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at the Sierrita Porphyry Copper Deposit, Arizona

be accepted as fulfilling this part of the requirements for the degree of Master of Science

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HYDROTHERMAL ACTIVITY AS RELATED TO ORE DEPOSITION
AT THE SIERRITA PORPHYRY, COPPER-MOLYBDENITE DEPOSIT,
SOUTHWESTERN ARIZONA

A thesis submitted to the
Division of Graduate Studies
of the University of Cincinnati
in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

1972

BY

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INTRODUCTION

A common characteristic of porphyry copper ore deposits is the close association between ore mineralization and wall rock alteration. Due to this association a great deal of study has been devoted to the examination of altered rocks with the hope of defining a genetic relationship between hydrothermal alteration and ore mineralization which would assist geologists in the search for new ore deposits. The majority of these studies have resulted in qualitative descriptions of minerals in hydrothermally altered rocks in many porphyry copper ore deposits; however, none have succeeded in establishing what critical mineralogical and/or chemical criteria might be used to define ore-mineralized as opposed to barren areas.

The importance of defining this relationship is easily demonstrated by the increasing demand for copper ore and the increasing difficulty in discovering new low grade, but high tonnage deposits utilizing previously established exploration techniques. Geologists in the past have been able to locate sizable ore deposits by examination of surface outcrops, many of which contained mineralized veins indicative of large ore occurrences. The majority of these more easily definable deposits have now been discovered, which necessitates further search for more ore with new and improved techniques. The tools for this type of study have reached a fairly sophisticated stage of development which relegates the problem to one of employing these instruments and understanding the data derived from their use in the correct manner in the search for additional ore reserves.

The recognition of the association of wall rock alteration and ore mineralization was used by early prospectors in their search for ore deposits. Later studies of alteration in aluminosilicate rocks, by geologists have essentially progressed through four stages. The first stage was that of a hand specimen description of the effect of alteration surrounding veinlets. Studies of this type were useful in pointing out alteration as a major aspect of ore deposits but did little to help define the reason for the development of this characteristic feature. The second stage started with the advent of the polarizing microscope and significant qualitative descriptions of alteration minerals appeared in the literature. Notable in this respect are papers by Ransome (1905), Lindgren (1905), Reber (1916), and Emmons (1927). These investigators began to recognize the significant effects of alteration, such as the dominant minerals formed, and the change in alteration mineralogy away from areas containing high concentrations of ore minerals. Still, however, these researchers were handicapped by the difficulty of distinguishing fine-grained alteration minerals, such as clays, which are very important at many porphyry copper deposits. Furthermore, they could not develop any quantitative data to help them in determining reasons for these alteration effects.

Data obtained in the 1940's through the use of X-ray diffraction techniques, mark the beginning of the third stage and were very important for the determination and characterization of fine-grained alteration minerals. Two significant papers dealing with hydrothermal alteration at porphyry copper deposits published at this time were by

Peterson, Gilbert and Quick (1946) and Schwartz (1947). These papers stressed the importance of clay minerals as alteration products at porphyry copper deposits and further pointed out the existing variations in total alteration mineralogy at many deposits. The problem of accumulating good qualitative data was essentially solved, however, there still remained the problem of establishing reliable quantitative data and using these to understand the genetic implications of alteration and ore deposition.

The present stage of development in the examination of hydrothermal alteration began with the development of the X-ray fluorescence unit which produced reliable quantitative data. The development of the atomic absorption unit has now made possible an even faster and to some extent more accurate method of obtaining quantitative information. Important papers which have attacked the problem of hydrothermal alteration using a quantitative approach are those by Creasey (1959), Burnham (1962), Hemley and Jones (1964), Meyer and Hemley (1967) and Rose (1970). It is now generally accepted that data obtained by these investigators indicate that some genetic relationship exists between hydrothermal alteration and ore deposition. In addition, these authors have demonstrated that the establishment of the exact relationship will only be realized after a considerably greater amount of quantitative as well as qualitative data from several porphyry copper deposits has been developed.

Previous Related Studies

The study of alteration and its relationship to ore mineralization at porphyry copper deposits has been of primary interest to many exploration geologists during the last century. As additional mining activity became centered in the west in the late 1800's, many investigators began studying and describing mineralization and associated wall rock alteration.

One of the first significant documented studies of this relationship was by Ransome (1905). In his study of the geology of Bisbee, Arizona, Ransome described alteration as a type of metamorphism after recognizing tremolite, diopside, garnet, vesuvianite, quartz and chlorite, in the limestone; and quartz, sericite, chlorite, kaolin, and a little epidote in the granite porphyry. He also noticed that a large amount of alumina occurring with the oxidized ores was tied in "kaolinite and clay" within the limestone, a feature he could not explain. Furthermore, he pointed out that the metamorphic minerals mentioned were not distributed uniformly throughout the limestone but were arranged in zones about the porphyry mass. Ransome described two "zones" as follows: (1) nearest the porphyry mass, the former limestone which is now a fine-grained aggregate consisting chiefly of calcite and quartz, and (2) encircling the siliceous zone are the pale-green altered limestones in which pyrite, tremolite, diopside, grossularite, and probably vesuvianite are the characteristic minerals. He also noted that the ore occurred predominantly within this outer zone of alteration. Finally, he concluded that "the greater part

at least of the mineralization must have taken place after the porphyry had solidified". He further states that "it is probable, although perhaps not in this case susceptible of definite proof, that the mineralization and metamorphism were effected by heated aqueous solutions".

Spurr (1905) should be noted as another major contributor to the study of alteration of mineralized areas. In his paper on the Tonopah mining district, Nevada, he described in detail the alteration of specific minerals and further postulated what primary components may have been carried by the altering fluids.

Significant papers following these include those by Lindgren (1905), Reber (1916), and Emmons (1927). These investigators often recognized the major characteristic minerals of alteration; however, being restricted to at most the use of a polarizing microscope and crude procedures for chemical analysis, they crudely related basic qualitative descriptions of deposits to the fragmentary quantitative information.

The importance of clay minerals associated with hydrothermal alteration was recognized in the 1940's with the development of X-ray diffraction procedures. Peterson, Gilbert and Quick (1946) used advanced qualitative information of this type to define alteration mineralogy in their study of the Castle Dome copper deposit in Arizona. They also attempted to suggest some relationships between the alteration mineralogy and chemical analysis of fresh and altered rock. Their conclusions as to the relationship between ore and alteration were, however, based on qualitative information gained through the

study of the clay minerals.

Schwartz (1947) combined the work of several other authors, placing an emphasis on alteration minerals which consistently occur at a variety of important deposits in the United States. He then went on to define four types of alteration (1) quartz-orthoclase, (2) quartz-sericite-pyrite, (3) sericite and argillic alteration with quartz subordinate, and (4) biotitic alteration. He summarized his conclusions as follows: "available chemical data indicate that calcium and sodium are generally removed from the rock to a significant degree, and potassium remains constant or increases. Silica is gained in a few deposits but commonly shows minor changes". This paper perhaps set the stage for classification schemes for porphyry copper deposits as used to the present day, and in addition more precisely defined possible mobile chemical components involved in alteration at porphyry deposits. It became very apparent at this time however, that ore mineralization at all porphyry copper deposits was not associated with the same alteration mineralogy. The generalizations used by Schwartz, helped to define some of the consistent alteration mineral assemblages which were to be found at a variety of deposits but did little to help explain the processes associated with alteration and ore mineralization.

Creasey (1959) next presented a classification scheme for alteration at porphyry copper deposits in which he attempted to use chemical parameters. He outlined three principal alteration facies termed the propylitic, argillic, and potassium silicate facies. He used the ACF diagram in order to define the propylitic alteration. The characteristic minerals are muscovite (sericite), epidote, chlorite, and a member of

the carbonate group. The AKF diagram was used to define the argillic and potassium silicate facies. "The characteristic minerals of the argillic facies are kaolinite (or other members of the group) and muscovite (sericite); and of the potassium silicate facies, muscovite (sericite), biotite, and K-feldspar. He found that "for the argillic and potassium silicate facies chemical analysis indicated a loss of alumina, iron, magnesium, calcium, and sodium and a gain in potassium, hydroxyl ion (water), and sulfur." (p. 352). Data were insufficient to show the chemical changes between the fresh and altered rocks in the propylitic facies. The drawback of this investigation was again the lack of critical mineralogical and/or chemical criteria linking ore mineralization to hydrothermal alteration. In addition Creasey further complicated the problem by using chemical criteria to define a "potassic" alteration and mineralogical criteria to define the argillic and propylitic alterations.

Burnham (1962) grouped hydrothermally altered rocks into two principal facies, namely: the argillic and phyllic (mica) facies. Within these major facies, he outlined propylitic, montmorillonitic and kaolinitic alteration as being predominant in the argillic facies and muscovitic and biotitic alteration in the phyllic facies. More important than his definition of facies types was the emphasis he placed on the chemical components which tend to characterize particular porphyry copper deposits. He collected data as part of quantitative study of four hydrothermally altered porphyry copper ore deposits, Bingham, Utah; Santa Rita, New Mexico; Ithica Peak, Arizona and Crescent Peak, Nevada. The chemical mineralogical data from these deposits coupled with available

data from other deposits led Burnham to establish the following relationships: "The rock of the outermost propylite subzone generally are enriched in CaO , HgO , Na_2O , H_2O , and CO_2 . The rock of the intermediate montmorillonite subzone are only slightly changed in bulk composition, but those of the inner kaolinite subzone are impoverished in the very constituents that have been added to the propylite subzone. The rocks of the innermost phyllic zone are also impoverished in CaO , HgO and Na_2O but are enriched in K_2O , however, their outer parts (muscovite subzone) are more impoverished in CaO , HgO and Na_2O than their inner parts (biotite subzone)." (p. 768). The importance of this study can easily be seen as it employs quantitative measures in an attempt to understand alteration. Although Burnham could not define any particular mineral assemblage or chemical criteria which could be used to characterize an ore zone, the association of ore with particular chemical assemblages at some deposits is considered to be a significant step in the direction of understanding the relationship between alteration and ore mineralization.

Papers by Meyer and Hemley (1967) and Hemley and Jones (1964) have served to establish the critical reactions which must take place during hydrothermal alteration. These papers further establish the limited chemical and physical environment in which these reactions might take place and in a correlative manner establish possible relationships of alteration and sulfide assemblages. Rose (1970) further applied alteration mineralogy of several porphyry copper deposits to experimental mineralogical data established by Hemley (1959) and Shade (1968) to

explain mineralogical alteration zonation. The main emphasis which should be attached to the last several papers mentioned is the implication of some genetic relationship between hydrothermal alteration and ore deposition and the need for additional quantitative as well as qualitative data to determine the exact relationship.

Specific Statement of the Problem

A great number of variety of attempts have been made to describe and evaluate alteration halos and mineralization associated with porphyry copper deposits: Ransome (1905), Lindgren (1905), Reber (1916), Emmons (1927), Peterson, Gilbert and Quick (1946), Schwartz (1947, 1953), Creasey (1959), Burnham (1962), Meyer and Hemley (1967) and Rose (1970). Many of the previous mineralogical studies have been solely based on information obtained with the use of petrographic microscope. Although the microscope is an extremely useful instrument, the identification of very fine-grained alteration products by optical methods is often impossible. Furthermore, due to the lack of sufficiently reliable quantitative as well as qualitative data, previous investigators have often had difficulties in their attempts to explain the nature of ore forming and hydrothermal processes. The net result of all of these studies, has been a very detailed qualitative description of alteration halos and their mineralogical make-up. In a great majority of these studies, however, it was not concluded, at least not with a degree of certainty sufficient to satisfy most exploration geologists, what alteration mineral or mineral assemblage, if any, is characteristically associated with ore deposition. It is now generally accepted that data

obtained by Burnham (1962, 1967), Rose (1970) and Meyer and Hemley (1967) clearly indicate that some genetic relationship between hydrothermal activity and ore deposition exists. The purpose of this study is to understand the relationships between the mineralogy and/or bulk chemistry of hydrothermally altered aluminosilicate rocks and ore deposition in porphyry copper-molybdenum type deposits. All the data were collected from the Sierrita porphyry copper-molybdenite deposit of the Duval Corporation located south of Tucson, Arizona. The objectives of the study are four-fold:

- (1) The establishment of the existing mineralogical relationships between wall rock alteration and ore mineralization.
- (2) The characterization of hydrothermally altered rocks in terms of their bulk chemistry.
- (3) The delineation of critical mineralogical and chemical criteria typical of hydrothermal alteration and ore mineralization.
- (4) The selection of critical chemical and/or mineralogical criteria which may be used by exploration geologists to search for new ore deposits, or to outline the highly mineralized areas within a large hydrothermally altered terrain.

In summary, the main emphasis is placed on the establishment of critical chemical and/or mineralogical criteria most sensitive to ore deposition, rather than to use the data to provide a description of the Sierrita deposit.

The present study is not specifically designed to distinguish

alteration and ore mineralization features at every porphyry copper deposit, but is instead intended to show the usefulness and possible application of similar studies in other areas. Two limitations of this study must also be mentioned. One is the area covered in this investigation, which is rather restricted to the central part of the present pit. The second limiting factor is the sample locations which are controlled by previous drilling operations at Sierrita.

A few terms are here defined to help the reader throughout this thesis.

Hydrothermal alteration - is used to refer to chemical and mineralogical changes in the original rock through later introduction of aqueous solutions.

Porphyry Copper - the term porphyry copper as used in this thesis will essentially follow the definition presented by Titley and Hicks (1966) as a "large, low grade, epigenetic, hypogene copper deposit that can be mined by mass mining methods". Furthermore, these deposits typically have in addition to copper minerals as primary ore minerals, lesser amounts of molybdenum, lead, zinc, silver and gold ores associated with them.

Location, Topography and General Geology

The Sierrita porphyry copper-molybdenite deposit, shown in Figure 1, is located on the southeastern flank of the Sierrita Mountains in the Pima mining district, Pima County, Arizona. It is adjacent to the Esperanza porphyry copper deposit and is approximately 35 miles

south southwest of Tucson. The district is within the Sonoran Desert section of the Basin and Range Physiographic Province which is characterized by sharp ridges and narrow valleys, gullies and washes. To the north and east of the deposit is an extensive pediment covering most of the rest of the district. The deposit is at an altitude of approximately 4000 feet. The Santa Cruz River is the only major drainage for the area and flows intermittently with rainfall.



Figure 1. The Sierrita Porphyry Copper-Molybdenite deposit, Southwestern, Arizona, looking north.

Paleozoic rocks are limited to scattered exposures, again all north of Sierrita. According to Cooper, these are entirely sedimentary in origin. The basal unit is the Bolso quartzite of middle Cambrian age. The rest of the sedimentary complex consists of rocks listed in Table 1.

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General Geology of the District

The most complete description of the district is by Cooper (1959). Other reports giving some information on the district are by Ransome (1922), Weber (1929), Wilson (1941, p. 36-37, 1950, p. 39-51), Cummings and Romslo (1950), Lacy (1959), Mackenzie (1959), Irvin (1959), Journeay (1959), Richard and Courtright (1959) and Schmitt and others (1959).

Precambrian rocks in the district as mapped by Cooper, are to the north of Sierrita. These rocks are highly altered but the freshest appear to be of granitic composition. The granite generally contains xenoliths of fine-grained, dark grey schist and hornfels, which according to Cooper (1959, p. 67) is "presumed to be mafic metavolcanic rocks derived from the Pinal Schist of Precambrian age" and which is not exposed in the district.

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TABLE 1*

PALEOZOIC SEDIMENTARY ROCKS

Pennsylvanian and Permian, Haco group:

Concha limestone
Scherrer formation
Colina limestone
Earp formation
Morquilla limestone

Mississippian:

Escabrosa limestone

Devonian:

Martin limestone

Cambrian:

Abrigo formation
Bolsa quartzite

* After Cooper (1959)

Cooper found no Mesozoic rocks earlier than Cretaceous in the rest of the district. An intrusive of particular importance at Sierrita, The Harris Ranch quartz monzonite, however, has been dated at 190 m.y. (personal communication with Duval geologists). Because of the importance of this rock at the deposit, additional comment will be reserved for a later section.

The early Cretaceous rocks consist of a sedimentary-volcanic complex. Those of importance in the vicinity of Sierrita include interbedded andesite and sedimentary rocks generally overlain by rhyolite, quartzite, graywacke and conglomerate. Of particular importance at Sierrita is the Silver Bell andesite and the Oxframe rhyolite welded tuff

which includes flows and breccias.

Later Cretaceous rocks are intrusive quartz diorite, quartz monzonite porphyry and granodiorite. The granodiorite is the most extensive rock type in the district. It covers the entire western part of the district and has smaller outcrops in the eastern part. "The unaltered granodiorite is generally light gray, which in places has a pinkish, yellowish or brownish cast," Cooper (1959, p. 68). The granodiorite has three gradational varieties (a) granodiorite porphyry found in small bodies and as a local border phase of the larger bodies; (b) medium-grained equigranular granodiorite found in the medium sized bodies and in a zone 1/2 to 2 miles wide along the east side of the larger body; and (c) porphyritic granodiorite found in the large body west of the equigranular facies, Cooper (1959, p. 68). Granodiorite does not outcrop at Sierrita but is found less than 1/4 mile to the northwest. Within the Sierrita pit, however, a quartz diorite and quartz monzonite porphyry (Plate 1) are of extreme importance because of their mineralized nature. Also outcropping within the pit area but of little or no economic importance is the Ruby Star granodiorite. Each of these rock types will be discussed in much greater detail in a later section.

Other Tertiary intrusive rocks in the district are the Helmet fanglomerate and andesite dikes. Quarternary alluvium covers most of the eastern part of the district.

Structure

"An undulating low angle fault, called the San Xavier thrust by

Lacy (1959, p. 89), passes beneath the mineralized ground in the north-eastern part of the district. The thrust plate includes Precambrian granite, Paleozoic and Cretaceous rocks, intrusive granodiorite and quartz monzonite and the Helmet Fanglomerate", Cooper (1959, p. 93).

No major faults of the district are found in the immediate area of Sierrita or Esperanza; however, Cooper has mapped several small normal and reverse faults southeast of and one large fault south of Sierrita. The large fault extends approximately east-west while the smaller faults trend north-south.

Geology At Sierrita

The rock types found within the vicinity of Sierrita include Quartz latite porphyry, Quartz monzonite porphyry, the Ruby Star granodiorite, the Silver Bell andesite, Quartz diorite, the Harris Ranch quartz monzonite, Quartz diorite and Quartz monzonite porphyry. Consequently all samples selected for this study were collected from these three rock types, each of which will be discussed according to their economic importance.

Quartz Diorite

The major ore-bearing rock at Sierrita (according to Duval geologists) is the Quartz diorite, which occurs in the western portion of the pit (Plate 1). It is in contact with the Harris Ranch quartz monzonite to the south and west and the Quartz monzonite porphyry to the north and east. The rock is highly fractured with no apparent orientation to the fracturing. It has been dated at 58 ± 2 m.y..

(personal communication from Duval geologists).

Three main alteration minerals that are apparent in hand specimens of the Quartz diorite are quartz, epidote and minor amounts of alkali feldspar. In places there is secondary K-feldspar appearing as pink patches or as very small veinlets with quartz and minor epidote generally with sulfide minerals in the center of veinlets. Other smaller veinlets may contain only quartz and epidote with sulfide minerals.

Mineralization occurs in two ways: (a) as veinlets containing pyrite, chalcopyrite and molybdenite; and (b) as disseminated grains of these three minerals. The veinlets vary in thickness from about 1/32 to roughly 2 inches, generally being less than 1 inch. The presence of sulfide minerals filling fractures suggests that the deposition of pyrite, chalcopyrite and molybdenite continued after the fracturing of the Quartz diorite. Apparent in some veinlets, is the presence of thin films of molybdenite coating pyrite crystals indication that molybdenite deposition continued after the deposition of pyrite was completed.

Quartz Monzonite Porphyry

The Quartz monzonite porphyry is economically the second most important rock type in the pit area and has also been dated at 58 ± 2 m.y. Quartz monzonite porphyry (Plate 1) is found along the eastern and northern part of the Sierrita pit, in contact with the Quartz diorite to the west and the Harris Ranch quartz monzonite to the south. In the eastern portion of the pit the Quartz monzonite porphyry has been intruded by a breccia pipe in which are found various size inclusions

of Quartz monzonite porphyry. The major minerals consist of quartz, alkali feldspar and plagioclase with large flakes of biotite that are easily recognizable in hand specimen. Occasional phenocrysts of quartz and alkali feldspar away from the highly altered areas in the rock are subhedral to anhedral and are highly variable in size.

The most characteristic feature of the Quartz monzonite porphyry is the alteration which is dominated by thick bands of pink alkali feldspar adjacent to mineralized veinlets. These bands are typically 1 to 3 inches wide but may be wider. Alkali feldspar alteration is also often evident around high concentrations of disseminated mineralization. Quartz is the second most common alteration mineral occurring within the veinlets with the sulfide minerals. Epidote is not an uncommon alteration mineral which occurs between quartz and alkali feldspar alteration immediately adjacent to the veinlets. Due to the gray color of this rock and the distinctive alkali feldspar alteration, this rock is easily distinguished from the quartz diorite.

The three sulfide minerals which characterize the Quartz monzonite porphyry are again pyrite, chalcopyrite, and molybdenite occurring as disseminated grains and veinlets. The veinlets vary from approximately 1/32 to 3 inches in width; however, the majority appear to be less than 1 inch in width. Fracturing in this rock, often filled with ore minerals, is similar to that in the quartz diorite with no apparent orientation to the fracture pattern.

Harris Ranch Quartz Monzonite

The Harris Ranch quartz monzonite is located in the southern

portion of the Sierrita pit (Plate 1) in contact with the quartz diorite to the northwest and the quartz monzonite porphyry to the north-east and east. It is overlain to the south by the rhyolite welded tuff and the Silver Bell andesite. The rock has been dated at 190 million years according to Duval geologists. The Harris Ranch quartz monzonite is very similar to the quartz monzonite porphyry in its megascopic aspects. The major mineralogy includes quartz, alkali feldspar, plagioclase and biotite. The major difference between the two rock types appears to be a greater amount of biotite in the Quartz monzonite porphyry. Fracturing of the rock has again no apparent orientation. Sulfide mineralization is similar to that in the Quartz monzonite porphyry occurring as disseminated grains and as veinlets. Pyrite, chalcopyrite and molybdenite are the three predominant sulfide minerals in the Harris Ranch quartz monzonite. The veinlets are often bordered by thick selvages of alkali feldspar which grades into relatively unaltered rock. The veinlets themselves contain, in addition to the sulfide minerals, quartz and not uncommonly epidote. Large inclusions of an older and unidentified rock type occur in the Harris Ranch quartz monzonite in the southern part of the pit.

An additional rock type which deserves comment is the breccia pipe, which occurs as an elliptical body in plan intruding the Quartz monzonite porphyry. Fragments of Quartz monzonite porphyry occur as inclusions in this rock ranging in size from a few inches to three to four feet in diameter. The matrix is a fine-grained to aphanitic material comprising approximately 75 percent of the total breccia pipe. The fragments are angular or rounded and appear to show no preferred

orientation. Although the breccia pipe is not considered as economically important at Sierrita, mineralization again occurs both as veinlets and as disseminated grains both within the rock matrix and within the Quartz monzonite inclusions.

