21	.28	.80	2.71	5.32	38.58	47.19	14.23	179.	331.
2	2.00	6.77	61.95	8.85	.27	.88	2.45	4.90	35.86	49.51	14.63	187.	329.
3	2.45	6.42	60.35	9.56	.28	.85	2.20	5.38	37.75	45.05	17.19	192.	327.
4	1.50	6.95	64.80	7.30	.25	.78	2.76	4.14	32.89	55.20	11.91	154.	322.
5	2.08	4.93	71.75	7.52	.16	.41	1.94	4.03	36.47	44.68	18.85	53.	316.
6	3.40	5.81	57.60	11.20	.29	.60	1.79	6.10	39.82	37.96	22.21	173.	301.
7	2.32	6.00	60.35	9.02	.29	.65	2.08	4.82	36.69	45.66	17.65	154.	289.
8	.80	6.17	62.65	7.78	.28	.62	6.04	4.83	40.92	52.30	6.78	134.	288.
9	2.50	5.66	62.40	8.92	.27	.44	1.71	4.27	34.36	45.53	20.11	99.	258.
10	1.57	5.79	62.20	8.46	.27	.51	2.69	4.23	36.49	49.97	13.55	113.	258.
11	.25	9.93	70.80	1.83	.20	.80	4.34	1.09	9.63	88.15	2.22	171.	256.
12	.41	7.83	72.43	1.77	.18	1.55	2.41	.99	10.71	84.85	4.44	174.	215.
13	1.50	6.42	62.90	6.89	.27	.61	2.35	3.53	30.81	56.09	13.11	136.	246.
14	1.42	6.37	62.10	7.64	.28	.60	2.65	3.76	32.57	55.14	12.29	140.	244.
15	.80	6.90	66.15	4.38	.25	.60	2.56	2.05	21.01	70.78	8.21	122.	242.
16	2.02	4.80	57.80	9.42	.31	.59	2.43	4.90	41.83	40.94	17.23	140.	247.
17	2.38	6.02	58.60	9.10	.31	.52	1.82	4.34	34.06	47.26	18.68	152.	247.
18	2.00	6.40	59.50	8.51	.30	.39	2.10	4.21	33.37	50.77	15.86	123.	248.
19	1.32	6.85	63.50	7.99	.28	.44	3.39	4.47	35.38	54.18	10.44	114.	238.
20	.75	6.11	65.05	5.79	.25	.58	3.88	2.91	29.61	62.52	7.67	112.	238.
21	1.32	6.68	65.90	5.95	.25	.57	2.18	2.88	26.50	61.37	12.13	116.	238.
22	2.49	6.89	61.90	9.33	.27	.72	2.10	5.23	35.81	47.15	17.04	170.	337.
23	4.93	6.14	58.46	12.27	.28	.75	1.22	6.01	35.18	35.95	28.87	196.	341.
24	3.46	6.82	60.89	10.48	.26	.75	1.56	5.40	34.43	43.50	22.07	184.	353.
25	.62	4.60	83.09	1.41	.12	.29	1.58	.98	15.81	74.19	10.00	27.	359.
26	.50	4.98	83.92	3.67	.08	1.23	6.20	3.10	36.12	58.06	5.83	71.	360.
27	.26	7.35	75.16	1.74	.20	4.53	5.26	1.37	15.24	61.87	2.90	200.	442.
28	1.34	6.80	63.23	7.56	.28	.41	2.92	3.92	32.49	56.40	11.11	109.	436.
29	1.12	5.66	70.56	5.57	.22	.25	2.78	3.11	31.47	57.21	11.32	44.	450.
30	4.15	6.60	51.48	15.86	.33	.55	2.07	8.58	44.38	34.15	21.47	351.	497.
31	.93	7.20	68.42	5.44	.25	31.73	4.32	4.01	33.05	59.29	7.66	298.	498.
32	2.23	5.35	63.06	9.85	.25	1.37	2.13	4.75	38.53	43.39	18.08	171.	498.
33	2.51	5.89	63.63	8.55	.26	1.06	1.79	4.48	34.80	45.72	19.48	163.	505.
34	4.34	5.24	50.87	17.15	.34	1.14	2.14	9.27	49.19	27.79	23.02	475.	500.
35	.73	8.77	61.24	7.25	.31	.80	6.43	4.70	33.08	61.78	5.14	240.	535.
36	1.59	8.23	61.11	8.90	.28	.78	3.50	5.57	36.19	53.48	10.33	223.	536.
37	2.53	7.15	63.80	8.33	.25	.67	1.77	4.57	31.95	50.01	18.04	153.	296.
38	2.46	7.62	64.42	8.15	.24	.49	1.87	4.61	31.36	51.89	16.75	129.	296.
39	2.22	7.24	63.92	7.96	.26	.70	1.97	4.37	31.60	52.35	16.05	157.	296.
40	1.68	7.46	65.51	6.11	.26	.63	1.85	3.11	25.40	60.89	13.71	140.	296.
41	2.37	7.16	64.03	7.91	.26	.70	1.80	4.26	30.68	51.93	17.19	154.	296.
42	.99	7.18	64.56	7.21	.27	.61	4.33	4.28	34.39	57.66	7.95	139.	296.
43	2.40	7.12	64.75	7.75	.25	.75	1.77	4.25	30.86	51.71	17.43	155.	296.
44	2.53	7.00	64.20	9.11	.23	.56	1.96	4.96	34.23	48.31	17.46	130.	294.
45	1.09	7.81	67.57	5.34	.24	.71	2.73	2.97	25.03	65.79	9.18	144.	296.
47	4.00	4.81	55.52	14.22	.33	.26	1.94	7.75	46.81	29.04	24.15	93.	288.
48	5.71	5.27	56.64	13.51	.30	.46	1.23	7.02	39.00	29.28	31.72	143.	296.
49	5.84	5.29	57.07	13.28	.29	.46	1.14	6.64	37.37	29.77	32.86	138.	296.
50	5.74	5.59	58.48	12.65	.28	.51	1.11	6.35	35.93	31.61	32.46	140.	296.
51	3.97	5.84	58.72	11.69	.29	.54	1.57	6.23	38.85	36.40	24.75	150.	296.
52	4.99	6.07	58.53	12.10	.28	.62	1.23	6.16	35.75	35.26	28.99	171.	296.
53	3.62	5.97	59.14	11.23	.30	.57	1.67	6.04	38.65	38.19	23.16	153.	296.
54	2.72	6.76	59.56	10.02	.30	.54	1.98	5.39	36.26	45.45	18.29	162.	295.
55	2.20	6.78	61.65	8.98	.29	.55	2.32	5.11	36.30	48.06	15.64	144.	296.
56	1.97	7.51	61.66	8.70	.28	.53	2.66	5.24	35.62	51.01	13.38	157.	296.
57	2.73	6.17	62.61	9.34	.27	.92	1.84	5.03	36.12	44.29	19.60	168.	311.