METHOD OF INVESTIGATION

A total of 49 samples were collected from drill core locations at approximately equal intervals across the Sierrita pit as indicated on Plate 1. Sample numbers for this study are indicated by the upper number at each location on Plate 1 while drill hole numbers as recorded by the Duval Corporation are indicated by the lower number in parenthesis. The collection of these samples was limited to the location of drill holes and does not represent a statistically defined grid pattern.

Although working with a small number of samples imposes certain limitations on the data and the derived conclusions, it has the following advantage: exploration companies would like to be able to derive the greatest amount of information concerning a prospective deposit by doing as little costly drilling as is necessary. Furthermore, data derived from this study will be shown to consistently indicate that dynamic patterns of hydrothermal alteration can be investigated at the sample scale used in this investigation.

In addition to samples collected from drill holes, three samples were collected over a ten foot area from each of the three rock types studied. These samples are intended to show that the variation in chemistry within any one rock type is smaller than that between rock types. Additional information concerning the specific collection of samples is included in Appendix 1.

Treatment of the Samples

Thin sections were first made from each of the samples. The major

consideration during this procedure was to avoid sectioning any area containing mineralized veinlets which could be seen in hand specimen. It was felt that this was necessary for accurate point counting in the determination of the major mineralogy of the rocks. The thin sections were then stained following the method of Laniz, Stevens, and Norman (1964) to facilitate accurate determination of K-feldspar and plagioclase. Modal data are listed in Appendix 2.

The remainder of the samples were then ground to -200 mesh. Veinlets measuring greater than 1/4 inch were eliminated before this procedure so that accurate whole rock analysis could be performed without introducing errors resulting from large amounts of secondary mineralization. After the samples were completely ground they were thoroughly homogenized and fractions were split out for X-ray diffraction analysis, X-ray fluorescence analysis and atomic absorption analysis. Heavy liquid separation was performed on those samples intended for X-ray diffraction determination. Pellets were made for X-ray fluorescence analysis, details of which are included in Appendix 2. The technique of Medlin, Suhr and Bodkin (1969) was used for the preparation of samples used for chemical analyses by atomic absorption. The details of this procedure and the results are included in Appendix 2.

In addition to these mineralogical and chemical treatments of the samples, three rock chips from each sample were used to determine the density. The average of three measurements from each sample (9 total measurements for each sample) were averaged. This number was then used as the average density of each rock sample. This treatment of the samples was necessary for later manipulation of chemical data. The

procedure for density determination and tabulated results can be found in Appendix 2.

All of the data derived from the above procedures were further refined using three computer programs. The specific programs used can be found in Appendix 4. They consist of (1) a program for the normalization of chemical components to 100 percent, which also includes the determination of the molality of the oxides and molality of the elements; (2) a program for the calculation of normative mineralogy and (3) another normative program for the calculation of mole percents of albite, orthoclase and anorthite.

RESULTS

Mineralogical Data

Mineralogical composition of the rocks at Sierrita was determined in two ways. First was the determination of modal mineralogy using thin sections of each sample. The second type of analysis was by X-ray diffraction. Because of the extremely good agreement between X-ray mineralogy and modal mineralogy, this section will concentrate on the petrographic analyses of the rocks.

Quartz Monzonite Porphyry

Table 2 gives the average modal percentages of all minerals present in the Quartz monzonite porphyry. The major minerals consist of quartz, K-feldspar, plagioclase and biotite phenocrysts which are set in a fine to medium grained groundmass of quartz and K-feldspar. Accessory minerals present include K-mica, chlorite, epidote, a very few clay minerals and the sulfides pyrite, chalcopyrite and molybdenite. Figure 2 shows a typical quartz monzonite porphyry as seen in thin section.

TABLE 2

AVERAGE MODAL MINERALOGY OF THE QUARTZ MONZONITE PORPHYRY

Quartz	24.5
K-feldspar	31.1
Plagioclase	34.8
Biotite	4.3
Chlorite	1.2
K-mica	1.8
Pyrite	0.9
Chalcopyrite	1.0
Molybdenite	0.4
	100.0

Quartz phenocrysts are distributed throughout the rock. They may be euhedral but are typically subhedral to anhedral ranging in size from about $1/2$ mm to 1 mm across. Quartz is also present as an

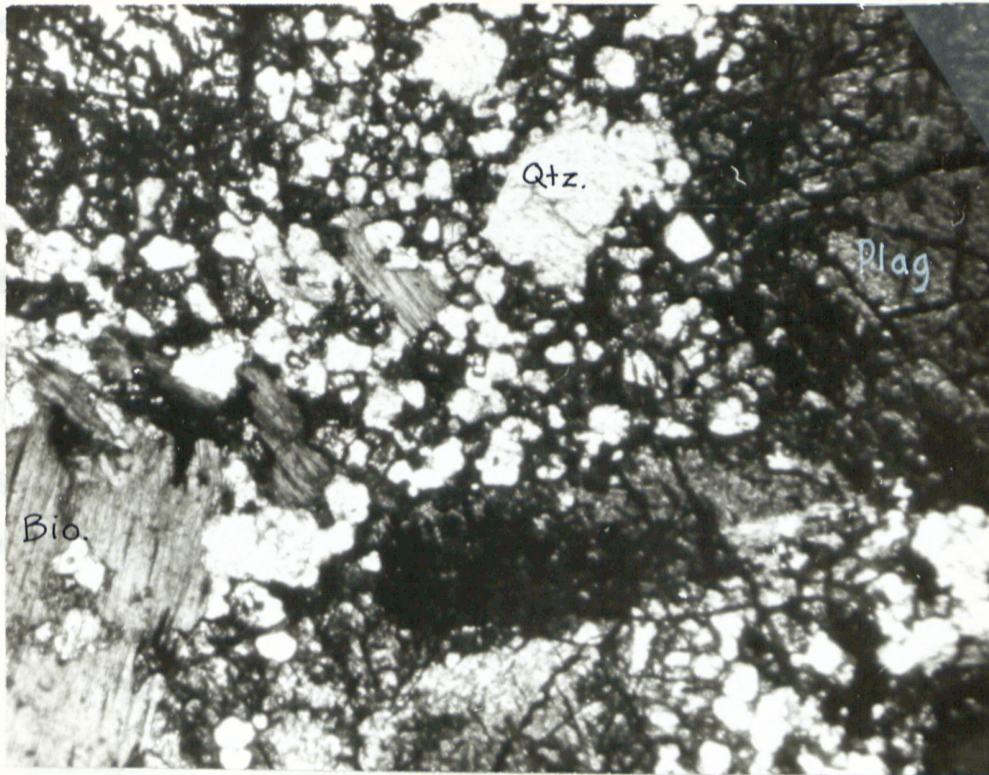


Figure 2. Typical Quartz monzonite porphyry (300X).
 Qtz: quartz; Plag: plagioclase; Bio: biotite;
 K-feld: K-feldspar. Uncrossed nicols.

3.	15
4.	22
5.	21
6.	14
7.	15
8.	19
9.	17
10.	23

* After Wright (1913) each number representing ten measurements from different plagioclase grains in ten separate thin sections of the Quartz monzonite porphyry.

Alteration effects are most typically noted along grain boundaries and twinning planes. Some plagioclase grains, on the other hand, are

entirely altered to K-feldspar or retain only a small plagioclase center surrounded by K-feldspar. Other grains may be cut by K-feldspar alteration as seen in Figure 4.

Biotite occurs in large flakes generally varying in size from

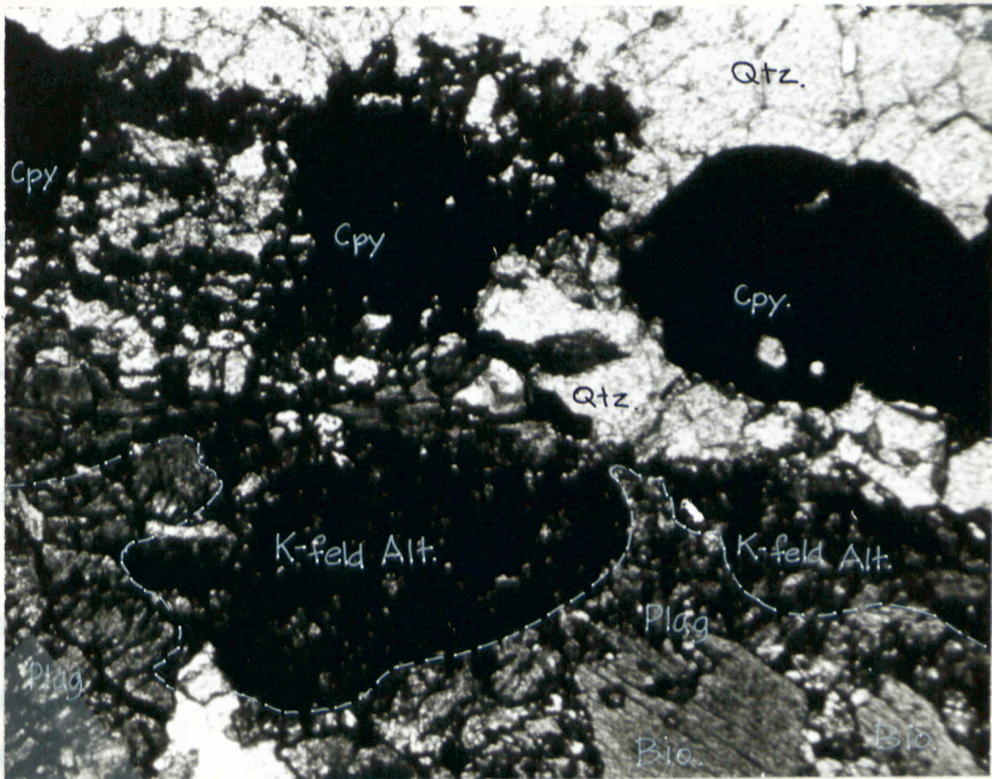


Figure 3. Mineralized veinlet in the Quartz monzonite porphyry (300 X). Note the alteration of plagioclase to K-feldspar. Qtz: quartz; plag: plagioclase; Bio: biotite; K-feld Alt: K-feldspar alteration; Cpy: Chalcopyrite. Uncrossed nicols.

Investigators and is probably due to the confusion in the literature when describing alteration types. Accessory minerals found in the Quartz monzonite porphyry include K-feldspar, chlorite, epidote and a few clay minerals. K-feldspar and chlorite, although not abundant, do occur around highly altered areas. An example of K-feldspar in a mineralized veinlet in the Quartz monzonite porphyry can be seen in Figure 5.

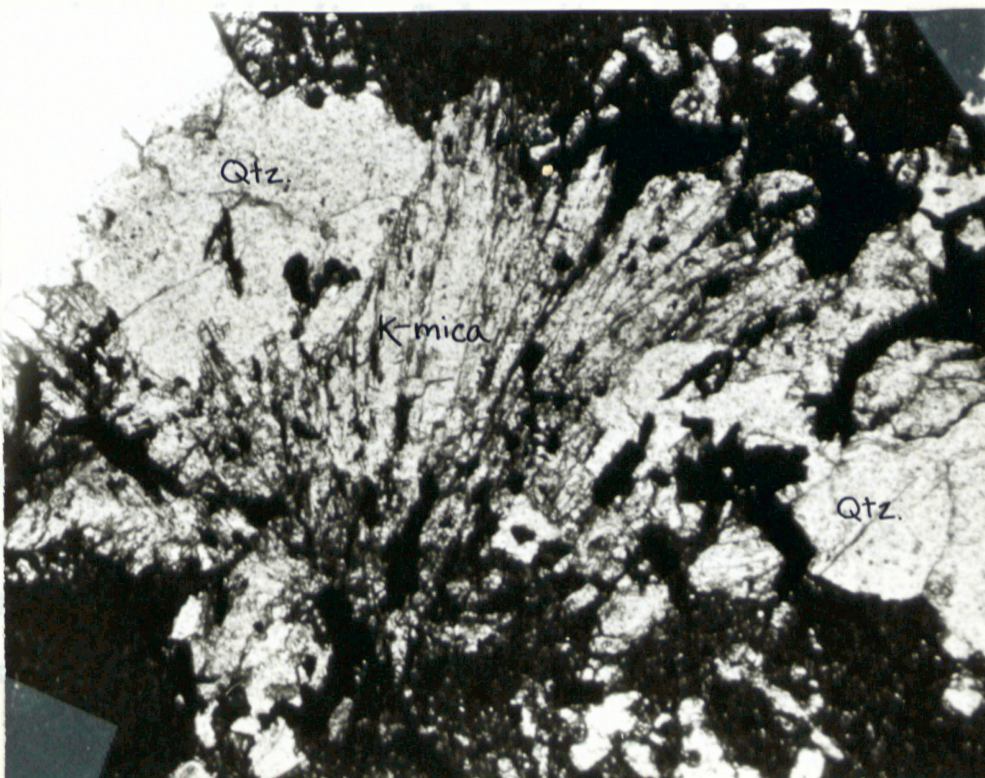
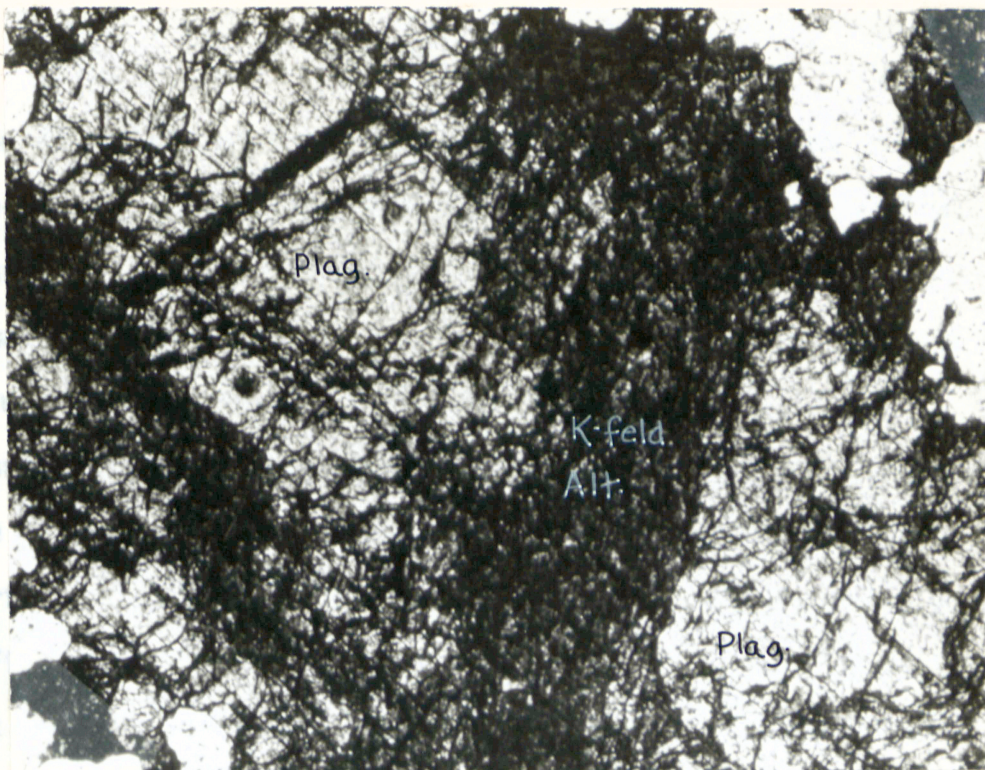
entirely altered to K-feldspar or retain only a small plagioclase center surrounded by K-feldspar. Other grains may be cut by K-feldspar alteration as seen in Figure 4.

Biotite occurs in large flakes generally varying in size from 1 mm to 3 mm and is distributed throughout the rock. Biotite is light brown to tan in plain light and can often be seen to contain inclusions of zircon, apatite and sphene. Alteration of biotite to chlorite can often be seen along grain boundaries and cleavage surfaces.

K-feldspar occurs as anhedral to subhedral phenocrysts ranging in size from .5 mm to 2 mm; however, it occurs dominantly as anhedral material with quartz filling spaces between larger grains. Although K-feldspar phenocrysts are not as common as are quartz, plagioclase, and biotite, a few can generally be observed in most thin sections. Optical determinations of K-feldspar and plagioclase grains is often very difficult in some cases due to alteration effects of plagioclase to K-feldspar. Where there was difficulty in distinguishing these two minerals, grains containing more than 50 percent observable K-feldspar were counted as K-feldspar and those with more than 50 percent plagioclase as plagioclase. This difficulty has no doubt hampered other investigators and is probably one of the factors affecting confusion in the literature when describing alteration zones. Accessory minerals found in the Quartz monzonite porphyry include K-mica, chlorite, epidote and a few clay minerals. K-mica and chlorite, although not abundant, do occur around highly altered areas. An example of K-mica in a mineralized veinlet in the Quartz monzonite porphyry can be seen in Figure 5.

Figure 4. K-feldspar alteration in plagioclase (300X).
Plag: plagioclase; K-feld. Alt: K-feldspar
alteration. Uncrossed nicols.

Figure 5. K-mica as alteration product along mineralized
veinlet (300 X). Qtz: quartz; K-mica.



The groundmass of the Quartz monzonite porphyry varies from a very fine-grained material composed solely of equigranular quartz and K-feldspar to a coarser material generally not as equigranular. This coarser material still contains quartz and K-feldspar as the dominant minerals with some larger fragments of plagioclase.

Three sulfide minerals dominate ore mineralization in the Quartz monzonite porphyry and the Sierrita pit in general; these are pyrite, chalcopyrite and molybdenite (an example of a mineralized veinlet is seen in Figure 3). With respect to mineralization, it must be kept in mind that in the selection of thin sections mineralized parts of the samples were avoided so that observations of the rock with as few effects of alteration could be made. This necessarily places a negative bias on the percentage of sulfide minerals counted in thin sections. In general, however, chalcopyrite is the dominant sulfide mineral in the quartz monzonite porphyry followed by pyrite with very little disseminated molybdenite. Chalcopyrite generally occurs as small veinlets with selvages of quartz, K-feldspar, biotite, pyrite and occasionally epidote. Chalcopyrite also occurs as small disseminated grains throughout some of the thin sections studied. Pyrite occurs in small veinlets with the same alteration mineral assemblages as chalcopyrite. Smaller disseminated euhedral grains of pyrite are often found in the rock. Molybdenite, when present, occurs as very small disseminated grains and typically is associated with pyrite and chalcopyrite although neither of the latter need be present. Samples 4428, 4437, and 4445 contain the highest percentages of molybdenite in the Quartz monzonite porphyry in thin section studied.

Quartz Diorite

Quartz diorite is a fine-grained rock composed almost entirely of quartz, plagioclase and biotite with minor amounts of chlorite, epidote, K-feldspar, pyrite, chalcopyrite, molybdenite and clay minerals. A typical Quartz diorite is pictured in Figure 6. Table 4 gives the average modal percentage of minerals present in the Quartz diorite.

TABLE 4
AVERAGE MODAL MINERALOGY OF THE QUARTZ DIORITE

Quartz	7.6
K-feldspar	0.5
Plagioclase	61.3
Biotite	12.5
K-mica	0.5
Chlorite	15.9
Epidote	0.4
Pyrite	1.0
Chalcopyrite	0.1
Molybdenite	1.2
	100.0

Plagioclase is the dominant mineral in the rock. It occurs as a mesh of essentially equigranular grains with spaces between grains filled with quartz and biotite. The majority of the plagioclase grains are not longer than 1/2 mm. Much of the plagioclase shows albite and carlsbad twinning and some of the larger grains are zoned. Measurements of albite and carlsbad twins (Table 5) indicate a compositional range approximating andesine. In many of the sections plagioclase can be observed to be altered to sericite + quartz, however, there are few grains in which alteration has been significant in producing clay minerals as

an alteration product.

TABLE 5

DETERMINATION OF PLAGIOCLASE COMPOSITION
IN QUARTZ DIORITE FROM CARLSBAD-ALBITE TWINS*

Mole % Anorthite

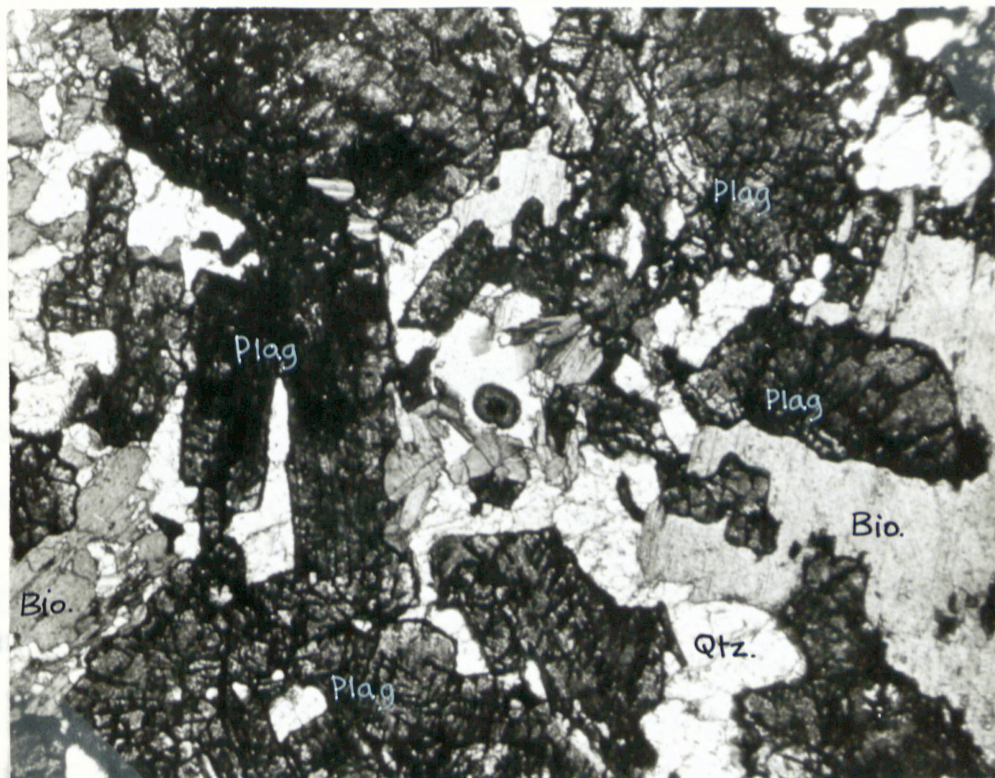


Figure 6. Typical quartz diorite (300X). Qtz: quartz;
Plag: plagioclase; Bio: biotite. Uncrossed
nicols.

Unaltered biotite is generally dark brown to brown in color. Alteration generally produces a mottled appearance so that an intermediately altered biotite flake will have a mottled appearance ranging from dark brown to light brown to green. K-feldspar is also present in some sections closely associated with biotite.

Quartz is the only other major mineral recognized in all thin sections of the Quartz diorite. It is typically fine-grained anhedral material filling spaces between plagioclase grains. It may, however,

an alteration product.

TABLE 5
DETERMINATION OF PLAGIOCLASE COMPOSITION
IN QUARTZ DIORITE FROM CARLSBAD-ALBITE TWINS*

	Mole % Anorthite
1.	44
2.	43
3.	44
4.	39
5.	41
6.	42
7.	44
8.	42
9.	42
10.	41

*After Wright (1913), each number representing ten measurements from different plagioclase grains in ten separate thin sections of the Quartz diorite.

Biotite is generally the second most abundant mineral in the Quartz diorite. It occurs in anhedral flakes ranging in size from .5 mm to 1 mm. It is generally altered to an intermediate green mica or to chlorite although fresh unaltered biotite may be observed in every thin section. Unaltered biotite is generally dark brown to brown in color. Alteration generally progresses along cleavage surfaces so that an intermediately altered biotite flake will have a mottled appearance ranging from dark brown to light brown to green. K-mica is also present in some sections closely associated with biotite.

Quartz is the only other major mineral recognized in all thin sections of the Quartz diorite. It is typically fine-grained anhedral material filling spaces between plagioclase grains. It may, however,

occur as relatively large anhedral to subhedral phenocrysts as observed in a few sections. Quartz is also found as vein material and as an alteration product of plagioclase along with sericite.

Additional minerals found in the quartz diorite include chlorite, K-feldspar and K-mica with some epidote. These all appear to occur as alteration minerals.

Molybdenite is the dominant sulfide mineral present in the quartz diorite followed by pyrite and chalcopyrite. One curious feature about the occurrence of molybdenite is its typical association with biotite. Pyrite may also occur with biotite and molybdenite but this is not common. Pyrite and chalcopyrite along with molybdenite make up the major minerals in veinlets cutting the rock and also occur as disseminated grains.

Harris Ranch Quartz Monzonite

The Harris Ranch quartz monzonite is megascopically and microscopically very similar to the Quartz monzonite porphyry. The average modal mineralogy of the Harris Ranch Quartz monzonite is presented in Table 6. A typical Harris Ranch Quartz monzonite is seen in Figure 7. Quartz occurs as relatively small subhedral to anhedral phenocrysts and as anhedral material between larger grains. Quartz phenocrysts are smaller than those in the quartz monzonite porphyry and are generally not seen as frequently.

Nearly all plagioclase in the Harris Ranch quartz monzonite shows the effects of alteration. Most grains have been altered to K-feldspar around the rims and along twin surfaces. Figure 8 shows

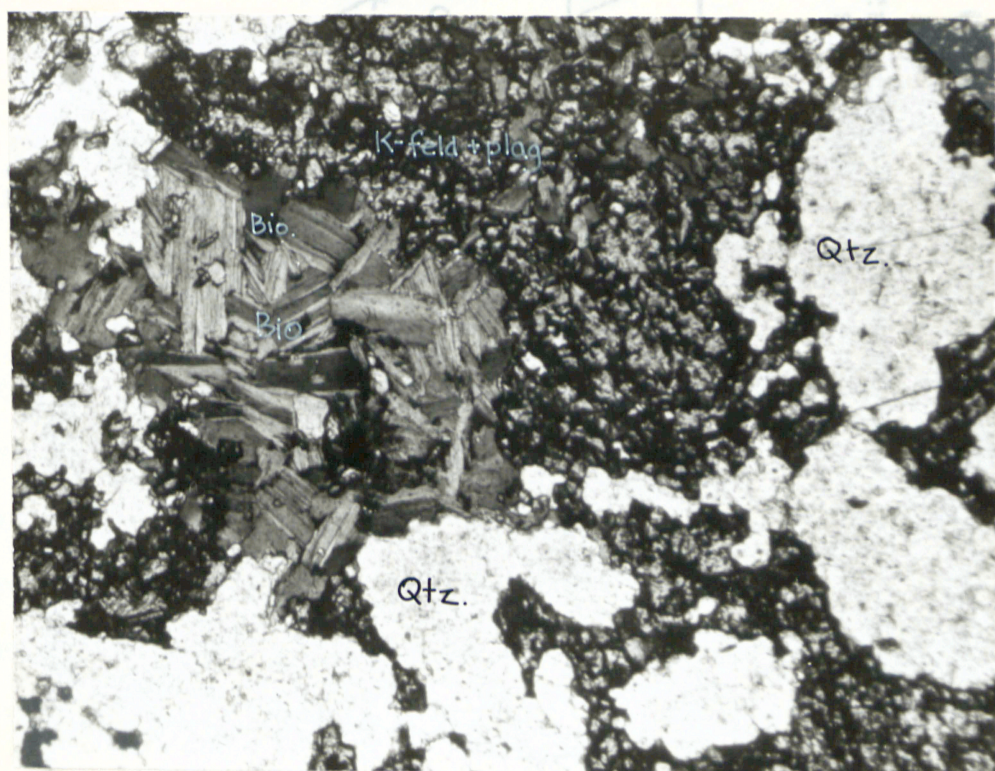


Figure 7. Typical Harris Ranch quartz monzonite (300X).
 Qtz: quartz; K-feld + Plag: plagioclase
 altered to K-feldspar; Bio: biotite.
 Uncrossed nicols.

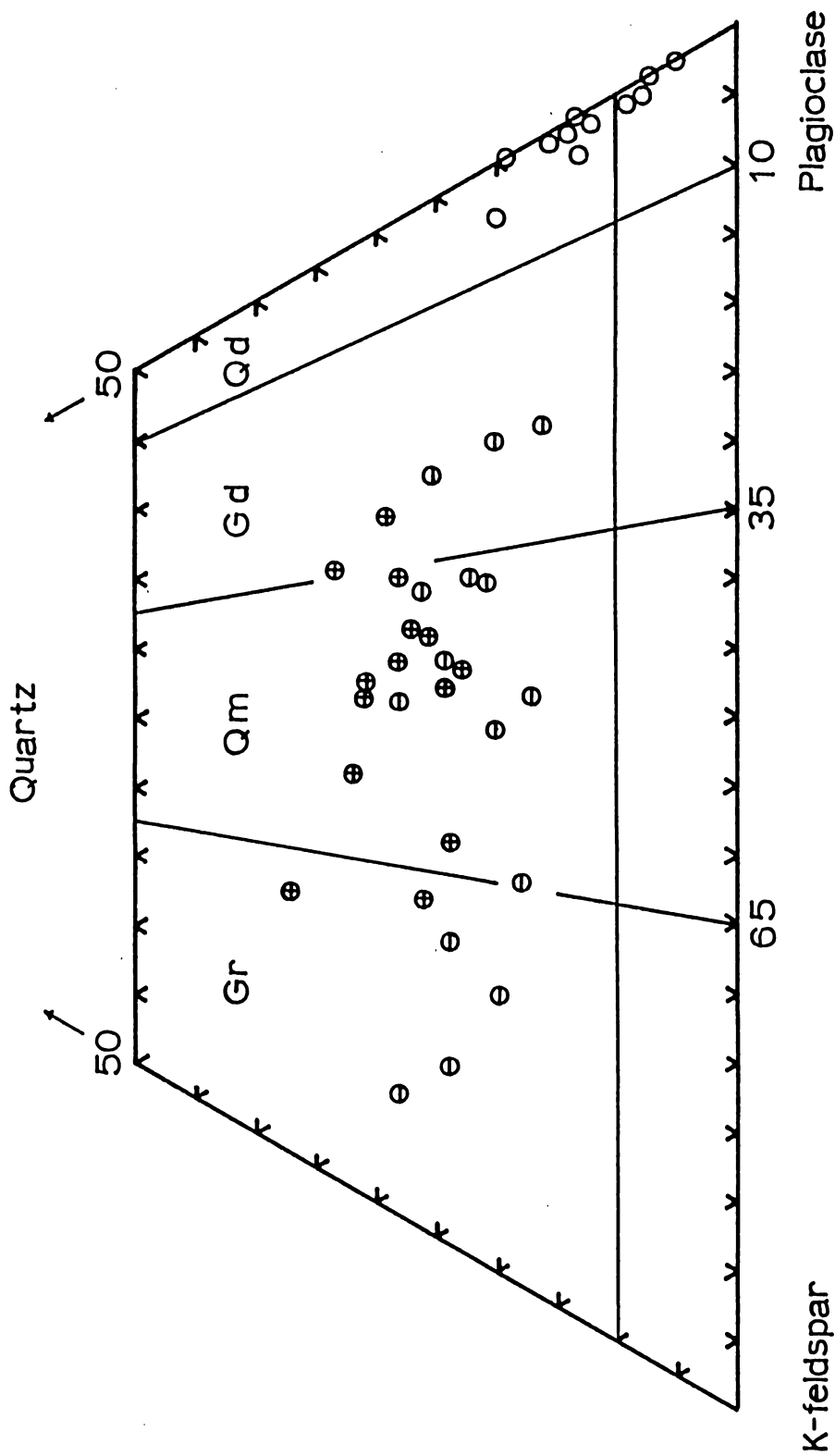


Figure 8. Modal quartz - K-feldspar - plagioclase plot of the Sierrita Rocks (After Bateman, et al., 1963). Gr: Granite; Qm: quartz monzonite; Gd: granodiorite; D: diorite.

Symbols: O = Quartz diorite; ⊗ = Harris Ranch quartz monzonite; ⊙ = Quartz monzonite porphyry.

TABLE 6

AVERAGE MODAL MINERALOGY OF THE
HARRIS RANCH QUARTZ MONZONITE

Quartz	20.2
K-feldspar	36.0
Plagioclase	35.4
Biotite	2.7
Chlorite	1.7
K-mica	1.8
Pyrite	1.9
Chalcopyrite	1.8
Molybdenite	0.5
	100.0

a K-feldspar vein cutting plagioclase. Some plagioclase shows remnant carlsbad-albite twins although no zoning was evident. All plagioclase grains were found to be either subhedral or anhedral. Most showed perceptible alteration to K-feldspar with some K-mica and clays in and around the centers of the grains. Many more plagioclase grains show K-feldspar alteration than those in the Quartz monzonite porphyry.

K-feldspar is the dominant mineral in the Harris Ranch quartz monzonite. The majority of K-feldspar, however, is in the fine-grained matrix material with quartz and only a few appear as phenocrysts. K-feldspar also occurs as the dominant alteration product of plagioclase. Most of the K-feldspar and quartz in the groundmass of the Harris Ranch quartz monzonite is significantly coarser than those in the groundmass of the Quartz monzonite porphyry. Secondly, the majority of these grains are not as equidimensional as in the Quartz monzonite porphyry.

Biotite in the Harris Ranch quartz monzonite is singularly the most easily distinguishable mineral when comparing this rock to the

Quartz monzonite porphyry. In the Harris Ranch quartz monzonite biotite occurs as clumps of relatively small flakes with very few inclusions. When fresh, it is generally dark brown, although much of it shows an intermediate green color where there is significant alteration. Some has been completely altered to chlorite.

The only recognizable sulfides present are chalcopyrite, pyrite, and molybdenite. Chalcopyrite and pyrite are the chief sulfides in small veinlets where they occur with quartz, K-feldspar, K-mica and biotite. They are also found as small disseminated grains throughout the rock. Although a few small molybdenite veinlets were seen in some thin sections, it is not a common mineral and when present generally occurs as disseminated grains. Sections containing the greatest amounts of molybdenite were 4401, 4410, 4416, 4424, 4425, and 4429.

Petrographic data indicate that the igneous rocks at Sierrita are mineralogically simple and more than 90 percent of the modes can be represented by quartz, plagioclase, K-feldspar, biotite and K-mica. Consequently, major variations in modal mineralogy of these rocks can be described using three or four component diagrams. Such a modal plot in terms of plagioclase, orthoclase and quartz (Dateman, et al., 1963) is shown in Figure 8. This plot reveals several distinctive features of the Sierrita rocks. First, all of the Quartz diorite samples plot within the diorite-quartz diorite fields of the diagram. The only significant variation in these samples is along the quartz-plagioclase side. Secondly, the Quartz monzonite porphyry and Harris Ranch quartz monzonite samples show a wide scatter from the granodiorite to granite fields of the diagram although the majority of the samples appear to

be within the quartz monzonite field. It is also interesting to note that the Harris Ranch quartz monzonite samples show the greatest scatter with the ratio K-feldspar/K-feldspar + plagioclase varying from 25 to approximately 90 percent.

Figure 9 is a modal plot of plagioclase versus potassium bearing minerals, namely, K-feldspar, K-mica and biotite in the Sierrita rocks. The most outstanding feature of this diagram is the inverse relationship between these components of the rocks. As the amount of potassium bearing minerals increased, there is a corresponding decrease in the amount of plagioclase. Also evident is the fact that all of the Quartz diorite samples plot between 50 and 70 percent plagioclase and the quartz monzonitic rocks plot between 10 and approximately 50 percent plagioclase.

In an attempt to show the spatial distribution of potassium-bearing phases modal K-feldspar was plotted on a geologic map of the pit (Plate 2). One very high area of concentration is located in the south central area of the pit, around sample site 4426, in the Harris Ranch quartz monzonite. In addition to this, two other areas of moderately high concentration can be seen. The first is a broad high extending south from the very high concentration and encompassing sample numbers 4409, 4424, 4425, and 4432. A second area of approximately equally high concentration is seen in the northern portion of the pit centered around sample number 4435 in the quartz monzonite porphyry.

The final interpretation and explanation of the features displayed by Figures 8 and 9 and by Plate 2 will be discussed in a later section after the chemical characteristics of the rocks have been presented.

Chemical Data

A total of 56 samples were chemically analyzed in terms of major elements. These analyses were carried out using both X-ray fluorescence and Atomic Absorption techniques. The specific procedures, sample preparation and analytical results are included in Appendix 2. In addition to SiO_2 , Al_2O_3 , total Fe (as Fe_2O_3), CaO , Na_2O and K_2O , copper and molybdenum content of the rocks were also determined. The raw chemical data were first normalized to 100 percent on an anhydrous basis using a computer program (Appendix 4). Next, using these data and the density of the samples, gains and losses in the various chemical constituents of the rocks were calculated for 1000 cm^3 of rock. The method is described in detail in Appendix 5. These data are then recast in the form of several isoplith maps. The chemical data were also used to calculate normative mineralogy of the rocks. In order to find out the variation in the bulk chemistry of the rocks around each sample location, three samples were collected from each rock type within an area of 10 feet in diameter. The chemical analyses of these samples listed in Appendix 2 show that the variation within samples is smaller than the variation between samples.

Figure 10 is a weight percent plot of normative quartz, orthoclase, and plagioclase generated from chemical data. All of the quartz diorite samples plot near the plagioclase corner of the figure, containing between 20 and 30 percent normative K-feldspar and between approximately 10 and 25 percent normative quartz. The quartz monzonitic rocks cluster in an area between approximately 35 and 75 percent normative K-feldspar

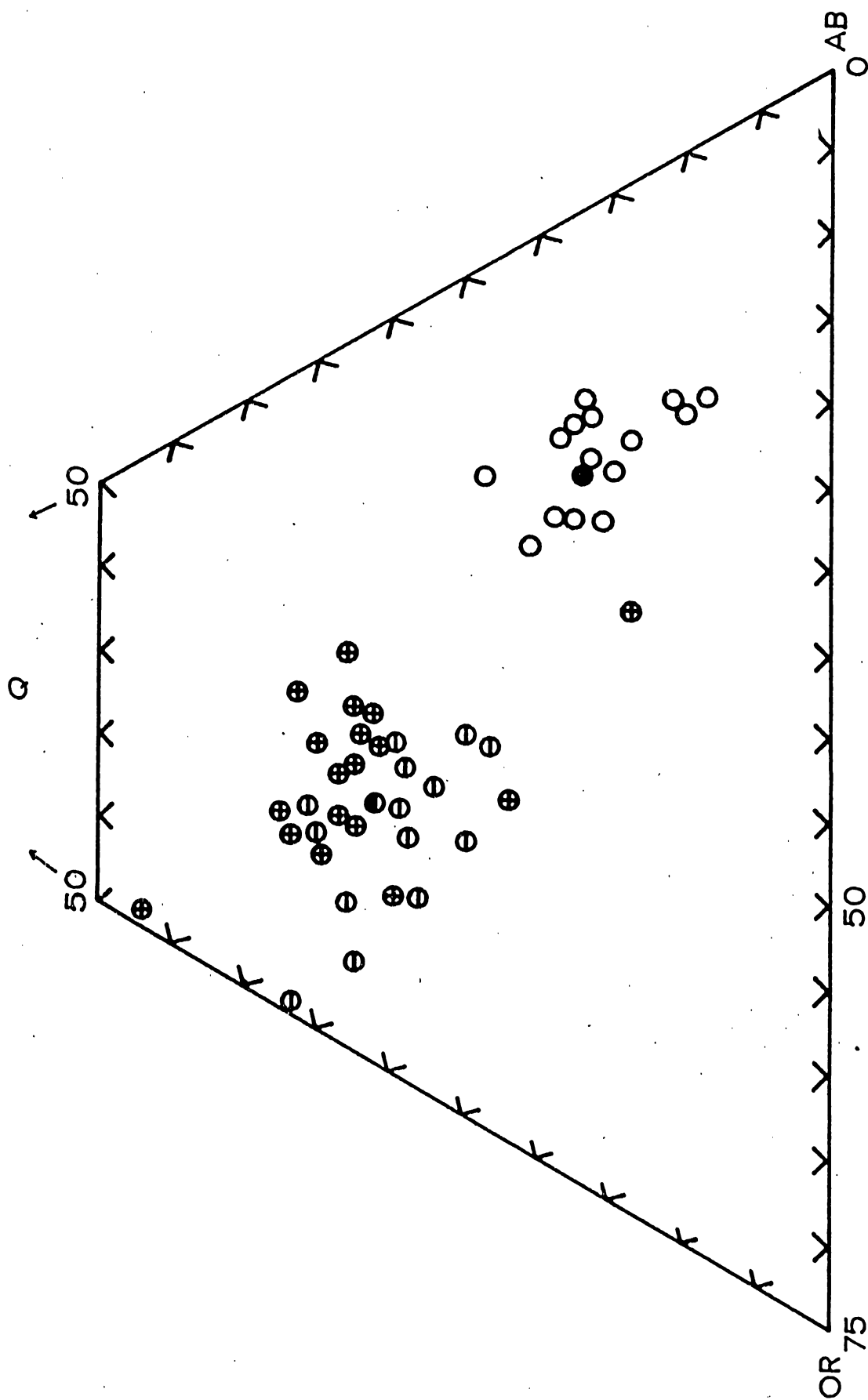


Figure 10. Normative Quartz-Orthoclase-Albite plot of the Sierrita Rocks.

Symbols: O = Quartz diorite; ⊙ = Harris Ranch quartz monzonite;
⊗ = Quartz monzonite porphyry.

and approximately 25 and 40 percent normative quartz. It is also apparent that the Harris Ranch quartz monzonite samples typically contain less quartz than do the Quartz monzonite samples. Another interesting feature of the Sierrita rocks as shown in Figure 10, is the limited variation in their quartz/orthoclase ratio as opposed to rather widely varying quartz/albite as well as orthoclase/albite ratios.

Figure 11 shows the chemical variation in the rocks in terms of weight percent normative feldspar components, i.e., orthoclase, albite and anorthite. The most apparent feature of this diagram is that the Quartz diorite and quartz monzonite type rocks cluster in two separate areas. The Quartz diorites, except for two samples, contain between approximately 40 and 50 percent anorthite and between approximately 15 and 25 percent orthoclase. The majority of the quartz monzonite type rocks contain between approximately 25 and 40 percent anorthite and approximately 30 to 60 percent orthoclase.

Two apparent trends are also noted in this diagram. First, the Quartz diorite samples appear to be plotting in a direction away from extending the An corner of the diagram toward the Ab/Or side. The quartz monzonitic rocks show an opposite trend with the long axes of this trend being parallel to the Or/Ab side of the diagram.

Figures 12 and 13 show the distribution of the Sierrita rocks in terms of the most mobile chemical components. Figure 12 presents two of the chemical components used in weight percent normative and mole percent normative calculations of Figures 10 and 11. In this figure $^{23}\text{Na}_2\text{O}$ is the molality of sodium oxide and $^{39}\text{K}_2\text{O}$ is the molality of potassium oxide. The first feature apparent in this diagram is the

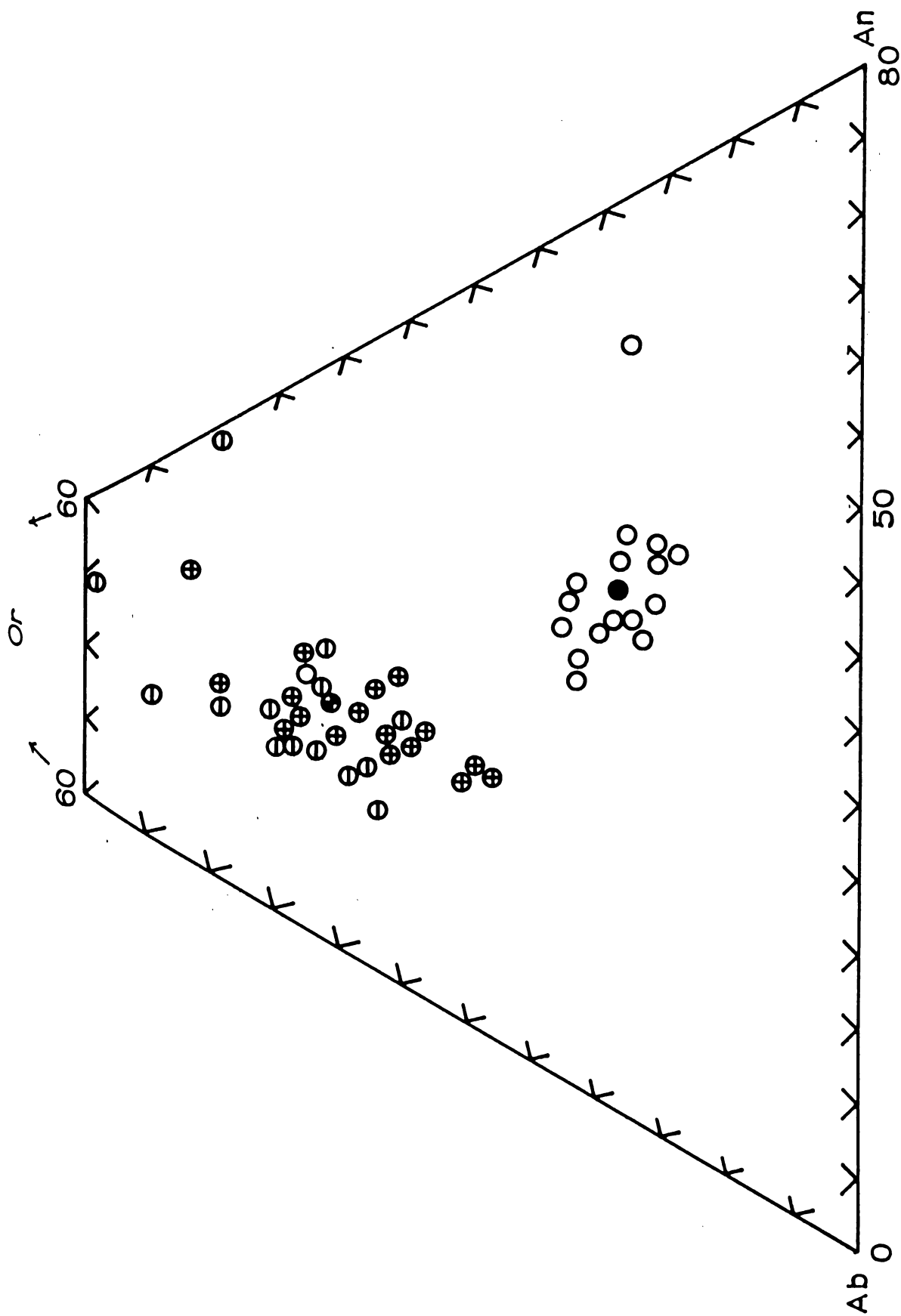


Figure 11. Normative Orthoclase - Albite - Anorthite plot of the Sierra rocks.