58	2.40	6.15	59.66	10.92	.30	.59	2.46	5.90	40.82	42.57	16.61	155.	304.
59	2.53	7.08	62.85	7.92	.27	.73	1.63	4.12	30.01	51.57	18.43	167.	304.
60	3.11	6.90	59.78	9.69	.30	.70	1.72	5.35	34.83	44.92	20.25	191.	304.
61	2.70	7.47	62.20	8.74	.27	.72	1.79	4.83	32.21	49.79	18.00	181.	304.
62	3.43	6.72	57.43	11.43	.31	.62	1.82	6.23	38.05	41.02	20.94	208.	304.
63	.76	8.32	71.16	3.88	.21	.96	3.15	2.40	20.89	72.49	6.62	156.	304.
64	.65	8.06	71.49	3.58	.21	1.00	3.51	2.28	20.75	73.33	5.91	153.	304.
65	.40	8.82	73.80	2.18	.19	1.29	3.37	1.35	12.76	83.45	3.78	173.	304.
66	.34	8.04	74.46	2.31	.19	1.39	4.10	1.39	14.26	82.26	3.48	159.	440.
67	1.19	8.00	67.73	5.55	.23	1.24	2.57	3.06	24.95	65.33	9.72	195.	385.
68	1.26	6.37	67.64	6.43	.23	1.50	2.82	3.56	31.78	56.95	11.27	169.	420.
69	1.51	6.49	68.10	5.82	.24	1.21	1.93	2.91	26.67	59.49	13.84	154.	451.
70	2.12	6.10	64.54	8.48	.25	1.09	2.20	4.66	36.16	47.37	16.45	163.	475.
71	1.24	6.19	70.85	5.72	.20	1.75	2.79	3.45	31.73	56.87	11.39	152.	385.
72	1.58	7.70	67.87	5.95	.22	1.44	2.12	3.35	26.50	60.99	12.51	199.	360.
74	4.23	5.78	61.29	10.65	.26	.90	1.38	5.83	36.79	36.50	26.71	168.	480.
75	.97	7.35	69.66	4.14	.23	1.01	2.64	2.56	22.47	69.00	8.53	160.	472.
76	2.16	5.06	63.64	9.49	.27	1.19	2.51	5.43	42.91	40.01	17.08	148.	385.
77	1.66	6.36	65.85	7.32	.25	1.73	2.57	4.27	34.72	51.77	13.51	193.	385.
78	2.12	6.02	65.06	8.31	.24	1.69	2.36	5.00	38.03	45.83	16.14	188.	360.
79	.85	7.64	69.39	5.09	.22	1.58	3.71	3.16	27.11	65.60	7.30	192.	365.
80	1.92	6.05	65.26	7.43	.26	1.42	2.13	4.10	33.96	50.13	15.91	175.	425.
81	1.95	6.05	63.02	9.24	.26	1.38	2.72	5.30	39.86	45.48	14.66	195.	480.
82	2.53	5.36	64.06	9.12	.25	1.55	2.06	5.21	39.78	40.91	19.31	171.	451.
83	1.87	7.01	64.33	7.75	.26	1.15	2.30	4.30	32.63	53.18	14.19	194.	380.
84	3.12	4.93	61.11	10.54	.29	1.05	1.95	6.08	43.02	34.90	22.08	156.	430.
85	2.12	5.25	61.74	10.30	.26	.78	2.87	6.09	45.25	39.00	15.75	137.	370.
86	1.79	7.42	63.91	7.86	.26	.70	2.50	4.48	32.73	54.19	13.07	161.	345.
87	2.12	7.18	64.57	7.73	.25	.76	2.04	4.32	31.71	52.72	15.57	158.	345.
88	2.86	5.78	64.48	9.16	.24	.63	1.72	4.93	36.32	42.60	21.08	115.	360.
89	2.71	4.50	57.29	12.55	.32	.47	2.56	6.93	49.02	31.82	19.16	117.	480.
90	8.09	3.86	55.17	16.15	.28	.70	1.02	8.28	40.93	19.08	39.99	156.	468.
96	7.17	6.34	54.59	15.02	.26	1.29	1.04	7.43	35.49	30.27	34.24	373.	500.
97	7.68	6.39	53.27	15.45	.28	1.30	1.05	8.03	36.34	28.91	34.75	437.	500.
98	7.61	7.06	54.37	14.33	.27	1.39	.95	7.19	32.90	32.29	34.81	439.	500.
99	5.37	5.96	56.84	13.35	.28	.75	1.33	7.13	38.61	32.29	29.10	215.	440.
100	7.13	5.44	52.78	16.09	.31	.46	1.16	8.30	39.76	26.07	34.17	221.	413.
101	7.15	5.37	52.79	16.25	.30	.44	1.17	8.37	40.08	25.70	34.22	212.	413.
102	6.98	5.53	54.36	14.88	.30	.59	1.10	7.69	38.08	27.37	34.55	220.	412.
103	6.94	5.52	54.52	14.90	.30	.60	1.10	7.65	38.03	27.46	34.52	216.	412.
104	6.98	5.43	54.40	14.91	.30	.60	1.10	7.66	38.16	27.06	34.78	217.	412.
105	8.73	6.39	51.87	16.20	.29	1.10	.90	7.82	34.08	27.86	38.06	486.	520.
106	8.76	6.39	51.61	16.19	.31	1.07	.89	7.79	33.96	27.86	38.19	501.	520.
107	9.82	5.94	50.88	17.15	.29	.97	.80	7.83	33.18	25.18	41.63	497.	520.
108	6.27	5.34	55.15	14.86	.29	.63	1.10	6.92	37.35	28.81	33.83	203.	413.
109	6.66	5.12	55.41	14.58	.29	.62	1.06	7.06	37.46	27.18	35.36	187.	415.
110	3.15	6.32	62.84	9.85	.25	.82	1.69	5.34	36.04	42.68	21.27	160.	425.
111	5.09	6.00	60.17	11.55	.26	.87	1.17	5.94	34.89	35.22	29.88	184.	495.
112	5.13	6.59	58.30	11.84	.27	.96	1.20	6.16	34.46	36.85	28.69	242.	500.
113	1.19	7.62	69.58	4.87	.23	.89	2.13	2.53	22.32	67.18	10.49	146.	420.
114	5.42	6.65	48.24	17.16	.35	.74	1.60	8.63	41.82	32.05	26.12	870.	715.
115	3.88	8.33	50.65	15.60	.34	.95	2.24	8.68	41.54	39.89	18.58	717.	715.
116	4.01	8.43	50.68	15.09	.36	.71	1.97	7.91	38.85	41.43	19.71	616.	715.
117	5.06	8.22	51.78	13.09	.32	.90	1.20	6.07	31.27	42.48	26.15	574.	715.
271	4.22	6.42	53.06	13.48	.33	.93	1.69	7.14	40.14	36.12	23.74	383.	715.
118	2.70	7.68	55.78	12.74	.32	.67	2.66	7.17	40.86	43.75	15.38	286.	715.
119	2.73	10.43	56.43	10.66	.30	.81	1.96	5.45	29.21	55.69	14.90	409.	715.
120	1.85	10.21	55.43	9.14	.34	.83	2.55	4.72	28.13	60.85	11.03	405.	715.
121	1.66	9.60	57.39	8.42	.35	.69	2.68	4.45	28.31	61.12	10.57	316.	715.
122	2.20	10.86	60.10	5.93	.31	.81	.97	2.13	14.01	71.50	14.49	321.	715.
123	1.86	11.32	62.67	6.09	.25	.81	1.54	2.86	17.85	70.56	11.59	287.	715.