Symbols: O = Quartz diorite; ⊗ = Harris Ranch quartz monzonite;
 + = Quartz monzonite porphyry.

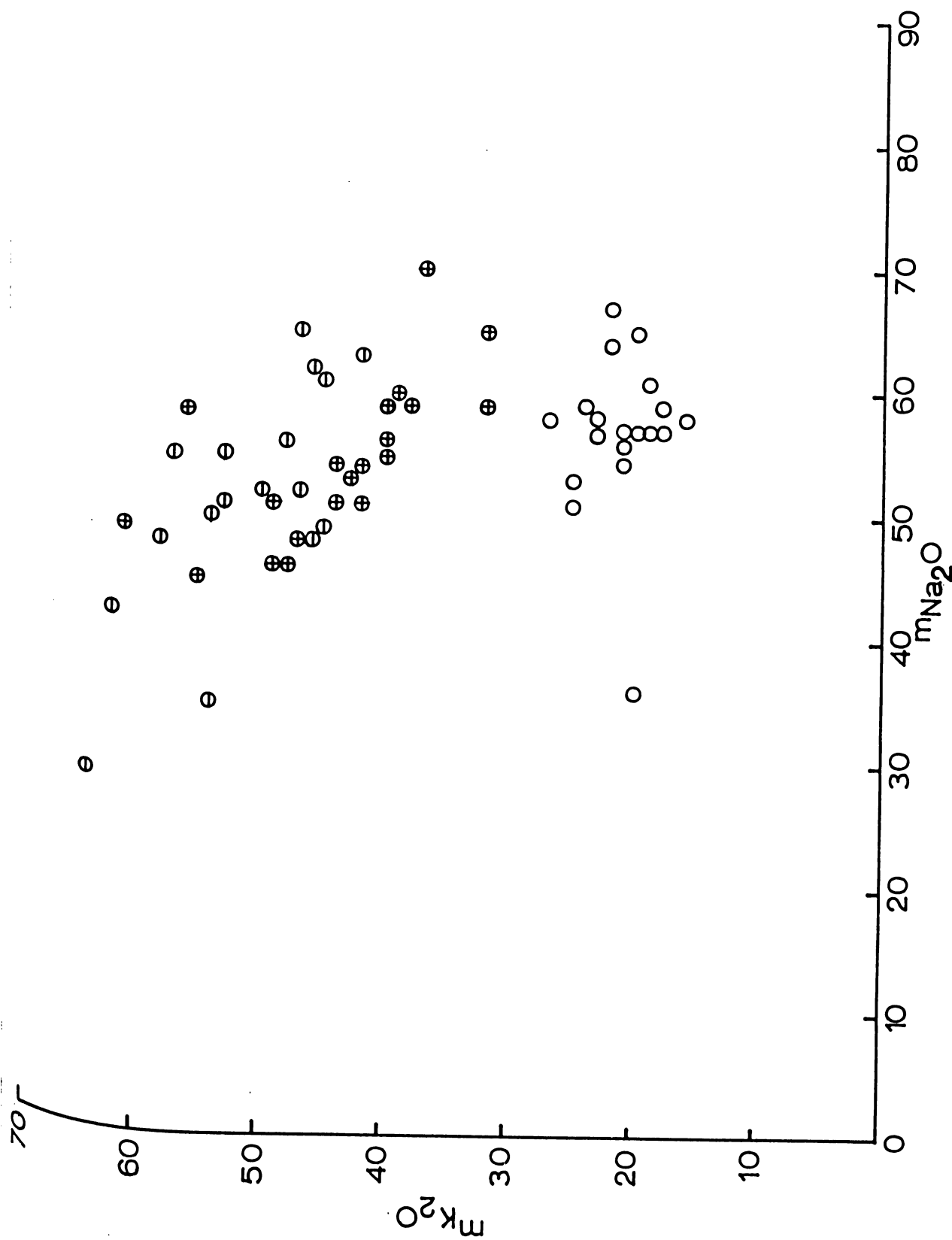


Figure 12. Plot of the Sierrita Rocks in terms of the molality of Na_2O versus K_2O .

Symbols: $\circ$ = Quartz diorite; $\oplus$ = Harris Ranch quartz monzonite; $\otimes$ = Quartz monzonite porphyry.

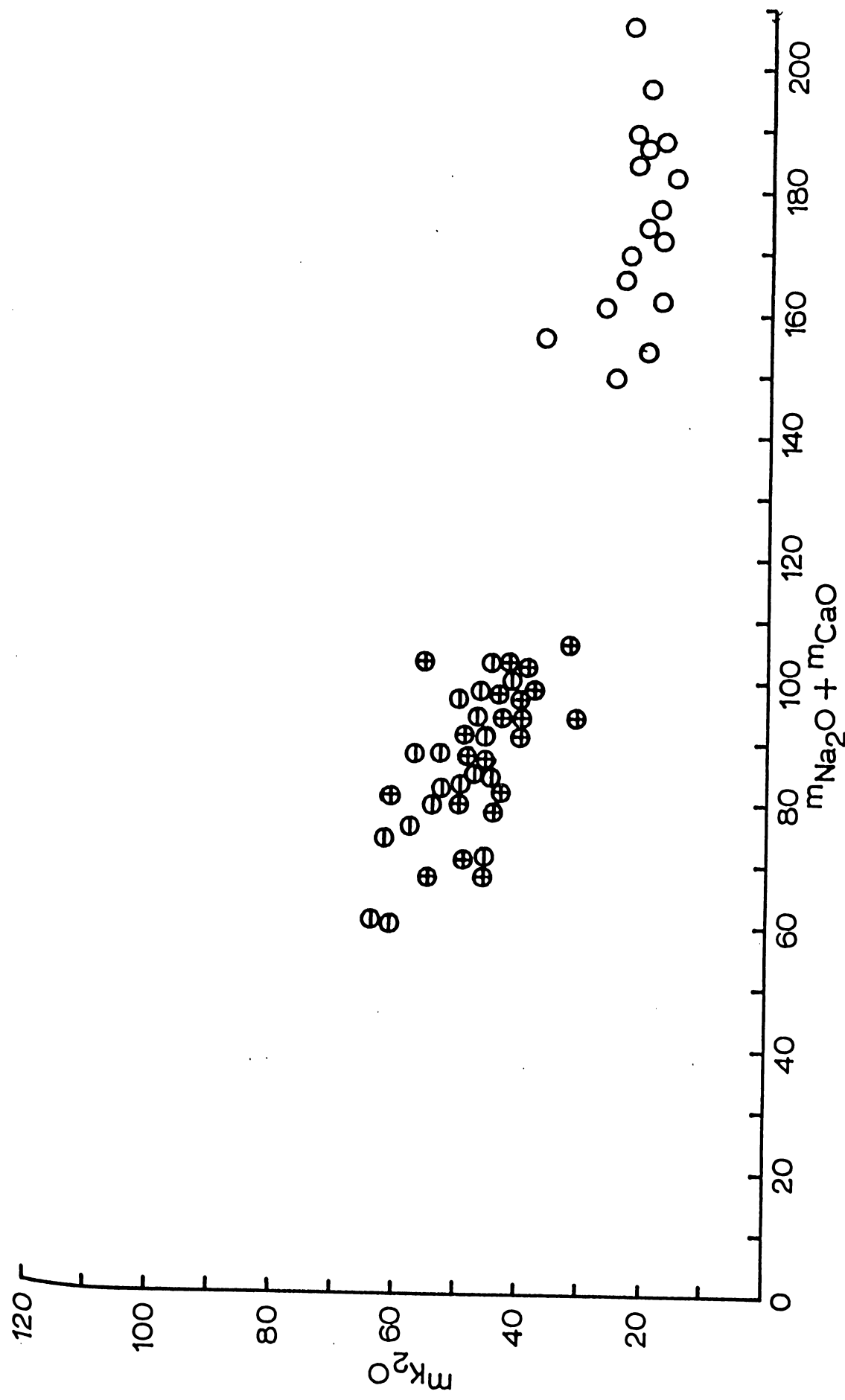


Figure 13. Plot of the Sierrita Rocks in terms of the molality of $\text{Na}_2\text{O} + \text{CaO}$ versus K_2O .

Symbols: O = Quartz diorite; $\oplus$ = Harris Ranch quartz monzonite; $\oplus$ = Quartz monzonite porphyry.

clustering of samples into two groups, mK_2O in the Quartz diorite samples ranges from approximately 15 to 25 and mNa_2O from approximately 50 to 70. The quartz monzonitic rocks cluster at higher mK_2O . In this group mK_2O varies between 30 to 65 and mNa_2O between 40 to 70. Quartz monzonitic samples have an apparent tendency to show an inverse relationship between mK_2O and mNa_2O . It is also apparent from Figure 12 that the majority of the Harris Ranch quartz monzonite samples have a higher $^mK_2O/^mNa_2O$ ratio than the Quartz monzonite porphyry samples.

Figure 13 is similar to Figure 12 except that mCaO , the molality of calcium oxide, is considered as an additional component on the horizontal axis of the figure. Again, the most apparent feature of this figure is the clustering of the Quartz diorite samples and the samples of quartz monzonitic rocks into two separate groups. The $^mNa_2O + ^mCaO$ in the Quartz diorite samples range from approximately 150 to 210, whereas mK_2O ranges from approximately 15 to 25. The $^mNa_2O + ^mCaO$ in the quartz monzonitic rocks varies between 60 to 105, and mK_2O between 30 to 65. A second significant feature of Figure 13 is the general inverse relationship between mK_2O and $^mNa_2O + ^mCaO$. A final feature of this figure is the better separation of the two groups of samples which is not clear in Figure 12.

Chemical Isopleth Maps of the Sierrita Pit

Chemical isopleth maps were constructed to facilitate a better understanding of the distribution of alteration across the Sierrita pit. Three types of chemical isopleth maps are presented in Plates 2 through

11. The first type, of which Plates 3, 5, and 9 are representative examples, indicate the distribution of normalized chemical data. This type of isopleth map was constructed to determine the high and low areas of various chemical concentrations. Specific data used to determine the isopleth patterns shown on these plates can be found in Appendix 2. Isopleths on these plates are extended across contacts between the Harris Ranch quartz monzonite and Quartz monzonite porphyry as these rock types compare closely in total chemical composition. On the other hand, isopleths were not extended across the Quartz diorite contacts with the other two rock types because of the significant differences in chemical composition.

Plates 4, 6, 7, 8 and 10 represent the second type of isopleth map, namely, those constructed after the normalized chemical data had been subjected to density calculations. These calculations were performed to determine absolute enrichment and depletion of various chemical components from the altered rocks. The data developed from these calculations is tabulated in Appendix 2. Positive numbers indicate absolute enrichment or addition of the respective chemical constituents to the rock and negative numbers indicate absolute depletion or subtraction from the rock.

The third type of isopleth map is represented by Plate 11 showing the distribution of copper across the Sierrita pit. This plate shows original chemical data with no additional number handling.

K₂O Weight Percent - Normalized K₂O data were plotted on the

geologic map of Sierrita in order to determine high and low K_2O concentration areas (Plate 3). The highest area of concentration is in the south central area of the pit (around sample number 4432) within the Harris Ranch quartz monzonite. The concentration is approximately 6.0 weight percent and decreases fairly rapidly from this centrally located high area. The rate of decrease in concentration is greater to the east and west of this high area where K_2O content of the samples drop to approximately 3.0 weight percent.

Two other areas of relatively high concentration, both averaging approximately 5.0 weight percent K_2O are in the west central (sample 4434) and southwest (sample 4409) areas of the pit. In both areas K_2O concentration drops off rapidly to the east and west. The decrease in concentration also appears rapid toward the south but more gentle in the northern area of the pit.

Two of the previously mentioned areas of high K_2O concentration are located in the Harris Ranch quartz monzonite, the third in the Quartz monzonite porphyry. The lowest concentrations are found, as expected, in the Quartz diorite.

Weight Percent K_2O after Density Correction - Plate 4 shows, in the form of an isopleth map, absolute enrichment and depletion of K_2O across the Sierrita pit. Three significant areas of K_2O enrichment are seen within the Sierrita pit. These areas correspond to those of high K_2O concentration presented in Plate 3. The two areas of highest K_2O addition are those in the south central (samples 4432 and 4426) and northeastern (samples 4443 and 4434) areas of the pit. The third

area in the southwestern part of the pit is around sample number 4409. A comparison of Plates 3 and 4 show that the areas of high K_2O concentration actually reflect areas of enrichment and that they are easily distinguishable when presented in the form of Plate 4. This is particularly true with reference to the area around sample number 4409 which is somewhat obscure on Plate 3 but very clear on Plate 4.

A fourth broad area of mild K_2O enrichment is found in the Quartz diorite, extending south from sample number 4407. It is noted that this area corresponds to one of low K_2O concentration presented on Plate 3. A comparison of the two plates, however, indicates that the absolute addition of K_2O to the rocks extends in a southerly direction, a greater distance on Plate 4 than is evidenced on Plate 3.

Another major feature of Plate 4 is delineation of areas of depletion of K_2O . These are found to essentially border areas of K_2O enrichment (rather than areas of no chemical change) and the pit in general. Plate 3 merely distinguishes these areas as places of low K_2O concentration. The area of greatest K_2O depletion is seen along the eastern margin of the pit adjacent to the areas of greatest K_2O enrichment.

A final significant feature of Plate 4 is the linear trend of samples 4403, 4404, 4448, 4427, 4438, indicating depletion of K_2O which nearly bisects the pit. The eastern part of this area is seen to almost directly coincide with the southern contact of the Breccia Pipe. Possible explanations for this feature will be presented in a later section.

Na₂O Weight Percent - Plate 5 represents the distribution of Na₂O, plotted in weight percent, across the Sierrita pit. Four areas of high concentration are seen. One major area lies within the Quartz diorite encompassing samples 4408, 4412 and 4419 reflecting an average of 4.0 weight percent Na₂O. Two other areas of equal concentration are represented by sample numbers 4401 in the Harris Ranch quartz monzonite and sample 4446 in the Quartz monzonite porphyry, both in the southern part of the pit. These two areas border a centrally located area around sample 4432, which corresponds to a low area of Na₂O concentration.

A fourth area of high Na₂O concentration is found in the north-eastern corner of the pit encompassing sample numbers 4436 and 4445 and extends in both westerly and southerly directions. This broad area, within the Quartz monzonite porphyry, contains approximately 3.5 weight percent Na₂O.

Weight Percent Na₂O after Density Correction - Plate 6 reflects several interesting features concerning the distribution of Na₂O which are not evident on Plate 5. Probably the most outstanding feature represented on Plate 6 is the significant amount of Na₂O that has been leached from the central area of the pit around sample 4432. It is also apparent that the two areas of high Na₂O concentration in the southern part of the pit which are seen on Plate 5, now reflect an Na₂O addition to the rocks which essentially extends in a narrow band from the east to the western side of the pit. This band borders the above mentioned central area of Na₂O depletion.

When the entire pit, as shown on Plate 6, is compared with

Plate 4, depicting K_2O distribution, it becomes obvious that the area of Na_2O depletion corresponds to the area of K_2O enrichment. Similarly, the broad band showing Na_2O enrichment and extending across the southern portion of the pit, is seen to correspond with an area of K_2O depletion.

A similar inverse relationship between K_2O and Na_2O is also noted in the north central portion of these two plates around sample 4448. Na_2O has been moderately leached from this area while there is a mild enrichment of K_2O , progressing to the east and west to areas of moderate to high K_2O enrichment and mild leaching of Na_2O . The area in the far northeastern corner of these plates around samples 4437 and 4445 also indicate high Na_2O enrichment and moderate to high K_2O depletion adjacent to an area of high K_2O enrichment (samples 4434 and 4443).

One final feature to be noted on Plate 6 is the area of mild Na_2O enrichment which again, nearly bisects the pit (samples 4403, 4411, 4419, 4427, and 4428). It is also noted that this area, as in Plate 4, corresponds to the southern boundary of the Breccia pipe.

Weight Percent CaO after Density Correction - No significant or unusual pattern appeared to be present when CaO was plotted in weight percent without using a density correction. After density calculations, the distribution pattern shown on Plate 7 was established. An area of CaO enrichment is seen in the west central part of the pit (sample 4419). This area is seen to extend in a southerly to southeasterly direction covering sample locations 4414 and 4425. Immediately adjacent to this area of enrichment, is a significant area of CaO depletion (sample 4418)

which trending in a southerly direction encompasses sample sites 4425, 5532, 4431, 4417, 4402 and 4424. The most significant aspect of this area of depletion of CaO, is its close correspondence to the area of Na₂O depletion and K₂O enrichment seen in previous plates.

A second area of CaO enrichment is present at sample site 4420 in the north central part of the pit. This area shows somewhat lesser CaO enrichment; however, the enrichment is still very clear. This area tends, for the most part, to correspond to very little enrichment to mild depletion of Na₂O. It also is seen to correspond to little change in the distribution of K₂O.

A final area of significant depletion of CaO is present in the northwestern corner of the pit. This area is found to correspond to mild K₂O enrichment and little change in Na₂O. In general, there appears to be an inverse relationship between K₂O and Na₂O as well as K₂O and CaO.

Weight Percent MgO after Density Correction - Plate 8 shows the distribution of MgO in the Sierrita pit after density corrections have been made. The most conspicuous feature of the diagram is the presence of three areas of high MgO enrichment in the south, west-central and northwestern part of the pit. The highest area, encompassing samples 4405 and 4413 shows no apparent relationship with the concentration of any of the other chemical constituents studied. This also appears to be true for the other two secondary high areas.

This plate does however, reflect an area of significant MgO depletion covering samples 4408, 4412, 4438 and 4434, which nearly

bisect the pit and is on a linear trend with the long axis of the Breccia Pipe. This area is bounded to the north and south by areas of significant MgO enrichment.

Total Fe (as Fe_2O_3) in Weight Percent - Total Fe has been plotted on Plate 9 in an attempt to establish areas of high and low concentration in the Sierrita pit. Reference to this plate will confirm three areas of high total Fe concentration. The two highest areas lie within the Quartz diorite, the highest around sample site 4418 and the second highest encompassing sample sites 4404 and 4420. These two areas form one broad area which is seen to have a concentration of 9.0 weight percent total Fe which is equal to the highest concentration found within the quartz monzonitic rocks. The highest area in the Quartz monzonite porphyry essentially encompassed sample site 4433 and 4449. Although sample site 4449 is shown to be within the Quartz monzonite porphyry on this geologic map of the pit, the sample was in actuality taken from a Quartz diorite which was intersected in the drill hole at the 3800 level. The significance of this point will become more evident with reference to Plate 10.

Weight Percent Total Fe After Density Correction - Total Fe after density calculations is presented in Plate 10. Three areas of significant total Fe enrichment are present at Sierrita. The two highest areas of Fe enrichment are in the central part of the pit, one around sample 4418 in the Quartz diorite and the other around sample site 4433 in the Quartz monzonite porphyry. These areas lie slightly adjacent to and overlapping the major area of K_2O enrichment seen on Plate 4.

The third area of total Fe enrichment, although much lower than the other two areas, appears to show only slight correspondence to an area of K_2O enrichment in the Quartz diorite.

To the north, east and west of the central pit area, there has been a depletion of total Fe from the rocks. Reference again to Plate 4 showing K_2O after density calculations indicates a strong relationship to the distribution of these two elements. The high degree of correspondence between total Fe and K_2O also reflects a negative correspondence to the distribution of Na_2O and CaO .

Weight Percent Cu - To facilitate a better understanding of the distribution of ore mineralization at Sierrita, weight percent copper distribution is shown in Plate 11. Four areas of high copper concentration of copper in these areas corresponds to high positive total Fe concentrations presented on Plates 9 and 10. The other two areas of high copper concentration (in the southern portion of the pit around sample sites 4439 and 4416 and in the northern portion of the pit around sample sites 4420 and 4430) also correspond to areas of total Fe enrichment but not as strongly as do the first two areas mentioned.

An area of very low copper concentration is seen to bisect the pit (samples 4403, 4404, 4448, and 4442). This area appears to correspond to the linear extension of the southern contact of the Breccia pipe. It also closely follows areas of similar design reflected in the distribution of other elements previously discussed.

Molybdenite - Weight percentage determinations were made for molybdenite using Atomic Absorption and X-ray fluorescence analysis.

Since none of these analyses indicated molybdenum concentrations over 1 ppm, molybdenite must occur predominantly as vein material at Sierrita.

DISCUSSION

A basic premise to which a considerable amount of this investigation has been directed, is that the increasing demand for future copper supplies necessitates a better understanding of the genetic relationship between ore deposition and hydrothermal alteration. Furthermore, the understanding of this relationship can be realized only after a great deal of information concerning physical and chemical criteria of this association have been evaluated utilizing reliable quantitative and qualitative data. Previous sections of this thesis have served to outline many of the critical features of alteration at Sierrita; however, it is the understanding and the application of these criteria which interests exploration geologists most and to which the discussion is now directed.

The mineralogical relationships at Sierrita as have been previously pointed out, are relatively simple and the rocks contain quartz, plagioclase, K-feldspar, biotite, and K-mica. Furthermore, reference to Appendix 2 establishes that quartz, K-feldspar and plagioclase are the major minerals of the Sierrita rocks. Previous reference to Figures 8, 10 and 11 have alluded to the obvious separation in the plot of the Quartz diorite samples with respect to the quartz monzonitic type rocks. It is here suggested that this is a reflection of the difference in original composition of these rock types and not the later compositional changes due to hydrothermal alteration. Furthermore, Figure 8 is useful in establishing several additional

mineralogical relationships. First, among the three minerals on the basis of which Figure 8 is constructed, quartz appears to be very insensitive to alteration. This is indicated, particularly in the quartz monzonitic rocks, by the small verticle variation in sample distribution. Although this feature is not as clearly evident with respect to the Quartz diorite samples, the modal percentage of quartz in these samples is within the range expected for unaltered quartz dioritic rocks. Secondly, K-feldspar and plagioclase appear to be very sensitive to alteration, which is obvious by the extreme variation in the K-feldspar/plagioclase ratio of all of the quartz monzonitic samples. The small variation in this ratio in the Quartz diorite samples simply indicates that there is little K-feldspar in this rock.

The degree to which the major minerals of the Sierrita rocks are affected by alteration can also be seen in the normative quartz-orthoclase-albite plot shown in Figure 10. It is clear from the small variation of quartz relative to large variation in Or/Ab ratio, that quartz is insensitive to alteration. In other words, it is the feldspar components of the rocks which appear to have changed by alteration.

Considering the previously established conclusion that the Sierrita rocks show major variation with respect to the feldspar components of the rocks, it will be instructive to focus attention on Figure 11 which shows the variation of these components. The most significant feature of Figure 11 is the variation in the Or/Ab+An ratio within the quartz monzonitic rocks, which may be interpreted as the formation of K-feldspar at the expense of plagioclase. Furthermore, the An component of the quartz monzonitic rocks remains approximately

constant throughout the figure while the Or component is increasing and the Ab component is decreasing. The constancy of An and variation of Or/Ab is expected if K_2O is added and Na_2O is removed from the rocks during alteration.

In Figure 11 an increase in normative orthoclase of the quartz monzonitic rocks can be explained by either the addition of K_2O to the rocks or removal of Na_2O from the rocks, or both. Consequently, the variation in the normative Or/Ab can be better represented by the variation in K_2O/Na_2O ratio. This ratio can also be used to explain the wide scatter of the samples in terms of their modal orthoclase/plagioclase ratio (Figure 8) as follows: since the normative anorthite component of the rocks (reflected by CaO) is generally constant as seen in Figure 10 an increase or decrease in K_2O/Na_2O+CaO (orthoclase/plagioclase) will be accompanied by an increase or decrease in the K_2O/Na_2O ratio. Consequently K_2O/Na_2O ratio is an increase of the sensitivity of the quartz monzonitic rocks to hydrothermal alteration (Fig. 12).

The Quartz diorite samples, however, indicate that Ab concentration is remaining fairly constant while the Or concentration is increasing and An concentration is decreasing (Fig. 11). The An concentration should be expected to decrease as the feldspars become more alkali rich since there exists no solid substitution between the Or and An components of the feldspar series. It has therefore been shown that the feldspars are undoubtedly being affected by alteration, that they are becoming more potassic and that the alteration of the feldspars in the Quartz diorites, although not reflecting K-feldspar

alteration, are being altered to a more alkali rich feldspar.

The above mentioned features of feldspar alteration indicate one of the major effects of hydrothermal fluids on the Sierrita rocks. It must be kept in mind, however, that biotite and K-mica thus far not included in the discussion of alteration mineralogy, are also present at Sierrita. Since these are both potassium bearing minerals, as is K-feldspar, Figure 9 was constructed in an attempt to establish the relationships of these minerals to plagioclase. The most significant feature of this figure is the inverse relationship in all of the Sierrita rocks as well as within each rock unit in terms of potassium bearing minerals versus plagioclase. Furthermore, the establishment of this relationship suggests that biotite and K-mica may be of significance with respect to the total effects of alteration.

The inverse relationship between potassium bearing minerals and plagioclase is also reflected in the bulk chemistry of the rocks, as has been alluded to throughout this discussion. In figure 13 ${}^m\text{Na}_2\text{O} + {}^m\text{CaO}$ represents the plagioclase component of Figure 9 and ${}^m\text{K}_2\text{O}$ is taken to represent the total K_2O tied in K-feldspar, K-mica and biotite. The major emphasis which should be attached to the comparison of Figures 9 and 13, is that Figure 13 facilitates the application of the same relationship displayed in Figure 9 using the chemical common denominator, K_2O , and thus leaving little ambiguity in terms of the basic effects of alteration.

Field and petrographic observations suggest that due to its predominance, K-feldspar is primarily responsible for the ${}^m\text{K}_2\text{O}$ variation in the bulk chemistry of the Sierrita rocks. This can be further

substantiated with chemical data. To determine the contribution of K-feldspar to the total K_2O variation, Plates 2 and 3 were constructed. The parallel variations in K_2O and modal K-feldspar (Plates 2 and 3) indicate that the greater proportion of the contribution to the total K_2O variation in the Sierrita rocks comes from K-feldspar, rather than biotite or K-mica. It is therefore, now possible to conclude that although the mineralogy of the Sierrita rocks includes quartz, plagioclase, K-feldspar, K-mica and biotite, the above analysis of the data clearly indicates that at the mineralogical level, K-feldspar and plagioclase are the two minerals most effected by hydrothermal alteration. In addition, a comparison of mineralogical and chemical data indicate that the chemical parameters most sensitive to alteration are K_2O , Na_2O and CaO .

The discussion thus far has served to substantiate major mineralogical and chemical variation in the Sierrita rocks and to point out what mineralogical and chemical constituents have been most drastically effected. High concentrations of any chemical component, however, for example K_2O , may be due to one of two factors: (1) the addition of K_2O to the rocks from hydrothermal fluids, or (2) the preferential removal of chemical components other than K_2O . Similarly, a low concentration of any chemical component may be due to (1) the preferential removal of that component from the rock, or (2) the addition of other chemical constituents.

If it is assumed that during alteration the volume of the rock remained more or less constant, then all chemical data can be recalculated for 1000 cm^3 of the rock (Hemley and Jones, 1964; Barth, 1962)

in order to establish the addition or removal of chemical compounds. Plate 4 shows the effect of this type of density calculation on the distribution of K_2O across the Sierrita pit. Furthermore, the relationship between Plates 2 and 3 now become even more meaningful. That is to say, that the parallel variations in K_2O and modal K-feldspar are due to the addition of K_2O in areas of high K_2O and low K-feldspar concentrations. This same relationship can also be applied to Plates 6, 7, and 8, which reflect the absolute enrichment or depletion of Na_2O , CaO and MgO , respectively.

It has been previously shown that areas of high K-feldspar concentration, high K_2O concentration and K_2O enrichment correspond with areas of low Na_2O and low CaO concentration and Na_2O and CaO depletion. It is now apparent that the hydrothermal fluids while enriching parts of the Sierrita rocks in K_2O , were at the same time leaching Na_2O and CaO . This further explains the inverse relationship of Figures 9, 12, and 13. In addition it now accounts for the characteristic K-feldspar alteration evident in hand specimen and in petrographic examination of the Sierrita rocks.

The relationships which have been described for the Sierrita porphyry copper-molybdenite deposit are also present at many other porphyry copper deposits. Spencer (1917) in his investigation of the Ely deposit, Nevada recalculated chemical analysis of 100 grams of rock and found that K_2O had been added to the altered rocks in every instance and that CaO and Na_2O as well as MgO had been removed from the rocks. In the highly ore mineralized portion of the deposit the alteration mineralogy which reflects this addition of K_2O is the breakdown of

hornblende and plagioclase to sericite and biotite. Orthoclase is not destroyed; however it is sometimes redistributed into smaller grains "under very strong alteration". Predominant ore minerals associated with this alteration are chalcopyrite and pyrite.

In the Castle Dome ore deposit, Peterson, Gilbert and Quick (1946) indicate that alteration is generally characterized by sericite and quartz. The sericite is replacing the plagioclase in the rocks indicating K_2O enrichment. Chemical analysis presented in the paper further substantiate that the altered rocks are characterized by higher K_2O concentrations and lower Na_2O as well as CaO concentrations than the fresh rocks. Peterson (1962) found what he considered a nearly identical alteration assemblage at the Copper Cities mine in the Globe-Miami district.

Gilluly (1946) in his study of the effects of alteration at Ajo, Arizona found that the rocks had been "impregnated" with quartz and K-feldspar and that plagioclase was breaking down to albite and sericite. As he found no major difference in the Na_2O content of the fresh and altered rocks, he concluded that albitization was a reflection of preferential removal of CaO . K_2O on the other hand showed definite increases adjacent to mineralized veinlets.

Stringham (1963) summarizes alteration at Bingham, Utah as being characterized by biotite, sericite and quartz. Again K_2O is associated with biotite and sericite, both of which can be directly associated with ore mineralization. In the rocks at Bingham, there has been little preferential removal of other chemical compounds from the rocks.

Additional examples of K_2O addition and Na_2O and CaO depletion from rocks at mineralized deposits may be found throughout the Titley and Hicks volume, Geology of Porphyry Copper Deposits Southwestern North America (1966). What is of greatest interest is that there is extremely good agreement in the trend of these chemical changes from deposit to deposit although the mineralogical reflection of these changes is extremely variable.

MgO , plotted on Plate 8, was also considered as an additional chemical parameter of the Sierrita rocks since several investigators have reported fluctuations in this compound between fresh and altered rocks. Although MgO was found to be added and depleted from various portions of the Sierrita deposit, it was not possible to relate the variation of MgO to any of the other chemical compounds. It is noted that high MgO areas of addition in the Quartz diorite probably reflect original chemical composition of the rocks. More precisely, MgO addition to these rocks reflects redistribution of this chemical component within this rock type.

Alteration alone has little significance until it can be related to ore deposition. Previous considerations of the distribution of total Fe and copper across the Sierrita pit, Plates 9, 10 and 11, have indicated that total Fe addition shows high positive correlation to high copper concentration. Furthermore, the mineralogical reflection of this is the high concentrations of chalcopyrite. It has also been shown that areas of K_2O addition and Na_2O as well as CaO depletion correspond directly to areas of high concentrations of chalcopyrite. It is therefore concluded that while hydrothermal fluids were leaching

H_2O and CaO from the rocks they were also enriching the rocks in K_2O and total Fe and copper (chalcopyrite).

Several other features of the Sierrita rocks which have been referred to throughout this thesis can now be expanded upon. Considerable reference has been made to the fact that the chemical trends in Plates 2 through 11 are nearly bisected by a linear trend parallel to the long dimensional axis of the Breccia pipe. No evidence can be presented to suggest conclusively the reason for this feature, although it is believed to most probably represent a remobilization phenomena (i.e., hydrothermal activity) associated with the intrusion of the Breccia pipe. A more detailed study is necessary, however, before any conclusive statement can be made as to the exact implications of this feature.

Whole rock analysis of major chemical components, particularly K_2O , H_2O and CaO as well as the ore chemistry, appears to provide a possible method for exploration of porphyry copper deposits. This kind of study may be extremely useful in several types of exploratory investigations. First, it might be applied in the investigation of buried deposits. Information derived from geophysical exploration may have served to establish an anomalous zone in an area overlain by sedimentary rocks or covered by dense vegetation. In the situation of a sedimentary rock cover, geochemical whole rock analysis may serve to establish the major alteration zone which might contain ore mineralization. In an area covered by dense vegetation (many parts of Canada, the northern United States and much of the circum Pacific belt), an exploration geologist with a small portable drill would be capable of

collecting necessary samples for the type of investigation described in this thesis.

Secondly, this study might be extended to areas characterized by fine-grained to aphanitic rocks where mineralized investigations are extremely difficult or impossible. Rocks of this type are very characteristic in the circumpacific belt (Bougainville Island, Panguana).

Thirdly, a mining company may be interested in better defining ore mineralized areas at a presently operating property. This may be done inexpensively utilizing present drill core data.

Regardless of the possible individual applications of this study, it should be emphasized that whole rock geochemical investigations can be conducted in very nearly all geographic areas and in all rock types. Classical investigations are very limited with respect to outcrop exposure and intrusive coarse grained rocks.

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APPENDIX 1

Sample Collection

A total of 49 drill core samples were collected from 3800 feet level at approximately 500 foot intervals, in a grid pattern across the mineralized portion of the Sierrita pit. Plate 1 indicates the specific location of all samples which were collected along grid lines 92.5 E, 93.0E, 93.5 E, 94.0 E, and 94.4 E. The number at the top of each sample site indicates the specific sample number while the number in parenthesis indicates the drill hole number as recorded by the Duval Corporation. Approximately ten feet of core was collected from the 3800 level (3795-3805) from each sample site. The samples were all collected without regard to rock type or the extent of alteration, however, all large mineralized veinlets (greater than 1/2 inch) were eliminated.

The selection of samples was limited by two factors and does not represent a statistically defined grid pattern. First, sample collection was limited to present drill holes and secondly the major factor which prevented such sample selection was due to the extremely large number of samples necessary to satisfy statistical qualifications. Samples could not be collected from the pit directly, first, due to mining methods and secondly due to the impossibility of collecting all samples at one level in the pit.

In addition to samples collected from drill holes, three samples were collected in an area of 10 feet in diameter from each of the three rock types studied. These samples were collected for chemical and mineralogical analysis in an attempt to show that variation of either of these two parameters within any one rock type is smaller than between

rock types.

Specific sample numbers and rock types are tabulated below.

4401 Harris Ranch quartz monzonite	4424 Harris Ranch quartz monzonite
4402 Quartz diorite	4425 "
4403 "	4426 "
4404 "	4427 "
4405 "	4428 Quartz monzonite porphyry
4406 "	4429 Harris Ranch quartz monzonite
4407 "	4430 "
4408 "	4431 "
4409 Harris Ranch quartz monzonite	4432 "
4410 "	4433 Quartz monzonite porphyry
4411 Quartz diorite	4434 Harris Ranch quartz monzonite
4412 "	4435 Quartz monzonite porphyry
4413 "	4436 "
4414 "	4437 "
4415 Quartz monzonite porphyry	4438 "
4416 Harris Ranch quartz monzonite	4439 "
4417 "	4440 "
4418 Quartz diorite	4441 "
4419 "	4442 "
4420 "	4443 "
4421 Quartz monzonite porphyry	4444 "
4422 "	4445 "
4423 Harris Ranch quartz monzonite	4446 "

4447 Quartz monzonite porphyry

4448 Quartz diorite

4449 "

QMP-1 Quartz monzonite porphyry

QMP-2 "

QMP-3 "

QD-1 Quartz diorite

QD-2 "

QD-3 "

HRQM-1 Harris Ranch quartz monzonite

HRQM-2 "

HRQM-3 "

APPENDIX 2

Modal Mineralogy

Normative Mineralogy

Atomic Absorption Analysis

X-ray Florescence Analysis

Density Determinations

ATOMIC ABSORPTION ANALYSIS

A total of 56 samples plus seven standards (BCR-1, AGV-1, SY-1, GSP-1, G-2, and QMC-1) and three blanks were prepared for Atomic Absorption Analysis using the technique of Medlin, Suhr and Bodkin (1969). This technique was used for the determination of SiO_2 , Al_2O_3 , total Fe (as Fe_2O_3), MgO , CaO , K_2O and Na_2O .

Drill core samples were first crushed using a jaw crusher. The samples were then ground to -200 mesh using a shatter box with tungsten carbide grinding plates. The samples were then carefully homogenized and a split fraction was reground and 100 mg of this material was weighed out for Atomic Absorption Analysis. The samples were then mixed with 0.500 grams of lithium metaborate and transferred to pre-ignited graphite crucibles. The crucibles containing the samples were placed in a muffle furnace for 15 minutes at 1000 degrees centigrade. A solution of 4% HNO_3 was prepared to dissolve the fusion samples. Exactly 40 ml of this solution was placed in a 200 ml polypropylene beaker with a teflon coated magnetic stirring bar. At the end of 15 minutes the samples were removed from the furnace and swirled to collect uncoalesced beads and the molten material was poured into the beaker. The beaker was covered to prevent evaporation loss and placed on a magnetic stirrer for approximately 15 minutes to allow the sample to completely dissolve. The final material was then placed in a clean soda lime bottle with a plastic stopper.

Separate solutions were next prepared (1) for the determination of SiO_2 , Al_2O_3 , CaO , MgO and total Fe, and (2) for the determination of H_2O and K_2O . The first was prepared by taking 5 ml of the above sample

solution and adding 30 ml of 1% lanthanum solution to this. This solution proved entirely satisfactory for the first set of the above mentioned determinations. Solutions were then prepared for K_2O and Na_2O using a 1:20 dilution with distilled deionized water. Extreme care was taken to avoid contamination in the determination of Na_2O .

The original solutions were also used for the determination of copper and molybdenum.

The results of Atomic absorption analysis are tabulated in this appendix. The excepted analytical value, presented in weight percent, for each chemical compound determined, represents the average of two readings (100 readings each or a total of 200 analysis) on a Perkin-Elmer 403 Atomic Absorption unit. In an attempt to determine the precision of the analytical data, a standard was used in the determination of each compound and was read ten times (each reading = 100 analyses, total of 1000 analyses). These data were then used to calculate the mean, the variance and the standard deviation, and listed on the following pages, under the heading of AA wt. %.

SiO₂ - AGU-1

Height %

60.6
58.9
59.8
- 61.02
58.7
59.6
60.9
59.6
59.3
60.7

Mean 59.93

Variance .76
Standard .87
deviation

Al₂O₃ - G-2

Height %

15.61
15.57
15.53
15.52
15.56
15.61
15.57
15.56
15.49
15.56

Mean 15.558

Variance .001
Standard .037
deviation

Total Fe (Fe₂O₃) - QMC-1

Height %

0.53
0.54
0.53
0.56
0.56
0.60
0.58
0.54
0.51
0.57

Mean .554

Variance .000
Standard .028
deviation

NGO -GSP-1

0.97
0.97
0.98
0.98
0.98
0.98
0.98
0.98
0.98
0.98
0.98

Mean .978
Variance .000
Standard .004
deviation

CaO - G-2

2.01
2.02
2.03
2.04
2.06
2.06
2.06
2.05
2.05
2.05
2.05

Mean 2.042
Variance .000
Standard .016
deviation

Na₂O - GSP-1

2.90
2.90
2.90
2.89
2.89
2.89
2.88
2.89
2.89
2.89

Mean 2.892
Variance .000
Standard .006
deviation

K₂O - GSP-1

4.46
4.48
4.47
4.48
4.48
4.48
4.47 Mean 4.476
4.47 Variance .000
4.48 Standard .008
4.49 deviation

Copper Su-1

.95
.94
.93
.93
.92
.92
.92
.92
.92
.92
.93

Mean .930
Variance .000
Standard .011
deviation

X-RAY FLOURESCENCE ANALYSIS

A fraction of the drill core sample which had been ground to -200 mesh was used for X-ray flourescence analysis. A 4.5 gr portion of this sample was carefully weighed and combined with phenolic resin, which served as a binder. The sample was then placed in a 25 ton ring press, and pressed into a pellet. To insure that the pellet would remain intact, it was then placed in a drying oven a 110 degrees centigrade for approximately 10 minutes.

Each of the pellets were then analyzed for SiO_2 , total Fe and copper using a General Electric XRD-6 X-ray flourescence unit. The results are tabulated in this appendix under the heading of X-ray Flour. Wt. %.

DENSITY DETERMINATIONS

Density measurements were made for all samples collected at Sierrita. These measurements were made using an Air Compression pycnometer and a balance. The volume of three subsamples from each sample was measured and their weights were determined. In order to determine the average density of each sample, the volume as well as the weight of each subsample was determined three times. This procedure resulted in nine measurements for each sample. The average of the nine measurements was then presented as the density of that sample in the upper right hand corner of the following pages.

SAMPLE NUMBER: 4401

Rock Type: HRQM

Density: 2.86

MINERALOGY

<u>Modal</u> <u>Percentage</u>	<u>Normative</u> <u>Percentage</u>
Quartz : 16.3	Quartz : 21.00
K-feldspar : 38.0	Orthoclase : 26.24
Plagioclase : 40.7	Albite : 33.93
Biotite : 1.3	Anorthite : 9.23
Chlorite : 2.8	Hypersthene : 3.71
K-mica : --	Corundum : 1.15
Epidote : --	Hematite : 5.19
Pyrite : .9	Wollastonite :
Chalcopyrite : --	Enstatite :
Molybdenite : --	
100.00	

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂ :	62.60	: 62.6
Al ₂ O ₃ :	14.77	: --
Total Fe :	4.81	: 4.91
MgO :	0.96	: --
CaO :	1.72	: --
Na ₂ O :	3.72	: --
K ₂ O :	4.12	: --
Copper :		: .085

SAMPLE NUMBER: 4402

Rock Type: QD

Density: 2.93

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 8.7	Quartz	: 13.96
K-feldspar	: 0.5	Orthoclase	: 10.46
Plagioclase	: 65.3	Albite	: 30.80
Biotite	: 5.2	Anorthite	: 27.90
Chlorite	: 16.8	Hypersthene	: 7.72
K-mica	: --	Corundum	: --
Epidote	: 1.7	Hematite	: 8.23
Pyrite	: 1.5	Wollastonite	: .49
Chalcopyrite	: .3	Enstatite	: .42
Molybdenite	:		
	100.00		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 55.40	: 55.6
Al ₂ O ₃	: 17.00	: --
Total Fe	: 7.72	: 7.70
MgO	: 3.07	: --
CaO	: 5.49	: --
Na ₂ O	: 3.41	: --
K ₂ O	: 1.66	: --
Copper	: --	: .110

SAMPLE NUMBER: 4403

Rock Type: QD

Density: 2.96

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 8.2	Quartz	: 7.39
K-feldspar	: --	Orthoclase	: 12.59
Plagioclase	: 62.3	Albite	: 30.63
Biotite	: 13.8	Anorthite	: 25.79
Chlorite	: 11.7	Hypersthene	: 7.06
K-mica	: 1.7	Corundum	: --
Epidote	: 1.0	Hematite	: 4.60
Pyrite	: 1.0	Wollastonite	: 6.41
Chalcopyrite	: 0.3	Enstatite	: 5.5
Molybdenite	: --		
	100.00		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 52.60	: 53.3
Al ₂ O ₃	: 16.20	: --
Total Fe	: 4.21	: 4.27
MgO	: 4.63	: --
CaO	: 7.58	: --
Na ₂ O	: 3.31	: --
K ₂ O	: 1.95	: --
Copper	:	: .040

SAMPLE NUMBER: 4404

Rock Type: QD

Density: 2.92

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 3.7	Quartz	: 12.40
K-feldspar	: --	Orthoclase	: 9.04
Plagioclase	: 63.0	Albite	: 30.38
Biotite	: 6.8	Anorthite	: 37
Chlorite	: 25.3	Hypersthene	: 5.65
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 10.07
Pyrite	: 1.0	Wollastonite	: 3.80
Chalcopyrite	: 0.2	Enstatite	: 3.29
Molybdenite	: --		
	100.00		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 56.20	: 56.31
Al ₂ O ₃	: 16.50	: --
Total Fe	: 9.86	: 9.97
MgO	: 3.51	: --
CaO	: 6.80	: --
Na ₂ O	: 3.51	: --
K ₂ O	: 1.50	: --
Copper	:	: .080

SAMPLE NUMBER: 4405

Rock Type: QD

Density: 2.94

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 7.3	Quartz	: 12.44
K-feldspar	: 0.2	Orthoclase	: 12.71
Plagioclase	: 65.5	Albite	: 29.87
Biotite	: 19.2	Anorthite	: 17.02
Chlorite	: 7.3	Hypersthene	: 8.55
K-mica	: --	Corundum	:
Epidote	: --	Hematite	: 8.10
Pyrite	: 0.5	Wollastonite	: 6.07
Chalcopyrite	: --	Enstatite	: 5.25
Molybdenite	: --		
	100.00		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 58.40	: 58.2
Al ₂ O ₃	: 14.00	: --
Total Fe	: 7.89	: 7.76
MgO	: 5.40	: --
CaO	: 6.20	: --
Na ₂ O	: 3.44	: --
K ₂ O	: 2.09	: --
Copper	: --	: 0.80

SAMPLE NUMBER: 4406

Rock Type: QD

Density: 2.97

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 5.3	Quartz	: 15.12
K-feldspar	: --	Orthoclase	: 10.46
Plagioclase	: 65.5	Albite	: 31.82
Biotite	: 10.3	Anorthite	: 23.46
Chlorite	: 17.5	Hypersthene	: 4.75
K-mica	: 0.2	Corundum	: --
Epidote	: --	Hematite	: 8.37
Pyrite	: 1.2	Wollastonite	: 3.23
Chalcopyrite	: --	Enstatite	: 2.79
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 49.90	: 58.6
Al ₂ O ₃	: 16.65	: --
Total Fe	: 8.34	: 8.46
MgO	: 3.02	: --
CaO	: 6.27	: --
Na ₂ O	: 3.75	: --
K ₂ O	: 1.76	: --
Copper	: --	: 0.40