184	3.39	6.58	60.18	10.94	.27	.72	1.81	6.15	38.14	40.83	21.03	181.	362.
185	1.98	7.18	63.45	8.58	.26	.82	2.44	4.83	34.51	51.34	14.16	176.	362.
186	1.94	7.00	62.75	8.98	.27	.79	2.74	5.32	37.31	49.09	13.60	175.	295.
187	2.89	6.62	60.63	10.39	.28	.77	2.02	5.83	37.99	43.17	18.85	184.	290.
188	1.89	7.66	66.18	6.89	.23	.88	2.03	3.84	28.68	57.21	14.12	169.	298.
189	2.12	7.41	63.88	8.33	.25	.90	2.27	4.82	33.60	51.63	14.77	196.	277.
190	2.85	6.80	59.15	10.52	.30	.45	2.04	5.82	37.60	43.97	18.43	148.	252.
191	1.69	7.70	67.08	6.43	.23	.89	2.04	3.45	26.88	59.96	13.16	164.	275.
192	1.66	7.80	65.66	6.78	.24	.77	2.33	3.87	29.05	58.50	12.45	164.	273.
193	1.97	7.48	65.36	7.00	.25	.69	1.95	3.83	28.85	56.32	14.83	150.	273.
194	1.83	7.75	65.26	6.89	.25	.73	2.14	3.91	28.98	57.45	13.57	162.	273.
195	1.67	7.88	65.64	6.60	.25	.81	2.25	3.76	28.25	59.20	12.55	171.	273.
196	2.84	7.35	62.64	9.10	.26	.83	1.67	4.74	31.74	49.23	19.02	189.	314.
197	2.04	7.35	64.63	7.67	.25	1.09	2.07	4.22	31.01	54.00	14.99	196.	225.
198	2.13	7.67	64.06	8.18	.25	1.01	2.23	4.76	32.68	52.69	14.63	203.	295.
199	3.38	6.59	59.62	10.88	.29	.73	1.75	5.91	37.22	41.50	21.28	190.	297.
200	1.15	8.28	65.54	5.99	.26	1.07	3.02	3.48	26.94	64.15	8.91	208.	294.
201	2.34	7.41	61.22	9.49	.28	.79	2.29	5.37	35.50	49.02	15.48	201.	312.
202	2.47	7.41	61.17	9.53	.27	.72	2.17	5.36	35.16	48.63	16.21	192.	327.
203	2.93	6.85	60.00	10.69	.28	.73	2.02	6.03	38.00	43.22	18.78	193.	325.
204	2.35	7.65	61.91	9.06	.27	.86	2.12	4.99	33.27	51.05	15.68	209.	313.
205	3.50	7.11	59.90	10.89	.26	.72	1.75	6.14	36.66	42.45	20.90	199.	324.
206	2.04	7.13	62.12	8.71	.28	.82	2.43	4.95	35.07	50.49	14.44	188.	320.
207	.14	8.74	72.87	2.28	.21	1.07	9.61	1.35	13.16	85.47	1.37	162.	340.
208	2.23	7.82	63.23	8.27	.26	.93	2.04	4.56	31.19	53.54	15.27	207.	341.
209	.52	8.91	69.24	4.39	.22	1.46	5.45	2.83	23.10	72.66	4.24	218.	338.
210	3.55	6.92	60.39	10.74	.27	1.04	1.62	5.74	35.41	42.69	21.90	229.	315.
211	3.97	6.66	60.62	11.04	.26	.88	1.40	5.57	34.36	41.12	24.51	200.	324.
212	.04	8.91	76.95	.78	.17	1.06	14.53	.58	6.10	93.48	.42	144.	305.
213	.07	8.95	76.81	.82	.17	1.01	7.91	.55	5.79	93.48	.73	141.	305.
214	2.52	6.88	62.00	9.41	.27	.93	2.09	5.28	35.95	46.88	17.17	195.	302.
215	2.05	7.34	63.82	8.08	.26	.96	2.23	4.60	32.87	52.42	14.71	191.	298.
216	3.82	6.86	55.60	14.37	.27	.81	2.29	8.75	45.02	35.32	19.67	289.	387.
217	4.52	6.72	54.44	14.71	.27	.82	1.91	8.65	43.47	33.79	22.73	321.	390.
218	3.22	7.74	58.48	10.98	.29	.91	2.07	6.67	37.83	43.90	18.26	273.	387.
219	4.83	7.04	54.26	14.34	.29	.82	1.63	7.88	39.91	35.64	24.45	343.	390.
220	5.53	6.90	53.79	14.87	.28	.82	1.43	7.92	38.92	33.90	27.17	354.	387.
221	3.24	8.44	58.58	10.71	.27	.83	1.83	5.93	33.69	47.92	18.40	282.	389.
222	3.20	7.60	56.58	12.60	.27	.91	2.34	7.48	40.92	41.58	17.51	313.	380.
223	3.05	7.93	59.87	10.36	.26	.87	1.93	5.88	34.89	47.02	18.09	248.	379.
224	6.73	6.16	54.93	14.79	.28	.82	1.14	7.72	37.36	29.82	32.82	279.	400.
225	1.43	8.71	64.99	6.60	.25	.98	2.90	4.14	28.99	60.99	10.01	215.	407.
226	6.23	6.42	54.29	14.88	.29	.93	1.31	8.17	39.25	30.83	29.92	333.	415.
227	1.95	8.14	63.80	7.79	.25	1.01	2.40	4.70	31.76	55.00	13.24	218.	422.
228	8.22	5.95	51.54	17.04	.29	.85	1.06	8.75	38.19	25.96	35.86	417.	395.
229	2.09	7.84	59.68	10.44	.27	.75	2.65	5.55	35.86	50.64	13.50	228.	375.
230	2.43	8.84	62.07	9.29	.27	.59	2.22	5.39	32.37	53.05	14.58	193.	387.
231	7.16	6.16	57.73	13.44	.25	.85	.92	6.59	33.09	30.95	35.97	222.	386.
232	1.81	6.62	61.80	9.74	.27	.95	3.11	5.63	40.06	47.07	12.87	192.	310.
233	2.63	6.05	62.31	9.35	.27	1.03	1.94	5.11	37.06	43.87	19.07	177.	310.
234	1.21	6.88	65.82	6.91	.25	1.01	3.14	3.80	31.98	57.85	10.17	166.	325.
235	1.08	7.42	68.61	5.60	.22	1.14	2.78	3.00	26.11	64.50	9.39	168.	315.
236	1.02	7.52	69.54	4.59	.23	1.28	2.38	2.43	22.12	68.58	9.30	172.	310.
237	.50	8.41	70.81	3.98	.22	1.17	4.84	2.42	21.37	74.22	4.41	176.	310.
238	.45	8.81	73.33	2.15	.20	.82	2.79	1.26	11.94	83.79	4.23	140.	243.
239	1.86	6.46	64.97	7.42	.27	.99	2.22	4.12	33.12	51.93	14.95	161.	325.
240	1.41	7.02	65.69	6.83	.26	1.15	2.71	3.83	31.23	57.27	11.50	181.	310.
241	.46	6.64	63.42	6.11	.24	1.11	8.80	4.05	36.30	59.57	4.13	149.	325.