SAMPLE NUMBER: 4407

Rock Type: QD

Density: 2.93

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 14.2	Quartz	: 14.42
K-feldspar	: --	Orthoclase	: 14.95
Plagioclase	: 60.5	Albite	: 30.38
Biotite	: 16.5	Anorthite	: 22.97
Chlorite	: 6.7	Hypersthene ^{5.36}	:
K-mica	: --	Corundum	:
Epidote	: --	Hematite ^{7.48}	:
Pyrite	: 2.0	Wollastonite	: 2.38
Chalcopyrite	: --	Enstatite	: 2.06
Molybdenite	: --		
	99.9		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 58.60	: 57.0
Al ₂ O ₃	: 16.50	: --
Total Fe	: 7.24	: 7.38
MgO	: 2.88	: --
CaO	: 5.59	: --
Na ₂ O	: 3.47	: --
K ₂ O	: 2.45	: --
Copper	:	: 0.45

SAMPLE NUMBER: 4408

Rock Type:

QD

Density: 2.87

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 14.2	Quartz	: 10.54
K-feldspar	: 2.7	Orthoclase	: 12.35
Plagioclase	: 52.7	Albite	: 30.38
Biotite	: 16.7	Anorthite	: 26.45
Chlorite	: 12.0	Hypersthene	: 6.07
K-mica	: 0.8	Corundum	: --
Epidote	: 0.3	Hematite	: 8.24
Pyrite	: 0.7	Wollastonite	: 3.00
Chalcopyrite	: --	Enstatite	: 2.59
Molybdenite	: --		
	100.1		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 54.50	: 53.5
Al ₂ O ₃	: 16.90	: --
Total Fe	: 7.80	: 7.82
MgO	: 3.29	: --
CaO	: 6.42	: --
Na ₂ O	: 3.74	: --
K ₂ O	: 1.98	: --
Copper	:	: 0.95

SAMPLE NUMBER: 4409

Rock Type:

HRQM

Density: 2.77

MINERALOGY

<u>Modal</u> - - - - -	<u>Percentage</u>	<u>Normative</u> - - - - -	<u>Percentage</u>
Quartz	: 19.4	Quartz	: 25.49
K-feldspar	: 45.0	Orthoclase	: 32.03
Plagioclase	: 27.8	Albite	: 25.05
Biotite	: 2.7	Anorthite	: 7.89
Chlorite	: 1.9	Hypersthene	: 2.32
K-mica	: 0.2	Corundum	: 2.57
Epidote	: 0.6	Hematite	: 4.65
Pyrite	: 0.7	Wollastonite	: --
Chalcopyrite	: 1.8	Enstatite	: --
Molybdenite	: --		
	100.1		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 64.50	: 63.8
Al ₂ O ₃	: 15.31	: --
Total Fe	: 4.39	: 4.27
MgO	: 0.88	: --
CaO	: 1.50	: --
Na ₂ O	: 2.80	: --
K ₂ O	: 5.12	: --
Copper	:	: .055

SAMPLE NUMBER: 4410

Rock Type:

HRQM

Density: 2.70

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 15.9	Quartz	: 26.15
K-feldspar	: 26.0	Orthoclase	: 29.37
Plagioclase	: 47.6	Albite	: 28.60
Biotite	: 7.8	Anorthite	: 7.84
Chlorite	: 2.0	Hypersthene	: 2.59
K-mica	: --	Corundum	: .94
Epidote	: --	Hematite	: 4.51
Pyrite	: 0.1	Wollastonite	: --
Chalcopyrite	: 0.7	Enstatite	: --
Molybdenite	: --		
	100.1		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 68.10	: 66.5
Al ₂ O ₃	: 14.40	: --
Total Fe	: 4.40	: 4.43
MgO	: 1.02	: --
CaO	: 1.54	: --
Na ₂ O	: 3.30	: --
K ₂ O	: 4.85	: --
Copper	: .190	

SAMPLE NUMBER: 4411

Rock Type:

QD

Density: 2.96

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 5.7	Quartz	: 10.54
K-feldspar	: --	Orthoclase	: 11.46
Plagioclase	: 55.5	Albite	: 30.12
Biotite	: 11.2	Anorthite	: 20.15
Chlorite	: 23.3	Hypersthene	: 5.92
K-mica	: 3.0	Corundum	: --
Epidote	: --	Hematite	: 9.10
Pyrite	: 1.3	Wollastonite	: 6.81
Chalcopyrite	: --	Enstatite	: 5.89
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 54.40	: 54.0
Al ₂ O ₃	: 14.40	: --
Total Fe	: 8.54	: 8.54
MgO	: 4.45	: --
CaO	: 6.90	: --
Na ₂ O	: 3.34	: --
K ₂ O	: 1.82	: --
Copper	:	: .055

SAMPLE NUMBER: 4412

Rock Type: QD

Density: 2.88

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 9.0	Quartz	: 6.69
K-feldspar	: 1.2	Orthoclase	: 12.35
Plagioclase	: 68.3	Albite	: 35.46
Biotite	: 11.8	Anorthite	: 25.56
Chlorite	: 8.8	Hypersthene	: 4.87
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 8.56
Pyrite	: 0.8	Wollastonite	: 3.50
Chalcopyrite	: --	Enstatite	: 3.02
Molybdenite	: --		
	99.9		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 55.20	: 56.8
Al ₂ O ₃	: 18.05	: --
Total Fe	: 8.34	: 8.39
MgO	: 3.09	: --
CaO	: 6.67	: --
Na ₂ O	: 4.08	: --
K ₂ O	: 2.04	: --
Copper	:	: .160

SAMPLE NUMBER: 4413

Rock Type: QD

Density: 2.91

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 8.5	Quartz	: 10.78
K-feldspar	: 2.3	Orthoclase	: 11.64
Plagioclase	: 57.2	Albite	: 29.02
Biotite	: 20.0	Anorthite	: 19.33
Chlorite	: 10.8	Hypersthene	: 9.46
K-mica	: --	Corundum	: --
Epidote	: 0.5	Hematite	: 8.74
Pyrite	: 0.7	Wollastonite	: 5.91
Chalcopyrite	: --	Enstatite	: 5.11
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 56.20	: 56.6
Al ₂ O ₃	: 14.30	: --
Total Fe	: 8.41	: 8.48
MgO	: 5.63	: --
CaO	: 6.50	: --
Na ₂ O	: 3.30	: --
K ₂ O	: 1.90	: --
Copper	: .030	

SAMPLE NUMBER: 4414

Rock Type: QD

Density: 2.95

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 5.8	Quartz	: 13.89
K-feldspar	: 0.3	Orthoclase	: 9.93
Plagioclase	: 67.0	Albite	: 29.95
Biotite	: 6.3	Anorthite	: 25.48
Chlorite	: 16.2	Hypersthene	: 4.31
K-mica	: --	Corundum	: --
Epidote	: 1.8	Hematite	: 7.99
Pyrite	: 2.3	Wollastonite	: 4.52
Chalcopyrite	: 0.2	Enstatite	: 3.91
Molybdenite	: --		
	<u>99.9</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 58.20	: 56.6
Al ₂ O ₃	: 16.70	: --
Total Fe	: 7.86	: 7.94
MgO	: 3.25	: --
CaO	: 7.20	: --
Na ₂ O	: 3.48	: --
K ₂ O	: 1.65	: --
Copper	:	: .160

SAMPLE NUMBER: 4415

Rock Type: QMP

Density: 2.71

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 28.9	Quartz	: 35.11
K-feldspar	: 35.4	Orthoclase	: 24.23
Plagioclase	: 30.0	Albite	: 26.74
Biotite	: 4.7	Anorthite	: 8.33
Chlorite	: --	Hypersthene	: 1.52
K-mica	: --	Corundum	: 1.84
Epidote	: --	Hematite	: 2.22
Pyrite	: 0.1	Wollastonite	: --
Chalcopyrite	: 0.7	Enstatite	: --
Molybdenite	: 0.2		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 71.90	: 72.4
Al ₂ O ₃	: 14.18	: --
Total Fe	: 2.17	: 2.18
MgO	: 0.60	: --
CaO	: 1.64	: --
Na ₂ O	: 3.08	: --
K ₂ O	: 4.00	: --
Copper	: .100	

SAMPLE NUMBER: 4416

Rock Type: HRQM

Density: 2.90

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 17.9	Quartz	: 22.67
K-feldspar	: 35.4	Orthoclase	: 25.18
Plagioclase	: 36.9	Albite	: 32.07
Biotite	: 9.1	Anorthite	: 11.71
Chlorite	: 0.3	Hypersthene	: 3.16
K-mica	: --	Corundum	: 0.51
Epidote	: --	Hematite	: 4.69
Pyrite	: 0.1	Wollastonite	: --
Chalcopyrite	: 0.2	Enstatite	: --
Molybdenite	: --		
	99.9		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 65.20	: 63.6
Al ₂ O ₃	: 15.01	: --
Total Fe	: 4.50	: 4.56
MgO	: 1.22	: --
CaO	: 2.26	: --
Na ₂ O	: 3.64	: --
K ₂ O	: 4.09	: --
Copper	:	: .185

SAMPLE NUMBER: 4417

Rock Type:

HRQM

Density: 2.82

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 24.8	Quartz	: 26.37
K-feldspar	: 26.8	Orthoclase	: 26.71
Plagioclase	: 43.0	Albite	: 29.36
Biotite	: 2.1	Anorthite	: 8.09
Chlorite	: 2.7	Hypersthene	: 2.19
K-mica	: --	Corundum	: 2.17
Epidote	: --	Hematite	: 5.10
Pyrite	: 0.2	Wollastonite	: --
Chalcopyrite	: 0.3	Enstatite	: --
Molybdenite	: 0.1		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 65.30	: 64.5
Al ₂ O ₃	: 14.96	: --
Total Fe	: 4.85	: 4.85
MgO	: 0.84	: --
CaO	: 1.55	: --
Na ₂ O	: 3.30	: --
K ₂ O	: 4.30	: --
Copper	:	: .125

SAMPLE NUMBER: 4418

Rock Type:

QD

Density: 2.94

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 2.7	Quartz	: 11.21
K-feldspar	: --	Orthoclase	: 13.83
Plagioclase	: 59.2	Albite	: 26.99
Biotite	: 11.8	Anorthite	: 19.62
Chlorite	: 24.8	Hypersthene	: 9.76
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 12.47
Pyrite	: 1.2	Wollastonite	: 3.28
Chalcopyrite	: --	Enstatite	: 2.84
Molybdenite	: --		
	99.7		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 52.80	: 53.3
Al ₂ O ₃	: 14.00	: --
Total Fe	: 11.67	: 11.59
MgO	: 4.73	: --
CaO	: 5.18	: --
Na ₂ O	: 2.98	: --
K ₂ O	: 2.19	: --
Copper	:	: .300

SAMPLE NUMBER: 4419

Rock Type: QD

Density: 2.98

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 7.7	Quartz	: 8.09
K-feldspar	: --	Orthoclase	: 11.29
Plagioclase	: 59.2	Albite	: 34.27
Biotite	: 11.5	Anorthite	: 22.32
Chlorite	: 18.3	Hypersthene	: 3.90
K-mica	: 0.5	Corundum	: --
Epidote	: 0.2	Hematite	: 8.78
Pyrite	: 2.7	Wollastonite	: 6.09
Chalcopyrite	: --	Enstatite	: 5.27
Molybdenite	: --		
	100.1		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 54.50	: 54.0
Al ₂ O ₃	: 16.10	: --
Total Fe	: 8.36	: 8.39
MgO	: 3.50	: --
CaO	: 7.08	: --
Na ₂ O	: 3.86	: --
K ₂ O	: 1.82	: --
Copper	:	: .030

SAMPLE NUMBER: 4420

Rock Type: QD

Density: 2.91

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 9.5	Quartz	: 15.17
K-feldspar	: 0.7	Orthoclase	: 13.71
Plagioclase	: 57.3	Albite	: 27.75
Biotite	: 17.3	Anorthite	: 18.35
Chlorite	: 13.7	Hypersthene	: 8.13
K-mica	: 0.3	Corundum	: --
Epidote	: 0.1	Hematite	: 10.09
Pyrite	: 0.8	Wollastonite	: 3.65
Chalcopyrite	: 0.1	Enstatite	: 3.15
Molybdenite	: --		
	99.8		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 56.70	: 55.6
Al ₂ O ₃	: 13.90	: --
Total Fe	: 9.58	: 9.72
MgO	: 4.30	: --
CaO	: 5.19	: --
Na ₂ O	: 3.12	: --
K ₂ O	: 2.20	: --
Copper		: .225

SAMPLE NUMBER: 4421

Rock Type: GMP

Density: 2.80

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 34.6	Quartz	: 31.80
K-feldspar	: 40.9	Orthoclase	: 26.95
Plagioclase	: 17.8	Albite	: 24.37
Biotite	: 3.8	Anorthite	: 11.51
Chlorite	: 1.0	Hypersthene	: 2.32
K-mica	: --	Corundum	: 0.69
Epidote	: --	Hematite	: 2.37
Pyrite	: --	Wollastonite	: --
Chalcopyrite	: 1.9	Enstatite	: --
Molybdenite	: 0.1		
	100.1		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 67.10	: 65.9
Al ₂ O ₃	: 13.52	: --
Total Fe	: 2.20	: 2.28
MgO	: 0.86	: --
CaO	: 2.15	: --
Na ₂ O	: 2.67	: --
K ₂ O	: 4.23	: --
Copper	:	: .125

SAMPLE NUMBER: 4422

Rock Type: QMP

Density: 2.78

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 27.1	Quartz	: 29.32
K-feldspar	: 19.1	Orthoclase	: 23.76
Plagioclase	: 46.4	Albite	: 28.43
Biotite	: 6.4	Anorthite	: 13.44
Chlorite	: --	Hypersthene	: 2.39
K-mica	: --	Corundum	: 0.46
Epidote	: --	Hematite	: 2.18
Pyrite	: 0.9	Wollastonite	: --
Chalcopyrite	: --	Enstatite	: --
Molybdenite	: --		
	<u>99.9</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 67.50	: 66.6
Al ₂ O ₃	: 14.42	: --
Total Fe	: 2.06	: 2.21
MgO	: 0.91	: --
CaO	: 2.56	: --
Na ₂ O	: 3.17	: --
K ₂ O	: 3.80	: --
Copper	: .075	

SAMPLE NUMBER: 4423

Rock Type: HRQM Density: 2.81

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 23.0	Quartz	: 24.66
K-feldspar	: 18.7	Orthoclase	: 27.48
Plagioclase	: 51.4	Albite	: 26.15
Biotite	: --	Anorthite	: 13.24
Chlorite	: 0.2	Hypersthene	: 3.96
K-mica	: 5.1	Corundum	: --
Epidote	: --	Hematite	: 4.69
Pyrite	: 0.6	Wollastonite	: --
Chalcopyrite	: 1.0	Enstatite	: --
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 65.80	: 63.8
Al ₂ O ₃	: 14.20	: --
Total Fe	: 4.50	: 4.61
MgO	: 1.53	: --
CaO	: 2.56	: --
Na ₂ O	: 2.97	: --
K ₂ O	: 4.47	: --
Copper	:	: .030

SAMPLE NUMBER: 4424

Rock Type: QMP

Density: 2.78

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 20.9	Quartz	: 28.07
K-feldspar	: 48.8	Orthoclase	: 23.58
Plagioclase	: 19.3	Albite	: 32.92
Biotite	: 6.9	Anorthite	: 6.94
Chlorite	: 2.4	Hypersthene	: 1.84
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 4.02
Pyrite	: 0.3	Wollastonite	: 1.41
Chalcopyrite	: 1.3	Enstatite	: 1.22
Molybdenite	: --		
	99.9		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 66.90	: 64.3
Al ₂ O ₃	: 12.40	: --
Total Fe	: 3.76	: 3.79
MgO	: 1.15	: --
CaO	: 1.95	: --
Na ₂ O	: 3.64	: --
K ₂ O	: 3.73	: --
Copper	:	: .115

SAMPLE NUMBER: 4425

Rock Type: QMP Density: 2.74

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 18.8	Quartz	: 29.67
K-feldspar	: 45.0	Orthoclase	: 29.90
Plagioclase	: 6.6	Albite	: 18.19
Biotite	: 0.4	Anorthite	: 12.45
Chlorite	: 2.3	Hypersthene	: 2.54
K-mica	: 25.2	Corundum	: 2.43
Epidote	: --	Hematite	: 4.81
Pyrite	: 1.0	Wollastonite	: --
Chalcopyrite	: 0.7	Enstatite	: --
Molybdenite	: --		
	<u>100.0</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 63.70	: 62.2
Al ₂ O ₃	: 14.90	: --
Total Fe	: 4.48	: 4.57
MgO	: 0.95	: --
CaO	: 2.34	: --
Na ₂ O	: 2.00	: --
K ₂ O	: 4.71	: --
Copper	: --	: .090

SAMPLE NUMBER: 4426

Rock Type: HRQM

Density: 2.70

MINERALOGY

<u>Modal</u> <u>Percentage</u>	<u>Normative</u> <u>Percentage</u>
Quartz : 23.1	Quartz : 29.86
K-feldspar : 61.0	Orthoclase : 34.28
Plagioclase : 12.8	Albite : 22.09
Biotite : 1.7	Anorthite : 6.16
Chlorite : 0.7	Hypersthene : 1.63
K-mica : 0.3	Corundum : --
Epidote : --	Hematite : 3.74
Pyrite : 0.1	Wollastonite : 1.20
Chalcopyrite : 0.3	Enstatite : 1.03
Molybdenite : --	
100.0	

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂ :	68.00	: 67.6
Al ₂ O ₃ :	12.10	: --
Total Fe :	3.58	: 3.66
MgO :	1.01	: --
CaO :	1.72	: --
Na ₂ O :	2.46	: --
K ₂ O :	5.47	: --
Copper :		: .115

SAMPLE NUMBER: 4427

Rock Type: HRQM

Density: 2.69

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 22.8	Quartz	: 26.92
K-feldspar	: 32.3	Orthoclase	: 25.14
Plagioclase	: 40.1	Albite	: 32.49
Biotite	: 3.8	Anorthite	: 8.04
Chlorite	: 0.4	Hypersthene	: 2.64
K-mica	: --	Corundum	: 1.41
Epidote	: --	Hematite	: 3.09
Pyrite	: 0.6	Wollastonite	: --
Chalcopyrite	: --	Enstatite	: --
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 69.50	: 69.2
Al ₂ O ₃	: 15.05	: --
Total Fe	: 3.03	: 3.14
MgO	: 1.04	: --
CaO	: 1.59	: --
Na ₂ O	: 3.77	: --
K ₂ O	: 4.22	: --
Copper	:	: .115

SAMPLE NUMBER: 4428

Rock Type: QMP

Density: 2.76

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 24.1	Quartz	: 34.85
K-feldspar	: 28.8	Orthoclase	: 26.06
Plagioclase	: 40.4	Albite	: 25.05
Biotite	: 5.9	Anorthite	: 8.86
Chlorite	: --	Hypersthene	: 1.06
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 2.47
Pyrite	: 0.2	Wollastonite	: .88
Chalcopyrite	: 0.6	Enstatite	: .76
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 71.50	: 70.48
Al ₂ O ₃	: 12.40	: --
Total Fe	: 2.38	: 2.38
MgO	: 0.70	: --
CaO	: 2.13	: --
Na ₂ O	: 2.85	: --
K ₂ O	: 4.24	: --
Copper	:	: .100

SAMPLE NUMBER: 4429

Rock Type:

HRQM

Density: 2.81

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 15.8	Quartz	: 33.40
K-feldspar	: 20.6	Orthoclase	: 25.06
Plagioclase	: 61.0	Albite	: 25.81
Biotite	: 0.8	Anorthite	: 10.17
Chlorite	: 1.8	Hypersthene	: 1.72
K-mica	: --	Corundum	: 1.77
Epidote	: --	Hematite	: 2.08
Pyrite	: 0.6	Wollastonite	: --
Chalcopyrite	: 0.3	Enstatite	: --
Molybdenite	: --		
	<u>100.1</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 69.60	: 67.8
Al ₂ O ₃	: 14.44	: --
Total Fe	: 1.99	: 2.07
MgO	: 0.66	: --
CaO	: 1.96	: --
Na ₂ O	: 2.92	: --
K ₂ O	: 4.05	: --
Copper	:	: .075

SAMPLE NUMBER: 4430

Rock Type: QMP

Density: 2.71

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 25.0	Quartz	: 30.92
K-feldspar	: 32.9	Orthoclase	: 27.24
Plagioclase	: 37.9	Albite	: 26.74
Biotite	: 4.0	Anorthite	: 9.34
Chlorite	: --	Hypersthene	: 1.18
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 3.05
Pyrite	: --	Wollastonite	: .82
Chalcopyrite	: 0.2	Enstatite	: .71
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 73.00	: 71.4
Al ₂ O ₃	: 13.70	: --
Total Fe	: 3.07	: 3.11
MgO	: 0.76	: --
CaO	: 2.29	: --
Na ₂ O	: 3.18	: --
K ₂ O	: 4.64	: --
Copper	:	: .230

SAMPLE NUMBER: 4431

Rock Type: HRQM

Density: 2.72

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 19.0	Quartz	: 33.21
K-feldspar	: 19.2	Orthoclase	: 25.59
Plagioclase	: 55.0	Albite	: 24.96
Biotite	: --	Anorthite	: 6.45
Chlorite	: 3.1	Hypersthene	: 2.32
K-mica	: 2.3	Corundum	: 3.53
Epidote	: --	Hematite	: 3.95
Pyrite	: 1.4	Wollastonite	: --
Chalcopyrite	: --	Enstatite	: --
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 70.60	: 70.6
Al ₂ O ₃	: 15.32	: --
Total Fe	: 3.92	: 4.04
MgO	: 0.92	: --
CaO	: 1.29	: --
Na ₂ O	: 2.93	: --
K ₂ O	: 4.30	: --
Copper	:	: .115

SAMPLE NUMBER: 4432

Rock Type: HRQM

Density: 2.74

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 17.9	Quartz	: 34.15
K-feldspar	: 53.6	Orthoclase	: 35.69
Plagioclase	: 17.8	Albite	: 15.32
Biotite	: --	Anorthite	: 8.78
Chlorite	: 0.7	Hypersthene	: 1.99
K-mica	: 9.8	Corundum	: 0.90
Epidote	: --	Hematite	: 3.17
Pyrite	: 0.3	Wollastonite	: --
Chalcopyrite	: --	Enstatite	: --
Molybdenite	: --		
	<u>100.1</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 69.40	: 70.1
Al ₂ O ₃	: 13.00	: --
Total Fe	: 3.02	: 3.11
MgO	: 1.76	: --
CaO	: 1.69	: --
Na ₂ O	: 1.73	: --
K ₂ O	: 5.76	: --
Copper	:	: .030

SAMPLE NUMBER: 4433

Rock Type: QD

Density: 2.78

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 5.5	Quartz	: 20.71
K-feldspar	: --	Orthoclase	: 31.38
Plagioclase	: 63.5	Albite	: 29.79
Biotite	: 8.3	Anorthite	: 12.90
Chlorite	: 21.7	Hypersthene	: 2.02
K-mica	: --	Corundum	: 0.24
Epidote	: --	Hematite	: 2.97
Pyrite	: --	Wollastonite	: --
Chalcopyrite	: 0.8	Enstatite	: --
Molybdenite	: --		
	99.8		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 53.80	: 53.8
Al ₂ O ₃	: 13.00	: --
Total Fe	: 2.34	: 2.47
MgO	: 0.64	: --
CaO	: 2.05	: --
Na ₂ O	: 2.77	: --
K ₂ O	: 4.18	: --
Copper	:	: .680