124	3.65	6.36	47.19	16.77	.37	.32	2.01	7.33	42.26	36.69	21.06	708.	715.
125	0.00	7.00	57.30	0.00	0.00	.64	I	0.00	0.00	100.00	0.00	222.	230.
126	0.00	6.44	58.00	0.00	0.00	.64	I	0.00	0.00	100.00	0.00	193.	230.
127	0.00	6.36	58.30	0.00	0.00	.72	I	0.00	0.00	100.00	0.00	201.	230.
128	0.00	6.46	56.70	0.00	0.00	.59	I	0.00	0.00	100.00	0.00	204.	230.
129	0.00	6.40	56.70	0.00	0.00	.54	I	0.00	0.00	100.00	0.00	191.	229.
130	0.00	6.38	56.90	0.00	0.00	.52	I	0.00	0.00	100.00	0.00	182.	229.
131	0.00	6.26	56.80	0.00	0.00	.54	I	0.00	0.00	100.00	0.00	186.	229.
132	0.00	6.57	56.50	0.00	0.00	.59	I	0.00	0.00	100.00	0.00	211.	229.
133	0.00	7.21	58.80	0.00	0.00	.75	I	0.00	0.00	100.00	0.00	225.	245.
134	0.00	7.13	59.40	0.00	0.00	.64	I	0.00	0.00	100.00	0.00	193.	245.
135	0.00	7.28	58.70	0.00	0.00	.64	I	0.00	0.00	100.00	0.00	207.	245.
136	0.00	7.13	59.00	0.00	0.00	.64	I	0.00	0.00	100.00	0.00	199.	245.
137	0.00	6.77	61.20	0.00	0.00	.54	I	0.00	0.00	100.00	0.00	146.	255.
138	0.00	5.70	56.70	0.00	0.00	.49	I	0.00	0.00	100.00	0.00	161.	256.
139	0.00	6.11	60.10	0.00	0.00	.59	I	0.00	0.00	100.00	0.00	150.	255.
140	0.00	7.95	64.00	0.00	0.00	.59	I	0.00	0.00	100.00	0.00	155.	256.
141	0.00	5.38	55.70	0.00	0.00	.59	I	0.00	0.00	100.00	0.00	185.	268.
142	0.00	6.28	60.00	0.00	0.00	.75	I	0.00	0.00	100.00	0.00	180.	268.
143	0.00	5.61	57.40	0.00	0.00	.56	I	0.00	0.00	100.00	0.00	163.	270.
144	0.00	6.15	59.50	0.00	0.00	.67	I	0.00	0.00	100.00	0.00	170.	280.
145	0.00	6.49	59.70	0.00	0.00	.69	I	0.00	0.00	100.00	0.00	181.	280.
146	0.00	6.49	58.80	0.00	0.00	.82	I	0.00	0.00	100.00	0.00	212.	282.
147	0.00	7.12	62.40	0.00	0.00	.72	I	0.00	0.00	100.00	0.00	172.	273.
148	0.00	7.20	63.60	0.00	0.00	.82	I	0.00	0.00	100.00	0.00	174.	268.
149	2.60	7.22	63.40	8.58	.25	.77	1.80	4.67	32.22	49.84	17.95	171.	229.
150	3.33	6.34	59.85	11.14	.28	.69	1.82	6.05	38.47	40.34	21.19	174.	227.
151	4.37	6.41	57.90	12.20	.29	.58	1.47	6.44	37.40	37.22	25.38	182.	226.
152	4.05	6.44	58.02	12.12	.29	.52	1.61	6.52	38.21	37.87	23.82	168.	225.
153	3.07	6.62	61.65	9.84	.27	.63	1.75	5.37	35.64	43.97	20.39	153.	220.
154	4.17	6.31	56.70	12.58	.31	.47	1.64	6.83	39.47	36.45	24.09	173.	239.
155	2.24	7.40	62.36	8.40	.28	.73	2.09	4.69	32.71	51.65	15.63	180.	241.
156	1.58	7.80	63.89	7.15	.27	.73	2.62	4.14	30.63	57.69	11.69	175.	241.
157	1.91	7.61	62.47	8.39	.27	.78	2.56	4.89	33.92	52.83	13.26	191.	247.
158	3.40	6.75	60.52	10.47	.27	.72	1.69	5.73	36.08	42.51	21.41	182.	253.
159	2.77	6.60	60.70	10.05	.29	.55	2.00	5.55	37.21	44.23	18.56	148.	255.
160	3.85	5.84	57.29	12.77	.30	.48	1.82	7.02	41.99	34.93	23.08	154.	257.
161	3.09	6.58	61.50	10.29	.26	.97	1.85	5.71	37.11	42.79	20.10	196.	237.
162	3.25	6.37	59.12	10.98	.30	.45	1.83	5.94	38.15	40.95	20.89	140.	263.
163	1.80	6.69	61.86	9.38	.28	.53	3.01	5.42	38.96	48.09	12.94	138.	272.
164	2.75	6.56	57.43	12.11	.31	.52	2.58	7.09	43.22	40.01	16.77	179.	274.
165	3.49	5.94	56.48	12.75	.32	.49	2.02	7.05	42.79	36.04	21.17	171.	275.
166	1.46	7.48	64.20	7.19	.27	.56	2.75	4.01	30.96	57.77	11.28	139.	274.
167	1.02	7.44	64.99	6.93	.26	.56	3.95	4.03	32.26	59.57	8.17	133.	272.
168	1.71	6.94	64.25	7.99	.27	.90	2.99	5.11	37.14	50.44	12.43	170.	290.
169	3.82	5.84	56.72	13.01	.30	.45	1.84	7.03	42.11	35.00	22.89	155.	290.
170	3.07	6.56	59.08	11.21	.29	.64	2.07	6.35	39.73	41.05	19.21	183.	280.
171	2.80	6.79	60.27	10.57	.28	.66	2.21	6.19	39.23	43.03	17.74	177.	279.
172	2.02	7.36	55.12	7.19	.25	.68	1.93	3.91	29.41	55.39	15.20	149.	265.
173	2.05	7.22	64.98	7.82	.24	.87	2.13	4.37	32.03	52.94	15.03	168.	283.
174	2.69	6.76	62.01	9.68	.27	.78	2.38	5.59	37.16	44.95	17.89	174.	282.
175	2.49	6.63	60.90	9.84	.29	.63	2.19	5.46	37.44	45.48	17.08	162.	283.
176	.81	7.83	69.11	5.01	.23	.92	3.56	2.89	25.03	67.94	7.03	156.	283.
177	2.71	6.15	59.73	10.71	.29	.50	2.27	6.15	40.99	40.96	18.05	139.	265.
178	3.04	6.02	60.22	10.70	.29	.58	1.93	5.87	39.32	40.32	20.36	145.	280.
179	2.38	6.30	61.52	9.74	.29	.49	2.33	5.54	28.96	44.30	16.74	126.	281.
180	2.68	6.73	61.93	9.68	.26	.71	1.99	5.34	36.20	45.63	18.17	165.	281.
181	3.36	6.68	60.54	10.70	.27	.77	1.75	5.87	36.90	41.98	21.12	187.	263.
182	3.52	6.43	59.72	11.66	.27	.75	1.90	6.68	40.15	38.67	21.17	188.	267.
183	3.82	6.57	60.51	10.86	.26	.83	1.56	5.97	36.48	40.17	23.35	191.	350.