SAMPLE NUMBER: 4434

Rock Type:

HRQM

Density: 2.75

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 27.4	Quartz	: 22.83
K-feldspar	: 33.1	Orthoclase	: 31.44
Plagioclase	: 35.4	Albite	: 29.11
Biotite	: 0.7	Anorthite	: 9.28
Chlorite	: 0.1	Hypersthene	: 2.17
K-mica	: 2.0	Corundum	: 1.82
Epidote	: --	Hematite	: 3.35
Pyrite	: 0.1	Wollastonite	: --
Chalcopyrite	: 1.1	Enstatite	: --
Molybdenite	: --		
	<u>99.9</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 62.80	: 65.0
Al ₂ O ₃	: 15.25	: --
Total Fe	: 3.07	: 3.09
MgO	: 0.80	: --
CaO	: 1.71	: --
Na ₂ O	: 3.15	: --
K ₂ O	: 4.88	: --
Copper	:	: .180

SAMPLE NUMBER: 4435

Rock Type: QMP

Density: 2.76

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 24.8	Quartz	: 32.80
K-feldspar	: 48.3	Orthoclase	: 28.01
Plagioclase	: 23.3	Albite	: 27.25
Biotite	: 3.4	Anorthite	: 8.19
Chlorite	: --	Hypersthene	: 1.67
K-mica	: --	Corundum	: 0.18
Epidote	: --	Hematite	: 1.89
Pyrite	: --	Wollastonite	: --
Chalcopyrite	: 0.1	Enstatite	: --
Molybdenite	: --		
	<u>99.9</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 70.90	: 70.6
Al ₂ O ₃	: 13.00	: --
Total Fe	: 1.81	: 1.94
MgO	: 0.64	: --
CaO	: 1.58	: --
Na ₂ O	: 3.08	: --
K ₂ O	: 4.53	: --
Copper	:	: .070

SAMPLE NUMBER: 4436

Rock Type: GMP

Density: 2.74

MINERALOGY

<u>Modal</u> <u>Percentage</u>	<u>Normative</u> <u>Percentage</u>
Quartz : 29.0	Quartz : 30.88
K-feldspar : 30.2	Orthoclase : 22.46
Plagioclase : 34.0	Albite : 30.72
Biotite : 2.4	Anorthite : 10.07
Chlorite : --	Hypersthene : 1.64
K-mica : 1.1	Corundum : 2.03
Epidote : --	Hematite : 2.20
Pyrite : 0.2	Wollastonite : --
Chalcopyrite : 2.8	Enstatite : --
Molybdenite : 0.2	
99.9	

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂ :	70.00	: 67.3
Al ₂ O ₃ :	15.40	: --
Total Fe :	2.14	: 2.13
MgO :	0.64	: --
CaO :	1.98	: --
Na ₂ O :	3.54	: --
K ₂ O :	3.70	: --
Copper :		: .040

SAMPLE NUMBER: 4437

Rock Type: QMP

Density: 2.84

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 25.7	Quartz	: 30.13
K-feldspar	: 30.4	Orthoclase	: 2.10
Plagioclase	: 38.1	Albite	: 29.19
Biotite	: 5.2	Anorthite	: 11.01
Chlorite	: --	Hypersthene	: 2.09
K-mica	: --	Corundum	: 2.32
Epidote	: --	Hematite	: 3.14
Pyrite	: 0.2	Wollastonite	: --
Chalcopyrite	: 0.3	Enstatite	: --
Molybdenite	: --		
	99.9		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 66.60	: 66.4
Al ₂ O ₃	: 15.19	: --
Total Fe	: 2.97	: 3.02
MgO	: 0.79	: --
CaO	: 2.10	: --
Na ₂ O	: 3.26	: --
K ₂ O	: 3.53	: --
Copper	: .195	

SAMPLE NUMBER: 4438

Rock Type: QMP

Density: 2.79

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 22.3	Quartz	: 31.24
K-feldspar	: 30.6	Orthoclase	: 24.29
Plagioclase	: 41.9	Albite	: 28.18
Biotite	: 5.0	Anorthite	: 10.68
Chlorite	: --	Hypersthene	: 1.85
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 2.54
Pyrite	: 0.2	Wollastonite	: 0.66
Chalcopyrite	: --	Enstatite	: 0.57
Molybdenite	: --		
	<u>100.0</u>		<u></u>

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 69.40	: 67.7
Al ₂ O ₃	: 13.20	: --
Total Fe	: 2.42	: 2.36
MgO	: 0.92	: --
CaO	: 2.36	: --
Na ₂ O	: 3.18	: --
K ₂ O	: 3.92	: --
Copper	:	: .080

SAMPLE NUMBER: 4439

Rock Type: GMP

Density: 2.71

MINERALOGY

<u>Modal</u> - - - - -	<u>Percentage</u>	<u>Normative</u> - - - - -	<u>Percentage</u>
Quartz	: 22.7	Quartz	: 33.25
K-feldspar	: 43.6	Orthoclase	: 17.55
Plagioclase	: 26.9	Albite	: 30.97
Biotite	: 3.9	Anorthite	: 9.72
Chlorite	: 1.3	Hypersthene	: 2.69
K-mica	: 1.2	Corundum	: 2.42
Epidote	: --	Hematite	: 3.38
Pyrite	: --	Wollastonite	: --
Chalcopyrite	: 0.4	Enstatite	: --
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 69.50	: 69.5
Al ₂ O ₃	: 14.75	: --
Total Fe	: 3.28	: 3.31
MgO	: 1.05	: --
CaO	: 1.90	: --
Na ₂ O	: 3.55	: --
K ₂ O	: 2.88	: --
Copper	:	: .230

SAMPLE NUMBER: 4440

Rock Type: ?GD

Density: 2.73

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	:	Quartz	: 42.30
K-feldspar	:	Orthoclase	: 25.41
Plagioclase	:	Albite	: 14.13
Biotite	:	Anorthite	: 9.68
Chlorite	:	Hypersthene	: 3.09
K-mica	:	Corundum	: --
Epidote	:	Hematite	: 4.00
Pyrite	:	Wollastonite	: 0.74
Chalcopyrite	:	Enstatite	: 0.64
Molybdenite	:		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 69.40	: 68.6
Al ₂ O ₃	: 10.10	: --
Total Fe	: 3.69	: 3.71
MgO	: 1.38	: --
CaO	: 2.13	: --
Na ₂ O	: 1.54	: --
K ₂ O	: 3.96	: --
Copper	:	: .080

SAMPLE NUMBER: 4441

Rock Type:

GMP

Density: 2.77

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 42.0	Quartz	: 29.86
K-feldspar	: 14.4	Orthoclase	: 21.33
Plagioclase	: 13.4	Albite	: 31.05
Biotite	: 1.3	Anorthite	: 11.11
Chlorite	: --	Hypersthene	: 2.29
K-mica	: 26.7	Corundum	: 2.14
Epidote	: --	Hematite	: 2.21
Pyrite	: 1.7	Wollastonite	: --
Chalcopyrite	: 0.4	Enstatite	: --
Molybdenite	: --		
	<u>99.9</u>		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 68.70	: 65.0
Al ₂ O ₃	: 15.59	: --
Total Fe	: 2.13	: --
MgO	: 0.89	: --
CaO	: 2.16	: 2.21
Na ₂ O	: 3.54	: --
K ₂ O	: 3.48	: --
Copper	:	: .055

SAMPLE NUMBER: 4442

Rock Type: QMP

Density: 2.84

MINERALOGY

<u>Modal</u> <u>Percentage</u>	<u>Normative</u> <u>Percentage</u>
Quartz : 30.2	Quartz : 30.03
K-feldspar : 35.2	Orthoclase : 23.82
Plagioclase : 28.1	Albite : 27.59
Biotite : 5.8	Anorthite : 11.86
Chlorite : --	Hypersthene : 1.92
K-mica : --	Corundum : 2.01
Epidote : --	Hematite : 2.79
Pyrite : 0.2	Wollastonite : --
Chalcopyrite : 0.2	Enstatite : --
Molybdenite : --	
99.7	

CHEMISTRY

<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂ : 68.10	: 64.4
Al ₂ O ₃ : 15.49	: --
Total Fe : 2.69	: 2.77
MgO : 0.74	: --
CaO : 2.30	: --
Na ₂ O : 3.14	: --
K ₂ O : 3.88	: --
Copper :	: .050

SAMPLE NUMBER: 4443

Rock Type: QMP

Density: 2.75

MINERALOGY

<u>Modal</u>	<u>Percentage</u>	<u>Normative</u>	<u>Percentage</u>
Quartz	: 21.3	Quartz	: 11.24
K-feldspar	: 27.7	Orthoclase	: 20.39
Plagioclase	: 47.9	Albite	: 36.64
Biotite	: 2.2	Anorthite	: 12.12
Chlorite	: --	Hypersthene	: 3.15
K-mica	: 0.9	Corundum	: --
Epidote	: --	Hematite	: 7.23
Pyrite	: --	Wollastonite	: 4.94
Chalcopyrite	: --	Enstatite	: 4.27
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 65.30	: 67.1
Al ₂ O ₃	: 16.15	: --
Total Fe	: 7.63	: 7.66
MgO	: 3.15	: --
CaO	: 5.10	: --
Na ₂ O	: 4.57	: --
K ₂ O	: 3.64	: --
Copper	: .140	

SAMPLE NUMBER: 4444

Rock Type: GMP

Density: 2.74

MINERALOGY

<u>Modal</u> <u>Percentage</u>	<u>Normative</u> <u>Percentage</u>
Quartz : 27.2	Quartz : 32.65
K-feldspar : 25.4	Orthoclase : 21.98
Plagioclase : 42.8	Albite : 28.94
Biotite : 4.3	Anorthite : 10.12
Chlorite : --	Hypersthene : 1.72
K-mica : --	Corundum : 2.75
Epidote : --	Hematite : 1.84
Pyrite : --	Wollastonite : --
Chalcopyrite : 0.1	Enstatite : --
Molybdenite : 0.1	
99.9	

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂ :	69.40	: 69.4
Al ₂ O ₃ :	15.49	: --
Total Fe :	1.77	: 1.93
MgO :	0.66	: --
CaO :	1.96	: --
Na ₂ O :	3.29	: --
K ₂ O :	3.58	: --
Copper :		: .070

SAMPLE NUMBER: 4445

Rock Type:

GMP

Density:

2.89

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 21.7	Quartz	: 31.06
K-feldspar	: 33.4	Orthoclase	: 21.93
Plagioclase	: 38.8	Albite	: 31.56
Biotite	: 6.0	Anorthite	: 11.05
Chlorite	: --	Hypersthene	: 1.46
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 2.38
Pyrite	: --	Wollastonite	: 0.30
Chalcopyrite	: 0.1	Enstatite	: 0.26
Molybdenite	: --		
	100.0		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 68.80	: 66.6
Al ₂ O ₃	: 13.40	: --
Total Fe	: 2.25	: 2.26
MgO	: 0.65	: --
CaO	: 2.24	: --
Na ₂ O	: 3.52	: --
K ₂ O	: 3.50	: --
Copper	:	: 0.60

SAMPLE NUMBER: 4446

Rock Type: QMP

Density: 2.82

MINERALOGY

<u>Modal</u> <u>Percentage</u>	<u>Normative</u> <u>Percentage</u>
Quartz : 25.4	Quartz : 30.90
K-feldspar : 28.1	Orthoclase : 17.79
Plagioclase : 41.2	Albite : 34.36
Biotite : 4.6	Anorthite : 11.36
Chlorite : --	Hypersthene : 1.89
K-mica : --	Corundum : 1.44
Epidote : --	Hematite : 2.27
Pyrite : 0.1	Wollastonite : --
Chalcopyrite : 0.6	Enstatite : --
Molybdenite : --	
100.0	

CHEMISTRY

<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂ : 71.20	: 68.9
Al ₂ O ₃ : 15.35	: --
Total Fe : 2.24	: 2.26
MgO : 0.75	: --
CaO : 2.26	: --
Na ₂ O : 4.01	: --
K ₂ O : 2.97	: --
Copper : .030	

SAMPLE NUMBER: 4447

Rock Type: QMP

Density: 2.78

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 27.3	Quartz	: 28.82
K-feldspar	: 24.7	Orthoclase	: 33.98
Plagioclase	: 42.6	Albite	: 25.72
Biotite	: 4.0	Anorthite	: 8.75
Chlorite	: 0.2	Hypersthene	: 1.01
K-mica	: 0.1	Corundum	: --
Epidote	: --	Hematite	: 1.52
Pyrite	: 0.3	Wollastonite	: 0.10
Chalcopyrite	: 0.2	Enstatite	: 0.08
Molybdenite	: 0.4		
	99.9		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 70.80	: 66.5
Al ₂ O ₃	: 14.00	: --
Total Fe	: 1.47	: 1.56
MgO	: 0.43	: --
CaO	: 1.76	: --
Na ₂ O	: 2.95	: --
K ₂ O	: 5.58	: --
Copper	: .	: .160

SAMPLE NUMBER: 4448

Rock Type: QD

Density: 2.91

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 10.0	Quartz	: 18.69
K-feldspar	: 0.7	Orthoclase	: 11.23
Plagioclase	: 62.5	Albite	: 18.95
Biotite	: 0.7	Anorthite	: 32.94
Chlorite	: 22.8	Hypersthene	: 7.47
K-mica	: 1.2	Corundum	: 0.99
Epidote	: 1.0	Hematite	: 9.73
Pyrite	: 1.2	Wollastōnite	: --
Chalcopyrite	: --	Enstatite	: --
Molybdenite	: --		
	100.1		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 51.30	: 52.1
Al ₂ O ₃	: 16.72	: --
Total Fe	: 8.65	: 8.69
MgO	: 2.67	: --
CaO	: 5.90	: --
Na ₂ O	: 1.99	: --
K ₂ O	: 1.69	: --
Copper	:	: .040

SAMPLE NUMBER: 4449

Rock Type: QD

Density: 2.88

MINERALOGY

<u>Modal</u> _ _ _ _ _	<u>Percentage</u>	<u>Normative</u> _ _ _ _ _	<u>Percentage</u>
Quartz	: 2.7	Quartz	: 14.34
K-feldspar	: --	Orthoclase	: 13.42
Plagioclase	: 57.7	Albite	: 31.05
Biotite	: 24.2	Anorthite	: 18.30
Chlorite	: 12.2	Hypersthene	: 5.71
K-mica	: --	Corundum	: --
Epidote	: --	Hematite	: 8.31
Pyrite	: 3.3	Wollastonite	: 4.75
Chalcopyrite	: --	Enstatite	: 4.10
Molybdenite	: --		
	100.1		

CHEMISTRY

	<u>A.A. Wt. %</u>	<u>X-ray Fluor. Wt. %</u>
SiO ₂	: 58.40	: 58.6
Al ₂ O ₃	: 14.65	: --
Total Fe	: 8.01	: 8.08
MgO	: 3.80	: --
CaO	: 5.76	: --
Na ₂ O	: 3.54	: --
K ₂ O	: 2.19	: --
Copper	: .030	

APPENDIX 3

Determination of Grains and Losses of Chemical Components from the Altered Rock

In an attempt to determine absolute gains and losses of various chemical compounds from the altered rocks at Sierrita, density measurements were made as explained in Appendix 2 and then multiplied by the weight percentage of each chemical compound present in the rock. Similar calculations were made for the unaltered Quartz diorite and quartz monzonitic rocks. Finally, the density corrected data for the altered rocks were compared with the density corrected unaltered rocks in order to determine the chemical gains and losses for 1000 cm³ of rock. These data were then presented in the form of isopleth maps in Plates 4, 6, 7, 8, and 10.

Sample Number P.T. Average Density 2.93

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	58.57	171.61
Al ₂ O ₃	16.48	24.14
Fe ₂ O ₃	8.95	13.11
CaO	6.48	18.99
MgO	3.94	11.54
Na ₂ O	3.55	5.20
K ₂ O	2.01	2.95

Sample Number P.T. Average Density 2.86

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	71.24	203.74
Al ₂ O ₃	16.62	23.77
Fe ₂ O ₃	3.20	4.58
CaO	2.07	5.92
MgO	.91	2.60
Na ₂ O	3.23	4.62
K ₂ O	4.43	6.33

Sample Number 4401

Density 2.86

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	67.53	193.14
Al ₂ O ₃	15.93	22.78
Fe ₂ O ₃	5.19	7.42
CaO	1.86	5.32
MgO	1.04	2.97
Na ₂ O	4.01	5.74
K ₂ O	4.44	6.35

Sample Number 4402

Density 2.93

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	59.09	173.13
Al ₂ O ₃	18.13	26.56
Fe ₂ O ₃	8.23	12.06
CaO	5.86	17.17
MgO	3.27	9.58
Na ₂ O	3.64	5.33
K ₂ O	1.77	2.59

Sample Number 4404

Density 2.92

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	57.42	167.67
Al ₂ O ₃	16.86	24.62
Fe ₂ O ₃	10.07	14.70
CaO	6.95	19.24
MgO	3.59	10.48
Na ₂ O	3.59	5.24
K ₂ O	1.53	2.23

Sample Number

4405

Density 2.94

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	59.95	176.25
Al ₂ O ₃	14.37	21.12
Fe ₂ O ₃	8.10	11.91
CaO	6.36	18.70
MgO	5.54	16.29
Na ₂ O	3.53	5.19
K ₂ O	2.15	3.16

Sample Number 4406 Density 2.97

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	60.09	178.47
Al ₂ O ₃	16.70	24.80
Fe ₂ O ₃	8.37	12.43
CaO	6.29	18.68
MgO	3.03	9.00
Na ₂ O	3.76	5.58
K ₂ O	1.77	2.63

Sample Number 4407 Density 2.93

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	60.58	177.50
Al ₂ O ₃	17.06	24.99
Fe ₂ O ₃	7.48	10.96
CaO	5.78	16.94
MgO	2.98	8.73
Na ₂ O	3.59	5.26
K ₂ O	2.53	3.71

Sample Number 4408

Density 2.87

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	57.59	165.28
Al ₂ O ₃	17.86	25.63
Fe ₂ O ₃	8.24	11.82
CaO	6.78	19.46
MgO	3.48	9.99
Na ₂ O	3.95	5.67
K ₂ O	2.09	3.00

Sample Number

4409

Density

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	68.25	189.05
Al ₂ O ₃	16.20	22.44
Fe ₂ O ₃	4.65	6.44
CaO	1.59	4.40
MgO	00.93	2.58
Na ₂ O	2.96	4.10
K ₂ O	5.42	7.51

Sample Number 4410 Density 2.70

Compound	Wt. % of Compound	Wt. % of Element after Density
SiO ₂	69.77	188.38
Al ₂ O ₃	14.75	19.91
Fe ₂ O ₃	4.51	6.02
CaO	1.58	4.27
MgO	1.04	2.81
Na ₂ O	3.38	4.56
K ₂ O	4.97	6.71

Sample Number 4411 Density 2.96

Compound	Wt. % of Compound	Wt. % of Element after Density
SiO ₂	57.96	171.56
Al ₂ O ₃	15.34	22.70
Fe ₂ O ₃	9.10	13.47
CaO	7.35	21.76
MgO	4.74	14.03
Na ₂ O	3.56	5.27
K ₂ O	1.94	2.87

Sample Number

4412

Density 2.88

CompoundWt. % of CompoundWt. % of Element
after DensitySiO₂

56.63

163.09

Al₂O₃

18.52

26.67

Fe₂O₃

8.56

12.33

CaO

6.84

19.70

MgO

3.17

9.13

Na₂O

4.19

6.03

K₂O

2.09

3.01

Sample Number

4413

Density 2.91

CompoundWt. % of CompoundWt. % of Element
after DensitySiO₂

58.40

169.94

Al₂O₃

14.86

21.62

Fe₂O₃

8.74

12.72

CaO

6.75

19.64

MgO

5.85

17.02

Na₂O

3.43

4.99

K₂O

1.97

2.87

Sample Number 4414 Density 2.95

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	59.18	174.58
Al ₂ O ₃	16.98	25.05
Fe ₂ O ₃	7.99	11.79
CaO	7.32	21.59
MgO	3.30	9.74
Na ₂ O	3.54	5.22
K ₂ O	1.68	2.48

Sample Number 4415 Density 2.71

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	73.69	199.64
Al ₂ O ₃	14.53	19.69
Fe ₂ O ₃	2.22	3.01
CaO	1.68	4.55
MgO	0.61	1.65
Na ₂ O	3.16	4.28
K ₂ O	4.10	5.56

Sample Number 4416 Density 2.90

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>67.97</u>	<u>197.11</u>
Al ₂ O ₃	15.65	22.69
Fe ₂ O ₃	4.69	6.80
CaO	2.36	6.84
MgO	1.27	3.68
Na ₂ O	3.79	5.50
K ₂ O	4.26	6.18

Sample Number 4417 Density 2.82

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>68.66</u>	<u>193.62</u>
Al ₂ O ₃	15.73	22.18
Fe ₂ O ₃	5.10	7.19
CaO	1.63	4.60
MgO	0.88	2.48
Na ₂ O	3.47	4.89
K ₂ O	4.52	6.37

Sample Number 4418 Density 2.94

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	56.44	165.93
Al ₂ O ₃	14.97	22.01
Fe ₂ O ₃	12.47	18.33
CaO	5.54	16.29
MgO	5.06	14.88
Na ₂ O	3.19	4.69
K ₂ O	2.34	3.44

Sample Number 4419 Density 2.98

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	57.24	170.58
Al ₂ O ₃	16.91	25.20
Fe ₂ O ₃	8.78	13.08
CaO	7.44	22.17
MgO	3.68	10.97
Na ₂ O	4.05	6.04
K ₂ O	1.91	2.85

Sample Number 4420 Density 2.89

Compound	Wt. % of Compound	Wt. % of Element after Density
<u> </u>	<u> </u>	<u> </u>
SiO ₂	59.69	173.10
Al ₂ O ₃	14.63	21.21
Fe ₂ O ₃	10.09	14.63
CaO	5.46	15.83
MgO	4.53	13.14
Na ₂ O	3.28	4.76
K ₂ O	2.32	3.36

Sample Number 4421 Density 2.80

Compound	Wt. % of Compound	Wt. % of Element after Density
<u> </u>	<u> </u>	<u> </u>
SiO ₂	72.36	202.25
Al ₂ O ₃	14.58	20.38
Fe ₂ O ₃	2.37	3.31
CaO	2.32	6.48
MgO	0.93	2.60
Na ₂ O	2.88	4.02
K ₂ O	4.56	6.37

Sample Number 4422 Density 2.78

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>71.49</u>	<u>198.74</u>
Al ₂ O ₃	15.27	21.23
Fe ₂ O ₃	2.18	3.30
CaO	2.71	7.53
MgO	0.96	2.67
Na ₂ O	3.36	4.67
K ₂ O	4.02	5.59

Sample Number 4423 Density 2.81

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>68.52</u>	<u>142.54</u>
Al ₂ O ₃	14.79	21.03
Fe ₂ O ₃	4.69	6.59
CaO	2.67	7.50
MgO	1.59	4.47
Na ₂ O	3.09	4.34
K ₂ O	4.65	6.53

Sample Number 4424 Density 2.78

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	71.53	198.85
Al ₂ O ₃	13.26	18.43
Fe ₂ O ₃	4.02	5.59
CaO	2.08	3.42
MgO	1.23	5.78
Na ₂ O	3.89	5.41
K ₂ O	3.99	5.55