242	1.54	6.31	61.52	9.63	.27	1.15	2.89	4.45	36.18	51.30	12.52	204.	313.
243	1.73	6.81	67.17	6.84	.24	1.17	2.32	4.01	31.97	54.25	13.78	166.	313.
244	1.59	6.93	68.72	6.11	.22	1.30	2.05	3.26	27.67	58.83	13.50	165.	295.
245	.60	7.46	75.14	2.07	.17	1.45	1.18	.71	8.06	85.09	6.84	147.	335.
246	.11	7.99	76.78	1.35	.16	1.35	5.84	.64	7.34	91.40	1.26	144.	335.
247	.13	8.04	76.32	1.54	.17	1.32	6.30	.82	9.11	89.44	1.45	146.	334.
248	2.53	6.29	63.36	8.51	.27	.72	1.72	4.35	33.01	47.77	19.21	144.	317.
249	2.24	6.30	59.28	9.81	.32	.48	2.35	5.27	38.14	45.63	16.22	142.	277.
250	3.57	5.61	62.71	9.44	.26	.96	1.34	4.78	34.22	40.20	25.58	155.	272.
251	1.55	6.73	64.92	8.13	.26	.86	3.21	4.97	37.52	50.78	11.70	156.	267.
252	2.92	6.75	61.31	9.82	.27	.63	1.78	5.21	35.00	45.38	19.63	161.	271.
253	2.81	7.13	60.89	9.74	.27	.65	1.94	5.45	35.41	46.33	18.26	177.	270.
254	2.82	7.17	60.53	9.74	.28	.69	1.91	5.40	35.08	46.59	18.33	189.	273.
255	4.96	5.67	55.66	13.87	.31	.40	1.48	7.34	40.83	31.56	27.61	152.	262.
256	5.07	5.57	55.92	13.78	.30	.45	1.45	7.35	40.85	30.97	28.19	158.	263.
257	6.12	4.69	53.59	15.92	.31	.48	1.33	8.12	42.88	24.78	32.34	178.	380.
258	6.27	5.16	53.26	15.72	.31	.50	1.29	8.09	41.44	26.44	32.12	208.	392.
259	2.44	6.61	64.10	8.70	.25	.91	1.99	4.85	34.87	47.57	17.56	165.	410.
260	2.34	5.91	62.68	9.17	.28	.49	2.11	4.93	37.42	44.83	17.75	110.	360.
261	2.32	5.95	61.52	9.28	.29	.51	2.15	4.98	37.58	44.91	17.51	122.	361.
262	4.35	5.66	57.81	12.48	.29	.47	1.52	6.61	39.76	34.06	26.18	142.	307.
263	3.74	5.76	59.12	11.63	.29	.46	1.67	6.26	39.71	36.56	23.74	129.	305.
264	2.32	6.75	64.82	7.91	.24	.60	1.72	3.99	30.54	51.70	17.77	127.	304.
265	7.47	4.24	55.19	15.39	.29	.35	.95	7.12	37.81	22.52	39.67	109.	282.
266	3.32	6.34	59.34	11.07	.28	.40	1.83	6.08	38.62	40.28	21.10	126.	270.
267	3.45	5.27	58.31	12.43	.29	.68	1.96	6.77	43.69	34.03	22.28	154.	272.
268	2.54	6.20	62.49	9.56	.26	1.03	2.01	5.11	36.87	44.78	18.35	180.	275.
269	4.96	5.27	61.16	11.34	.25	.79	1.09	5.42	34.62	33.68	31.70	144.	287.
270	3.85	5.36	59.92	11.12	.29	.51	1.44	5.53	37.50	36.37	26.12	122.	260.

Basalts Region 2

VARIABLE	CASES	MEAN	STD DEV
SIO2	3	51.4533	.5133
TIO2	3	1.4767	.0666
AL2O3	3	15.2867	.4539
FE2O3	3	4.4533	1.1931
FEO	3	3.8033	1.0609
MNO	3	.1367	.0058
MGO	3	9.1033	.6208
CAO	3	7.4033	.2139
NA2O	3	3.0500	.0300
K2O	3	3.1900	.2343
P2O5	3	.8100	.0173
LI	0	.10000000E+11	.10000000E+11
AG	0	.10000000E+11	.10000000E+11
SN	0	.10000000E+11	.10000000E+11
GA	0	.10000000E+11	.10000000E+11
PB	0	.10000000E+11	.10000000E+11
ZN	3	105.6667	2.5166
CU	3	30.0000	5.1962
B	0	.10000000E+11	.10000000E+11
BE	0	.10000000E+11	.10000000E+11
MO	0	.10000000E+11	.10000000E+11
V	0	.10000000E+11	.10000000E+11
ZR	3	241.3333	26.7270
NI	3	136.3333	24.8462
CO	3	30.6667	6.6583
Y	0	.10000000E+11	.10000000E+11
CE	0	.10000000E+11	.10000000E+11
CR	0	.10000000E+11	.10000000E+11
SC	0	.10000000E+11	.10000000E+11
SR	3	991.6667	5.8595
BA	0	.10000000E+11	.10000000E+11
RB	3	93.6667	17.8979
U	0	.10000000E+11	.10000000E+11
SRRATIO	0	.10000000E+11	.10000000E+11
DIST	3	520.0000	0

Basalts Region 3

VARIABLE	CASES	MEAN	STD DEV
SIO2	8	50.6988	2.0299
TIO2	8	1.3475	.3136
AL2O3	8	16.9700	.8090
FE2O3	8	4.4288	2.5525
FEO	8	4.0012	2.4127
MNO	8	.1350	.0469
MGO	8	5.0563	1.4189
CAO	8	9.5537	1.9684
NA2O	8	4.2350	.4660
K2O	8	2.6900	1.0287
P2O5	8	.7787	.7760
LI	1	92.0000	.10000000E+11
AG	0	.10000000E+11	.10000000E+11
SN	1	2.6000	.10000000E+11
GA	1	11.0000	.10000000E+11
PB	1	19.0000	.10000000E+11
ZN	3	90.3333	2.3868
CU	3	50.0000	9.5394
B	0	.10000000E+11	.10000000E+11
BE	1	.8000	.10000000E+11
MO	1	15.0000	.10000000E+11
V	1	259.0000	.10000000E+11
ZR	3	135.3333	22.2755
NI	3	56.0000	19.0788
CO	3	32.6667	4.0415
Y	1	32.0000	.10000000E+11
CE	0	.10000000E+11	.10000000E+11
CR	1	54.0000	.10000000E+11
SC	1	28.9000	.10000000E+11
SR	3	551.3333	234.1417
BA	1	346.0000	.10000000E+11
RB	3	68.0000	52.8299
U	1	.7100	.10000000E+11
SRRATIO	0	.10000000E+11	.10000000E+11
DIST	8	612.2500	144.1584

Andesites region 1

VARIABLE	CASES	MEAN	STD DEV
SIO2	71	58.7641	2.0522
TIO2	50	1.0872	.4474
AL2O3	50	16.6120	.9196
FE2O3	50	4.0208	1.0707
FEO	50	2.6754	.9445
MNO	50	.1102	.0282
MGO	50	3.4674	1.0897
CAO	50	5.8574	.6734
NA2O	71	3.9737	.3164
K2O	71	2.6734	.4874
P2O5	50	.4268	.2071
LI	44	12.0682	2.8481
AG	0	.10000000E+11	.10000000E+11
SN	0	.10000000E+11	.10000000E+11
GA	0	.10000000E+11	.10000000E+11
PB	0	.10000000E+11	.10000000E+11
ZN	0	.10000000E+11	.10000000E+11
CU	0	.10000000E+11	.10000000E+11
B	0	.10000000E+11	.10000000E+11
BE	0	.10000000E+11	.10000000E+11
MO	0	.10000000E+11	.10000000E+11
V	0	.10000000E+11	.10000000E+11
ZR	0	.10000000E+11	.10000000E+11
NI	0	.10000000E+11	.10000000E+11
CO	0	.10000000E+11	.10000000E+11
Y	0	.10000000E+11	.10000000E+11
CE	0	.10000000E+11	.10000000E+11
CR	0	.10000000E+11	.10000000E+11
SC	0	.10000000E+11	.10000000E+11
SR	65	741.0923	169.0336
BA	44	1103.2955	319.7709
RB	65	61.0615	18.6572
U	20	1.4270	.9585
SRRATIO	21	.7070	.0007
DIST	71	290.0141	54.5644

Andesites Region 2

VARIABLE	CASES	MEAN	STD DEV
SIO2	36	58.2733	2.7428
TIO2	36	1.0833	.3385
AL2O3	36	16.7369	1.0617
FE2O3	36	2.4794	.9980
FEO	36	4.1675	1.4786
MNO	36	.1019	.0253
MGO	36	4.3567	1.8804
CAO	36	6.5511	1.1057
NA2O	36	3.5872	.6165
K2O	36	2.2975	.7349
P2O5	36	.3153	.1711
LI	0	.10000000E+11	.10000000E+11
AG	0	.10000000E+11	.10000000E+11
SN	0	.10000000E+11	.10000000E+11
GA	0	.10000000E+11	.10000000E+11
PB	0	.10000000E+11	.10000000E+11
ZN	7	100.2857	5.2190
CU	20	44.3000	20.8708
B	0	.10000000E+11	.10000000E+11
BE	0	.10000000E+11	.10000000E+11
MO	0	.10000000E+11	.10000000E+11
V	13	138.8462	31.8953
ZR	20	217.5500	54.9847
NI	29	53.7586	40.7384
CO	20	25.5500	7.7763
Y	13	7.5385	3.6882
CE	0	.10000000E+11	.10000000E+11
CR	13	124.2308	137.0007
SC	13	37.8462	15.1209
SR	20	737.8000	182.1201
BA	13	706.1538	308.0460
RB	20	77.2000	52.6764
U	0	.10000000E+11	.10000000E+11
SRRATIO	0	.10000000E+11	.10000000E+11
DIST	36	351.4167	86.7721

Andesites Region 3

VARIABLE	CASES	MEAN	STD DEV
SIO2	28	58.0211	2.9817
TIO2	28	.9471	.3295
AL2O3	28	17.2039	1.0903
FE2O3	28	3.3404	1.5859
FEO	28	2.7750	1.6069
MNO	28	.1346	.0586
MGO	28	3.4846	1.8544
CAO	28	6.3979	1.2531
NA2O	28	3.9375	.9317
K2O	28	2.8071	.9078
P2O5	28	.3071	.3044
LI	12	25.5833	8.1626
AG	3	.2067	.1701
SN	3	2.8667	1.5177
GA	11	16.0000	1.8974
PB	11	15.0000	7.0852
ZN	19	91.7895	49.8994
CU	22	29.5909	18.6002
B	3	14.0000	13.0000
BE	9	2.9444	3.4681
MO	7	5.1429	3.5790
V	17	136.8235	64.2799
ZR	22	171.0000	58.4327
NI	21	57.6667	63.5518
CO	18	21.0000	7.7079
Y	17	27.8235	23.3030
CE	3	99.3333	43.8785
CR	12	57.1667	62.2967
SC	13	24.5077	16.7166
SR	22	516.5000	156.5791
BA	17	554.5882	193.7618
RB	22	101.7273	46.7813
U	13	2.3738	1.9497
SRRATIO	1	.7060	.10000000E+11
DIST	28	431.9286	169.9608

Dacites Region 1

VARIABLE	CASES	MEAN	STD DEV
SIO2	35	63.9109	1.3525
TIO2	32	.7156	.1209
AL2O3	32	16.5303	.5948
FE2O3	32	3.2256	.8419
FEO	32	1.5594	.6858
MNO	32	.0775	.0202
MGO	32	2.0028	.4346
CAO	32	4.1444	.5724
NA2O	35	4.1740	.4177
K2O	35	3.3523	.3937
P2O5	32	.3009	.0629
LI	29	17.7931	6.0201
AG	0	.10000000E+11	.10000000E+11
SN	0	.10000000E+11	.10000000E+11
GA	0	.10000000E+11	.10000000E+11
PB	0	.10000000E+11	.10000000E+11
ZN	0	.10000000E+11	.10000000E+11
CU	0	.10000000E+11	.10000000E+11
B	0	.10000000E+11	.10000000E+11
BE	0	.10000000E+11	.10000000E+11
MO	0	.10000000E+11	.10000000E+11
V	0	.10000000E+11	.10000000E+11
ZR	0	.10000000E+11	.10000000E+11
NI	0	.10000000E+11	.10000000E+11
CO	0	.10000000E+11	.10000000E+11
Y	0	.10000000E+11	.10000000E+11
CE	0	.10000000E+11	.10000000E+11
CR	0	.10000000E+11	.10000000E+11
SC	0	.10000000E+11	.10000000E+11
SR	32	569.8438	113.8570
BA	29	1115.0000	247.3611
RB	32	92.0313	27.3749
U	14	2.0593	1.5161
SRRATIO	3	.7069	.0004
DIST	35	292.3714	45.2802

Dacites Region 2

VARIABLE	CASES	MEAN	STD DEV
SIO2	35	64.8263	1.6209
TIO2	35	.7900	.1839
AL2O3	35	16.2866	.6591
FE2O3	35	2.6009	1.0235
FEO	34	2.0762	1.0223
MNO	35	.0749	.0180
MGO	35	2.0557	.5648
CAO	35	4.4477	.6723
NA2O	35	3.4954	.7978
K2O	35	3.1731	.5790
P2O5	34	.1821	.0466
LI	0	.10000000E+11	.10000000E+11
AG	0	.10000000E+11	.10000000E+11
SN	0	.10000000E+11	.10000000E+11
GA	0	.10000000E+11	.10000000E+11
PB	0	.10000000E+11	.10000000E+11
ZN	11	101.3636	18.4134
CU	16	22.5625	18.9278
B	0	.10000000E+11	.10000000E+11
BE	0	.10000000E+11	.10000000E+11
MO	0	.10000000E+11	.10000000E+11
V	6	126.6667	44.2342
ZR	17	189.0588	49.9881
NI	27	15.4074	20.2109
CO	17	12.4118	4.5334
Y	6	6.0000	.8944
CE	0	.10000000E+11	.10000000E+11
CR	6	34.1667	25.5767
SC	6	21.1667	8.1343
SR	17	463.1176	185.4063
BA	6	695.0000	172.1337
RB	17	166.7647	69.7276
U	0	.10000000E+11	.10000000E+11
SRRATIO	0	.10000000E+11	.10000000E+11
DIST	35	343.6286	57.3591

Dacites Region 3

VARIABLE	CASES	MEAN	STD DEV
SIO2	16	63.4731	1.2970
TIO2	16	.6762	.1170
AL2O3	16	16.6738	.6633
FE2O3	16	2.7731	1.1964
FEO	16	1.4750	1.1523
MNO	16	.1119	.0678
MGO	16	1.6944	.7083
CAO	16	5.1238	.9275
NA2O	16	3.9587	.8946
K2O	16	2.6525	.7836
P2O5	16	.2500	.0790
LI	9	34.4444	12.3300
AG	5	.1700	.1056
SN	3	7.3000	6.6836
GA	9	14.7778	2.5874
PB	9	19.2222	12.0600
ZN	12	81.2500	29.1520
CU	13	25.1538	21.4159
B	4	26.5000	9.1104
BE	8	1.1000	.3817
MO	7	7.1429	4.0999
V	12	80.4167	23.8764
ZR	13	139.0000	29.6423
NI	13	22.3846	23.5072
CO	10	9.9000	4.1753
Y	13	13.1538	7.7765
CE	3	59.6667	82.6458
CR	10	16.5000	11.6928
SC	10	9.3800	7.9430
SR	13	491.6923	160.1210
BA	13	560.0000	191.2877
RB	12	100.8333	33.0202
U	13	1.7292	.8245
SRRATIO	4	.7064	.0011
DIST	16	339.1250	138.7592

Rhyolites Region 1

VARIABLE	CASES	MEAN	STD DEV
SIO2	8	72.6788	3.0446
TIO2	8	.2562	.1651
AL2O3	8	14.4887	.9749
FE2O3	8	1.6425	.8826
FEO	8	.3000	.2975
MNO	8	.0525	.0354
MGO	8	.4238	.3108
CAO	8	1.4150	.8700
NA2O	8	4.1013	.2700
K2O	8	4.4663	.5054
P2O5	6	.1550	.0824
LI	2	15.0000	2.8284
AG	0	.10000000E+11	.10000000E+11
SN	0	.10000000E+11	.10000000E+11
GA	0	.10000000E+11	.10000000E+11
PB	0	.10000000E+11	.10000000E+11
ZN	0	.10000000E+11	.10000000E+11
CU	0	.10000000E+11	.10000000E+11
B	0	.10000000E+11	.10000000E+11
BE	0	.10000000E+11	.10000000E+11
MO	0	.10000000E+11	.10000000E+11
V	0	.10000000E+11	.10000000E+11
ZR	0	.10000000E+11	.10000000E+11
NI	0	.10000000E+11	.10000000E+11
CO	0	.10000000E+11	.10000000E+11
Y	0	.10000000E+11	.10000000E+11
CE	0	.10000000E+11	.10000000E+11
CR	0	.10000000E+11	.10000000E+11
SC	0	.10000000E+11	.10000000E+11
SR	2	297.0000	5.6569
BA	2	1087.5000	123.7437
RB	2	161.0000	43.8406
U	3	3.8367	1.4340
SRRATIO	0	.10000000E+11	.10000000E+11
DIST	8	310.3750	19.1605

Rhyolites Region 2

VARIABLE	CASES	MEAN	STD DEV
SIO2	14	71.2214	3.4095
TIO2	14	.4521	.1828
AL2O3	14	14.8850	1.4789
FE2O3	14	1.9157	1.3166
FEO	14	.6057	.7847
MNO	14	.1000	.1738
MGO	14	.7621	.4568
CAO	14	2.3743	.9826
NA2O	14	3.3736	.5891
K2O	14	4.1636	.4173
P2O5	14	.1736	.2857
LI	0	.10000000E+11	.10000000E+11
AG	0	.10000000E+11	.10000000E+11
SN	0	.10000000E+11	.10000000E+11
GA	0	.10000000E+11	.10000000E+11
PB	0	.10000000E+11	.10000000E+11
ZN	5	78.4000	12.8569
CU	5	13.8000	8.7864
B	0	.10000000E+11	.10000000E+11
BE	0	.10000000E+11	.10000000E+11
MO	0	.10000000E+11	.10000000E+11
V	0	.10000000E+11	.10000000E+11
ZR	5	160.2000	30.6056
NI	5	7.0000	5.3385
CO	5	6.2000	2.3875
Y	0	.10000000E+11	.10000000E+11
CE	0	.10000000E+11	.10000000E+11
CR	0	.10000000E+11	.10000000E+11
SC	0	.10000000E+11	.10000000E+11
SR	5	290.4000	105.7559
BA	0	.10000000E+11	.10000000E+11
RB	5	260.2000	14.8728
U	0	.10000000E+11	.10000000E+11
SRRATIO	0	.10000000E+11	.10000000E+11
DIST	14	352.1429	64.0767

Rhyolites Region 3

VARIABLE	CASES	MEAN	STD DEV
SIO2	9	73.9678	5.7298
TIO2	9	.3644	.1931
AL2O3	9	13.2022	3.2791
FE2O3	9	1.9533	1.4750
FEO	9	.5978	.5535
MNO	9	.0656	.0695
MGO	9	.8178	.5890
CAO	9	1.5889	1.5112
NA2O	9	3.1133	1.6358
K2O	9	3.5644	2.1634
P2O5	9	.1111	.0580
LI	3	20.6667	12.5033
AG	2	.8550	1.0819
SN	2	6.8500	2.4749
GA	7	14.8571	2.5448
PB	7	13.2857	9.7931
ZN	8	73.5000	90.1554
CU	6	52.5000	68.9659
B	0	.10000000E+11	.10000000E+11
BE	4	.5250	.1893
MO	0	.10000000E+11	.10000000E+11
V	6	84.8333	80.3229
ZR	8	134.0000	127.8772
NI	5	23.2000	28.6217
CO	3	7.3333	3.7859
Y	7	26.1429	29.3679
CE	0	.10000000E+11	.10000000E+11
CR	4	13.2500	3.5000
SC	4	8.1000	2.2554
SR	8	164.2500	141.6361
BA	7	459.8571	431.9230
RB	8	149.2500	112.2367
U	6	4.6250	5.3318
SRRATIO	0	.10000000E+11	.10000000E+11
DIST	9	368.4444	93.9443

Example of a program using QDGS subroutines and Fortran statements. This program plots the data points (as calculated from the Fortran statement) and labels them.

```
      PROGRAM SAMPLE1(INPUT,TAPE5=INPUT,TAPE24=0,OUTPUT,TAPE6=OUTPUT)
C
C                            VICENTE V. PALMA
C                            GEOLOGY DEPT. DALHOUSIE UNIVERSITY
C                            NOVEMBER , 1977
C
C THIS PROGRAM PLOTS A GRAPH OF LATITUDE VERSUS LONGITUDE. IT USES A SET
C OF QDGS ( QUICK DRAW GRAPHICS SYSTEM) SUBROUTINES PLUS   FORTRAN STATEMENTS.
C CALL THE GRAPH " GRAPH ".
C CALL THE PLUS SIGNS " PLUS".
C INITIALIZE
       INTEGER A(1000), B(1000), C(1000),GRAPH,PLUS
       REAL D(6,1000),Q(6)
      REAL K,M
      COMMON/LAVSA/A/LAVSB/B/LAVSC/C/LAVSD/D
        DATA GRAPH,PLUS/0,0/,INPUT/6/,PIBY2/1.570795/,LINES/0/
       CALL INITQ(1000)
C ESTABLISH AN X AXIS. SCALE TO BE USED IS  1.1  INCHS = 5000000.
C IN THE X AXIS WILL BE REPRESENTED THE LINES OF LATITUDE. THEY WILL
C GO FROM LATITUDE 14 TO LATITUDE 32. X= DEGREES OF LATITUDE TIMES 1.1
      CALL XFSTQ(0.0,0.0,1.0,1.0,0.0,0.0,Q)
      CALL AXISQ(19.8,18,14.0,1.0,0.1,0,Q,GRAPH)
C LABEL THE X AXIS. MAKE LETTERS .1  UNITS HIGH TO MATCH NUMBERS
      CALL XFSTQ(8.5,0.5,0.12,0.13,0.0,0.0,Q)
      CALL LABLQ(20HLATITUDE    (DEGREES),-20,Q,GRAPH)
C ESTABLISH  A Y AXIS. SCALE TO BE USED IS  1.1  INCHS = 5000000.
C PUT Y AXIS ON THE GRAPH.  Y AXIS GOES FROM LONGITUDE 73 TO LONGITUDE 63
      CALL XFSTQ(0.0,0.0,1.0,1.0,PIBY2,0.0,Q)
      CALL AXISQ(8.8,6,73.0,-1.0,-0.1,0,Q,GRAPH)
C LABEL THE Y AXIS. MAKE LETTERS .1  UNITS HIGH TO MATCH NUMBERS.
      CALL XFSTQ(-0.5,4.5,0.12,0.13,PIBY2,0.0,Q)
      CALL LABLQ(21HLONGITUDE    (DEGREES),-21,Q,GRAPH)
C DATA POINTS ARE DENOTED BY A PLUS SIGN.
C THE SIGN IS .5 UNITS BY .5 UNITS.
C THE PEN IS POSITIONED AT THE CENTER OF THE SIGN AFTER IT HAS BEEN DRAWN.
      CALL ADPTQ(0.5,0.0,0,PLUS)
      CALL ADPTQ(-0.5,0.0,1,PLUS)
      CALL ADPTQ(0.0,-0.5,0,PLUS)
      CALL ADPTQ(0.0,0.5,1,PLUS)
      CALL ADPTQ(0.0,0.0,0,PLUS)
C MOVE THE PEN TO THE FIRST DATA POINT WITHOUT DRAWING A LINE.
      READ 10,G,H,K,M,O,P
      X=((((((K/60)+H)/60)+G)-14)*1.1)
      Y=ABS((((((P/60.0)+O)/60.0)+M)-73.0)*1.1)
   10  FORMAT(13X,6F2.0,55X)
      CALL ADPTQ(X,Y,0,GRAPH)
C PLACE THE PLUS SIGN AT DATA POINT. THE PLUS SIGN IS SCALED TO BE .05 UNTS. SQ
   20 CALL XFSTQ(X,Y,.05,.05,0.0,0.0,Q)
      CALL ADELQ(PLUS,Q,GRAPH)
C READ THE REST OF THE POINTS ONE BY ONE.
C GO TO 20 TO ADD THE PLUS SIGN TO THAT POINT.
      READ 10,G,H,K,M,O,P
      X=((((((K/60)+H)/60)+G)-14)*1.1)
      Y=ABS((((((P/60.0)+O)/60.0)+M)-73.0)*1.1)
      IF(EOF(5LINPUT).NE.0.0) GO TO 30
      CALL ADPTQ(X,Y,0,GRAPH)
      GO TO 20
 C THE GRAPH HAS BEEN COMPLETED. DISPLAY IT.
  30   CALL DISPQ(GRAPH,100.0)
      STOP
       END
```

APPENDIX B

Preparation of Reference Standards

Synthetic standard solutions were prepared containing a background matrix of major elements composed of aluminum wire, calcium carbonate, iron wire, magnesium crystals, and potassium chloride, plus nitric, hydrochloric, perchloric, and boric acids. The standards which contain .1, .2, .4, .6, .8, 1, 2, 3, and 4 ppm of Vanadium, nickel, lithium, copper, and zinc were prepared by combining appropriate amounts of these elements, as solutions, with the major elements background solution to produce 200 mls of each standard.

Preparation of Major Elements Background Solution

3.491 grams of aluminum wire were dissolved with the aid of 5 drops of mercury, to act as a catalyst, in 300 mls of a 1:1 HCl solution. The mercury is covered once the aluminum has gone into solution. Next, dissolve consecutively 2.4618 grams of iron wire, .5302 grams of magnesium crystals, 3.9270 grams of calcium carbonate, 3.3176 grams of sodium chloride and 2.0878 grams of potassium chloride. The last four reagents should be dropped carefully into the solution because they effervesce. Then add 1 litre of distilled water and the following acids to solution: 99 mls of perchloric acid, 4.4 mls of nitric acid, 220 mls of hydrofluoric acid, and 35.2 grams of basic acid. Finally dilute the solution to 2.2 litres with distilled water and stir it in a hot plate for 20 minutes, let it cool, and store for later use.

Preparation of Reference Standards

A combined 100 ppm standard solution was made by combining 10 mls of 1000 ppm stock solutions of lithium, copper, vanadium, and nickel, and 20 mls of a 500 ppm stock solution of zinc, with 40 mls of distilled water in a 100 mls flask. Next by the use of a burette, transfer to a 200 mls volumetric flask 100 mls of background solution; an appropriate volume of combined-standard-solution; and enough distilled water to fill the flask to the mark. The volume of combined-standard-solution used depends on the required concentration of the reference standard being prepared. For example to prepare a 4 ppm standard solution use 8 cc of combined-standard-solution. A standard blank should be prepared by omitting the combined-standard-solution.

Procedure for Rock Dissolution

1. Weigh 1 gram of powdered-rock sample and pour it into a teflon cup. The teflon cup should contain a small amount of distilled water to prevent the powder from flying off.
2. Add 3 mls of $HNO_3$1 k5 nks if 4:1 mixture of HF and $CHlO_4$. This step should be done under a strong hood, and care should be taken to avoid contact of the acids with the skin.
3. Put the teflon cups in a sand bath at 60°C for 12 hours.
4. Open the cups and evaporate the solution until perchloric acid fumes appear.
5. Take the teflon cups from the sand bath and add 5 mls of HCl, and 16 mls of 5% basic acid.

6. Fill the teflon cups to 3/5 with distilled water, cover and leave them for 1 hour in the sand bath.
7. Let the teflon cups cool. Pour the solutions into 100 mls volumetric flasks and bring them to the mark with distilled water.
8. Transfer the solutions to plastic bottles and properly label them.
9. A sample blank is prepared by omitting the rock powder.

In this work a concentration reading was obtained from the Atomic Absorption unit (A.A.) and a small computer program was used to calculate the corrected concentration of the element being analysed from the sample solutions with respect to the reference standards. This step takes care of errors that may be introduced by drifts in the A.A. unit. Furthermore, the values were corrected for errors introduced in the overall analytical procedure by multiplying by a correction factor derived from the data of the standard rocks, Table 3.

TABLE 3

STANDARD ROCKS
(Values in ppm)

	← BCR-1 →			← NIM-N →		← TB →		← AGV-1 →			← DR-N →			
	A	A*	LR	B	B*	C	C*	D	D*	LR	E	E*	Correction Factor	Relative Accuracy
V	410	462	120-700	220	263	105	100	125	132	70-171	220	210	.946	95%
Ni	13	24	8-30	120	+	40	58	17	24	11-31	22	+	.637	64%
Li	13	16	-	-	7	115	136	14	12	-	45	47	.927	93%
Cu	19	32	7-33	13	24	50	61	63	79	58-83	52	61	.699	70%
Zn	120	153	-	-	83	-	114	88	117	-	150	206	.754	75%

NOTE: The values obtained in this work are reported under a letter followed by an asterisk. Those values which the standards are suppose to have are reported under the same, but plain, letter.

LR = literature range

\- = unknown value

\+ = value under plain letter assumed right during the calculations because it was used to bracket another standard rock.

$$\text{Correction Factor} = \frac{n}{\sum_{i=1}^{n} \frac{x_i^*}{x_i}}, \quad \text{where } x_i^* = A^*, \ldots, E^*$$

$$x_i = A, \ldots, E$$

TIME SPENT ON THE THESIS:

What was done	Time Spent
Analyses of 30 samples (25 samples from the Central Andes + 5 standards, putting them into solution (batch). Each sample was run 3 times)	60 hrs.
Literature Research (time spent in the library plus some reading)	60 hrs.
Development of QDGS, FORTRAN, and SPSS programs to produce the graphs and tables presented in this thesis.	100 hrs.
Drafting (I had to draft figures 1,2,3, and 2 or 3 others)	10 hrs.
Writing the thesis, including earlier drafts and final copy.	200 hrs. or more
TOTAL	430 hrs. Approx.