Sample Number 4425 Density 2.74

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	68.44	187.53
Al ₂ O ₃	16.01	21.93
Fe ₂ O ₃	4.81	6.59
CaO	2.51	6.88
MgO	1.02	2.79
Na ₂ O	2.15	2.95
K ₂ O	5.06	6.93

Sample Number 4426 Density 2.70

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>72.12</u>	<u>194.72</u>
Al ₂ O ₃	12.83	17.32
Fe ₂ O ₃	3.74	5.05
CaO	1.82	4.91
MgO	1.07	2.89
Na ₂ O	2.61	3.52
K ₂ O	5.80	7.83

Sample Number 4427 Density 2.69

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>70.77</u>	<u>190.37</u>
Al ₂ O ₃	15.33	20.62
Fe ₂ O ₃	3.09	4.16
CaO	1.62	4.36
MgO	1.06	2.85
Na ₂ O	3.84	5.17
K ₂ O	4.30	5.78

Sample Number 4428 Density 2.76

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	74.32	205.37
Al ₂ O ₃	12.89	17.81
Fe ₂ O ₃	2.49	3.41
CaO	2.21	6.11
MgO	0.73	2.02
Na ₂ O	2.96	3.59
K ₂ O	4.41	6.09

Sample Number 4429 Density 2.81

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	72.79	204.54
Al ₂ O ₃	15.10	21.22
Fe ₂ O ₃	2.08	2.92
CaO	2.05	5.76
MgO	0.69	1.94
Na ₂ O	3.05	4.29
K ₂ O	4.24	5.96

Sample Number 4430 Density 2.71

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	72.54	196.58
Al ₂ O ₃	13.61	18.44
Fe ₂ O ₃	3.05	4.13
CaO	2.28	6.18
MgO	0.76	2.06
Na ₂ O	3.16	4.28
K ₂ O	4.61	6.25

Sample Number 4431 Density 2.72

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	71.11	193.42
Al ₂ O ₃	15.43	20.98
Fe ₂ O ₃	3.95	5.37
CaO	1.30	3.54
MgO	0.93	2.53
Na ₂ O	2.95	4.01
K ₂ O	4.33	5.89

Sample Number

4432

Density

CompoundWt. % of CompoundWt. % of Element
after DensitySiO₂

72.78

199.42

Al₂O₃

13.63

18.67

Fe₂O₃

3.17

4.34

CaO

1.77

4.85

MgO

0.80

2.19

Na₂O

1.81

2.48

K₂O

6.04

8.28

Sample Number

4433

Density 2.78

CompoundWt. % of CompoundWt. % of Element
after DensitySiO₂

68.29

177.86

Al₂O₃

16.50

21.49

Fe₂O₃

2.97

12.65

CaO

2.60

6.78

MgO

0.81

2.11

Na₂O

3.52

4.57

K₂O

5.31

6.91

Sample Number 4434 Density 2.75

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>68.51</u>	<u>188.40</u>
Al ₂ O ₃	16.64	22.88
Fe ₂ O ₃	3.35	4.61
CaO	1.87	5.14
MgO	0.87	2.39
Na ₂ O	3.44	4.73
K ₂ O	5.32	7.31

Sample Number 4435 Density 2.76

Compound	Wt. % of Compound	Wt. % of Element after Density
<u>SiO₂</u>	<u>74.21</u>	<u>204.82</u>
Al ₂ O ₃	13.61	18.78
Fe ₂ O ₃	1.89	2.61
CaO	1.65	4.55
MgO	0.67	1.85
Na ₂ O	3.22	4.44
K ₂ O	4.74	6.54

Sample Number 4436 Density 2.74

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	71.87	196.73
Al ₂ O ₃	15.81	21.66
Fe ₂ O ₃	2.20	3.01
CaO	2.03	5.56
MgO	0.66	1.81
Na ₂ O	3.63	4.97
K ₂ O	3.80	5.21

Sample Number 4437 Density 2.84

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	70.52	200.28
Al ₂ O ₃	16.08	22.83
Fe ₂ O ₃	3.14	4.46
CaO	2.22	6.31
MgO	0.84	2.39
Na ₂ O	3.45	4.90
K ₂ O	3.74	5.31

Sample Number 4438 Density 2.79

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	72.74	202.95
Al ₂ O ₃	13.84	19.31
Fe ₂ O ₃	2.54	3.54
CaO	2.47	6.89
MgO	0.97	2.71
Na ₂ O	3.33	4.65
K ₂ O	4.11	5.73

Sample Number 4439 Density 2.71

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	71.72	194.36
Al ₂ O ₃	15.22	20.62
Fe ₂ O ₃	3.38	4.58
CaO	1.96	5.31
MgO	1.08	2.93
Na ₂ O	3.66	4.96
K ₂ O	2.97	4.02

Sample Number 4440 Density 2.73

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	75.27	205.11
Al ₂ O ₃	10.95	14.92
Fe ₂ O ₃	4.00	5.54
CaO	2.31	6.30
MgO	1.50	4.09
Na ₂ O	1.67	2.28
K ₂ O	4.30	5.86

Sample Number 4441 Density 2.77

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	71.20	197.22
Al ₂ O ₃	16.16	22.38
Fe ₂ O ₃	2.21	3.06
CaO	2.24	6.21
MgO	0.92	2.55
Na ₂ O	3.67	5.08
K ₂ O	3.61	5.00

Sample Number 4442 Density 2.84

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	70.69	200.76
Al ₂ O ₃	16.08	22.83
Fe ₂ O ₃	2.79	3.96
CaO	2.39	6.79
MgO	0.77	2.19
Na ₂ O	3.26	4.63
K ₂ O	4.03	5.73

Sample Number 4444 Density 2.74

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	72.18	203.19
Al ₂ O ₃	16.11	22.67
Fe ₂ O ₃	1.84	2.59
CaO	2.04	4.16
MgO	0.69	1.94
Na ₂ O	3.42	4.81
K ₂ O	3.72	5.24

Sample Number

4445

Density

2.89

CompoundWt. % of CompoundWt. % of Element
after DensitySiO₂

72.91

210.95

Al₂O₃

14.20

20.54

Fe₂O₃

2.38

3.44

CaO

2.37

6.86

MgO

0.69

2.00

Na₂O

3.73

6.96

K₂O

3.71

5.37

Sample Number

4446

Density

2.82

CompoundWt. % of CompoundWt. % of Element
after DensitySiO₂

72.08

203.51

Al₂O₃

15.54

21.94

Fe₂O₃

2.27

2.58

CaO

2.29

6.47

MgO

0.76

2.15

Na₂O

4.06

5.73

K₂O

3.01

4.25

Sample Number 4447

Density 2.78

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	73.00	202.58
Al ₂ O ₃	14.43	20.02
Fe ₂ O ₃	1.52	2.11
CaO	1.81	5.02
MgO	0.44	1.22
Na ₂ O	3.04	4.22
K ₂ O	5.75	7.98

Sample Number 4448

Density 2.91

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	57.69	167.59
Al ₂ O ₃	18.80	27.31
Fe ₂ O ₃	9.73	14.13
CaO	6.64	19.29
MgO	3.00	8.72
Na ₂ O	2.24	3.25
K ₂ O	1.90	2.76

Sample Number 4449

Density 2.88

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂	60.61	174.25
Al ₂ O ₃	15.20	21.85
Fe ₂ O ₃	8.31	11.95
CaO	5.98	17.19
MgO	3.94	11.33
Na ₂ O	3.67	6.73
K ₂ O	2.27	3.26

Sample Number

Density

<u>Compound</u>	<u>Wt. % of Compound</u>	<u>Wt. % of Element after Density</u>
SiO ₂		
Al ₂ O ₃		
Fe ₂ O ₃		
CaO		
MgO		
Na ₂ O		
K ₂ O		

APPENDIX 4
Computer Programs

IMPLICIT REAL*8(A-H,O-Z)

NORMCOMP - A FORTRAN IV PROGRAM TO CALCULATE CIPW AND MOLE PERCENTS	NORM	10
PROGRAM IS BASED ON THE CALCULATION METHOD OF C. KELSEY	NORM	20
ATOMIC WEIGHTS ARE BASED ON 1959 TABLE (O=16.000)		
EACH ANALYSIS:	NORM	35
CARD INPUT ORDER. THE FOLLOWING TWO CARDS ARE REQUIRED FOR	NORM	30
CARD # 1: CONTROL CARD TO DETERMINE CALC OF SULFUR AND CO ₂ .	NORM	40
A ONE IN COLUMN ONE CAUSES SO ₃ TO BE CALCULATED AS SO ₃ .	NORM	45
A BLANK OR ZERO RESULTS IN CALCULATION OF SO ₃ AS S.	NORM	50
A ONE IN COLUMN TWO RESULTS IN CALCULATION OF SODIUM CARBONATE	NORM	55
A BLANK OR ZERO CAUSES CALCULATION OF CALCITE	NORM	60
	NORM	65
CARD #2: DATA CARD. FORMAT(A5,14F4.2,6F3.2)	NORM	70
COLUMNS 1-5: ANY COMBINATION OF NUMBERS OR LETTERS.	NORM	75
COLUMNS 6-61, IN BLOCKS OF 4, THE WT % OXIDES IN THE ORDER:	NORM	80
SiO ₂ , TiO ₂ , Al ₂ O ₃ , Fe ₂ O ₃ , FeO, MnO, MgO, CaO, Na ₂ O, K ₂ O, P ₂ O ₅ , B ₂ O ₃ , SrO,	NORM	85
AND Cr ₂ O ₃ .	NORM	90
COLUMNS 62-79: IN BLOCKS OF 3, THE WT % OF F, Cl, SO ₃ , S, CO ₂ , ZrO ₂	NORM	95
	NORM	100
A CARD WITH A 9 IN COLUMN ONE SHOULD BE PLACED AT THE END OF THE	NORM	105
DATA CARDS TO STOP THE PROGRAM.	NORM	110
*****	NORM	115
	NORM	120
REAL*8 M(20),N(39),MN(38),PM(20),W(20)	NORM	125
LOGICAL*1 ID(5)	NORM	130
REAL*8 MW(20)/60.09,79.90,101.96,159.70,71.85,70.94,40.32,56.08,61.05,	NORM	135
1.982,94.20,141.95,153.36,103.63,151.02,19.35,45.7,80.066,32.066,44.06,	NORM	140
1.011,123.22/,MMW(38)/154.29,316.34,436.52,122.07,556.70,524.482,27.01,	NORM	145
18.22,284.122,60.09,0.0,140.73,203.79,86.125,0.0,100.41,131.54,0.0,	NORM	150
1232.34,200.82,263.88,116.17,231.02,329.88,151.75,196.07,79.90,135.0,	NORM	155
198,101.96,231.55,159.70,225.87,58.488,78.08,145.439,119.992,105.99,	NORM	160
13.100,091.183,31/	NORM	165
LOGICAL*4 NNA(38)/'KS','KP','LC','NS','OR','AB','AN','NE','O','OL','FO','FA','LN','HY','EN','FS','DN','I','WO','EN','FS','WO','AC','AP','IL','SP','RU','PV','C','MT','HEM','CH','HL','FR','TH','PR','INC','CC','Z','/,'OXA(20)/'SiO ₂ ','TiO ₂ ','Al ₂ O ₃ ','Fe ₂ O ₃ ','FeO','MnO','MgO','CaO','Na ₂ O','K ₂ O','P ₂ O ₅ ','B ₂ O ₃ ','SrO','Cr ₂ O ₃ ','F','CL','SO ₃ ','S','CO ₂ ','ZrO ₂ /'	NORM	170
1,'OXA(20)/2*' ,,'3' ,,'3' ,,'9*' ,,'3' ,,'6*' /	NORM	175
INTEGER*4 MAI(7)/5,3,3,4,8,8,5/,MBI(7)/2,10,9,9,3,2,4/,MAI(7)/24,5,	NORM	180
1,6,22,7,25,29/,NBI(7)/39,1,39,4,28,26,30/,INTN(38)	NORM	185
REAL*8 ZNB(7)/0.0,1.0,0.0,1.0,0.0,0.0,0.0/,YFAC(7)/0.0,6.0,6.0,4.0,	NORM	190
1,2.0,1.0,0.0/	NORM	195
INTEGER*4 NCI(5)/14,25,6,5,21/,NDI(5)/10,27,8,3,13/	NORM	200
REAL*8 BFAC(5)/2.,1.,.25,.50,2./,CFAC(5)/1.,1.,.25,.50,1./,DFAC(5)	NORM	205
1/2.,1.,1.,1.,2./,EFAC(5)/2.,1.,.25,.50,2./	NORM	210
IREAD=5	NORM	215
IPRINT=6	NORM	220
IPUNCH = 7	NORM	225
	NORM	230
	NORM	235
	NORM	240
	NORM	245
	NORM	250
	NORM	255

1 READ (IREAD,28) NSO₃, NCO₂
 IF (NSO₃.EQ.9) GO TO 27

WSUM=0.0	NORM 270
READ (IREAD,29)ID,(W(I),I=1,20)	
DO 3 I=1,20	NORM 275
3 WSUM=WSUM+W(I)	NORM 280
ZERC NORM VECTOR	NORM 285
DO 4 I=1,38	NORM 290
4 N(I)=0.0	NORM 295
CALC MOLE PROPORTIONS	NORM 300
BSUM=0.0	NORM 305
DO 5 I=1,20	NORM 310
M(I)=W(I)/MW(I)	NORM 315
PM(I)=M(I)	NORM 320
5 BSUM=BSUM+M(I)	NORM 325
DO 6 I=1,20	NORM 330
6 PM(I)=PM(I)/(BSUM*0.01)	NORM 335
IF (NSO3.EQ.1) GO TO 7	NORM 340
M(18)=M(17)+M(18)	NORM 345
M(17)=0.0	NORM 350
BEGIN NORM CALCULATIONS	NORM 355
7 N(38)=M(20)	NORM 360
Y=N(38)	NORM 365
M(5)=M(5)+M(6)	NORM 370
M(8)=M(8)+M(12)+M(13)	NORM 375
N(23)=M(11)	NORM 380
M(8)=M(8)-3.3*M(11)	NORM 385
IF (M(15).LT.0.6667*N(23)) GO TO 8	NORM 390
M(15)=M(15)-(0.6667*N(23))	NORM 395
N(33)=M(15)/2.0	NORM 400
M(8)=M(8)-N(33)	NORM 405
8 M(15)=0.0	NORM 410
N(32)=M(16)	NORM 415
M(9)=M(9)-(N(32)/2.0)	NORM 420
N(34)=M(17)	NORM 425
M(9)=M(9)-N(34)	NORM 430
N(35)=M(18)/2.0	NORM 435
M(5)=M(5)-N(35)	NORM 440
IF (NCO2.EQ.1) GO TO 9	NORM 445
CO2 = 0.0	NORM 446
IF (M(19).GT.M(8)) CO2 = M(19)-M(8)	NORM 447
N(37)=M(19) - CO2	NORM 450
M(8)=M(8)-N(37)	NORM 455
M(19) = CO2	NORM 456
9 N(36)=M(19)	NORM 460
M(9)=M(9)-N(36)	NORM 465
N(31)=M(14)	NORM 470
M(5)=M(5)-M(14)	NORM 475
DO 12 I=1,7	NORM 485
NA=NAI(I)	NORM 490
NB=NBI(I)	NORM 495
MA=MAI(I)	NORM 500
MB=MBI(I)	NORM 505
IF (M(MA)-M(MB)) 10,11,11	NORM 510
10 N(NA)=M(MA)	NORM 515

M(MB)=M(MB)-M(MA)	NORM 520
M(MA)=0.0	NORM 525
N(NB)=M(MB)	NORM 530
Y=Y+YFAC(I)*N(NA)+(N(NB)*ZNB(I))	NORM 535
GO TO 12	NORM 540
11 N(NA)=M(MB)	NORM 545
M(MA)=M(MA)-M(MB)	NORM 550
M(MB)=0.0	NORM 555
Y=Y+YFAC(I)*N(NA)	NORM 560
12 CONTINUE	NORM 561
XMGFE=M(5)+M(7)	NORM 565
RMGFE=M(7)/XMGFE	NORM 570
IF (M(8)-XMGFE) 14,13,13	NORM 575
13 N(17)=XMGFE	NORM 580
M(8)=M(8)-XMGFE	NORM 585
N(21)=M(8)	NORM 590
Y=Y+2.0*N(17)+N(21)	NORM 595
GO TO 15	NORM 600
14 N(17)=M(8)	NORM 605
XMGFE=XMGFE-M(8)	NORM 610
N(14)=XMGFE	NORM 615
Y=Y+2.0*N(17)+N(14)	NORM 620
15 IF (M(1)-Y) 17,16,16	NORM 625
16 N(9)=M(1)-Y	NORM 630
GO TO 23	NORM 635
17 D=Y-M(1)	NORM 640
DO 20 I=1,5	NORM 645
NA=NCI(I)	NORM 650
NB=NDI(I)	NORM 655
IF (D-(N(NA)/BFAC(I))) 18,18,19	NORM 660
18 N(NA)=N(NA)-BFAC(I)*D	NORM 665
N(NB)=D*CFAC(I)	NORM 670
GO TO 23	NORM 675
19 N(NB)=N(NA)/DFAC(I)	NORM 680
D=D-N(NA)/EFAC(I)	NORM 685
N(NA)=0.0	NORM 690
20 CONTINUE	NORM 695
IF (D-N(17)) 21,21,22	NORM 700
21 N(13)=N(13)+D/2.0	NORM 705
N(10)=N(10)+D/2.0	NORM 710
N(17)=N(17)-D	NORM 715
GO TO 23	NORM 720
22 N(13)=N(13)+N(17)/2.0	NORM 725
N(10)=N(10)+N(17)/2.0	NORM 730
D=D-N(17)	NORM 735
N(17)=0.0	NORM 740
N(2)=D/2.0	NORM 745
N(3)=N(3)-D/2.0	NORM 750
23 R=1.0-RMGFE	NORM 755
N(11)=RMGFE*N(10)	NORM 760
N(12)=R*N(10)	NORM 765
N(15)=N(14)*RMGFE	NORM 770
N(16)=N(14)*R	NORM 775


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N(18)=N(17)/2.0
N(19)=N(18)*RMGFE
N(20)=N(18)*R
N(22)=N(22)*2.0
ASUM=0.0
CALC MOLE NORM
DO 24 I=1,38
24 ASUM=ASUM+N(I)
ASUM=ASUM-(N(10)+N(14)+N(17))
ASUM=ASUM/100.0
DO 25 I=1,38
25 MN(I)=N(I)/ASUM
ASUM=0.0
CONVERT FROM NORM RATIOS TO WEIGHT NORM
DO 26 I=1,38
N(I)=N(I)*MMW(I)
26 ASUM=ASUM+N(I)
N(10)=N(11)+N(12)+N(13)
N(14)=N(15)+N(16)
N(17)=N(18)+N(19)+N(20)
WRITE (IPRINT,30) ID
WRITE (IPRINT,31)
WRITE (IPRINT,32) (OXA(I), OXB(I), W(I), PM(I), NNA(I), N(I), MN(I), I=1,2
10)
WRITE (IPRINT,33) (NNA(I), N(I), MN(I), I=21,38)
WRITE (IPRINT,34) WSUM, ASUM
CALL PETCAL(W, PM, N, MN)
GO TO 1
27 STOP

28 FORMAT (2I1)
29 FORMAT (5A1,14F4.2,6F3.2)
30 FORMAT ('1',T25,'SAMPLE NUMBER '5A1)
$
SY004I CCMMA*****
31 FORMAT ('0',T3,'OXIDE'T11,'WT PCT',T19,'MOLE PCT',T32,'NORMATIVE MNORM 935
$
SY004I CCMMA*****
31 MINERALS',T53,'WT PCT',T62,'MOLE PCT')
32 FORMAT(' ',T2,2A4,T11,F5.2,T20,F5.2,T38,A4,T53,F5.2,T63,F5.2)
33 FORMAT(' ',T38,A4,T53,F5.2,T63,F5.2)
34 FORMAT('0',T10,F6.2,T52,F6.2)

END

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NORM 80
 NORM 785
 NORM 790
 NORM 795
 NORM 800
 NORM 805
 NORM 810
 NORM 815
 NORM 820
 NORM 830
 NORM 835
 NORM 840
 NORM 845
 NORM 850
 NORM 855
 NORM 860
 NORM 865
 NORM 870
 NORM 875
 NORM 880
 NORM 885
 NORM 890
 NORM 891
 NORM 8895
 NORM 900
 NORM 902
 NORM 905
 NORM 910
 NORM 915
 NORM 920
 NORM 925
 NORM 930
 NORM 935
 NORM 940
 NORM 945
 NORM 950
 NORM 955
 NORM 960
 NORM 965

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      REAL CAC01/0./,C02/0./,CAC03/0./,F1/0./,P205/0./,APAT/0./,FLUO/0./
      3,FE01/0./,TI02/0./,F/0./,
      1FE0/0./,ILME/0./,SI021/0./,SPHE/0./,Q/0./,AL203/0./,NA20/0./,ALB/
      10./,SI02/0./,ACMI/0./,K20/0./,
      2ORTH/0./,CAN/0./,ANOR/0./,WOLL/0./,ALBN/0./,ORTHN/0./,ANORN/0./,MN
      40/0./,MGN/0./
      LOGICAL*1 ID(5)
      INTEGER CHEK /'END' /, FLAG
100 READ(5,1)FLAG, ID, SI02, TI02, AL203, FE203, FE0, MNO,
      1MGN, CAN, NA20, K20, P205, BE0, SR0, CR203, F, CL, SO3,
      2S, C02, 7R02
      1 FORMAT (A4,/,5A1,14F4.2,6F3.2)
      IF(FLAG.EQ.CHEK) GO TO 901
      WRITE(6,10) ID, SI02, TI02, AL203, FE203, FE0, MNO,
      1MGN, CAN, NA20, K20, P205, BE0, SR0, CR203, F, CL, SO3, S,
      2C02, 7R02
10  FORMAT('1',130(' ')/'OSAMPLE',5A1, ' INPUT IS'///1X,22(1X,F5.2))
      IF(C02.EQ.0)GO TO 110
      CAC01=C02*1.274
      CAC03=C02*2.274
110 IF(P205.LE.0)GO TO 120
      CAC01=CAC01+P205*.948
      F1=P205*.064
      APAT=P205*1.705
120 IF(F.LE.0)GO TO 130
      CAC01=CAC01*1.476*F
      FLUO=F*2.055
130 IF(TI02.LE.0)GO TO 145
      FE01=TI02*.899
      IF((FE0-FE01).GT.0)GO TO 144
      CAC01=CAC01+TI02*.702
      SI021=TI02*.752
      SPHE=TI02*2.454
      GO TO 145
144 ILME=TI02*1.899
145 CAC01=CAC01-CAC01
      Q=AL203/1.645
      IF(Q.GE.NA20)GO TO 160
      ALB=8.462*Q
      AL203=Q
      SI02=SI02-5.817*Q
      NA20=NA20-Q
      Q=FE0/2.318
      IF(Q.GE.NA20)Q=NA20
      IF(Q.EQ.0)GO TO 500
      FE0=FE0-Q*2.318
      SI02=SI02-Q*3.878
      ACMI=7.197*Q
      GO TO 500
160 ALB=NA20*8.462
      AL203=AL203-1.645*NA20
      SI02=SI02-5.817*NA20
      Q=AL203/1.082

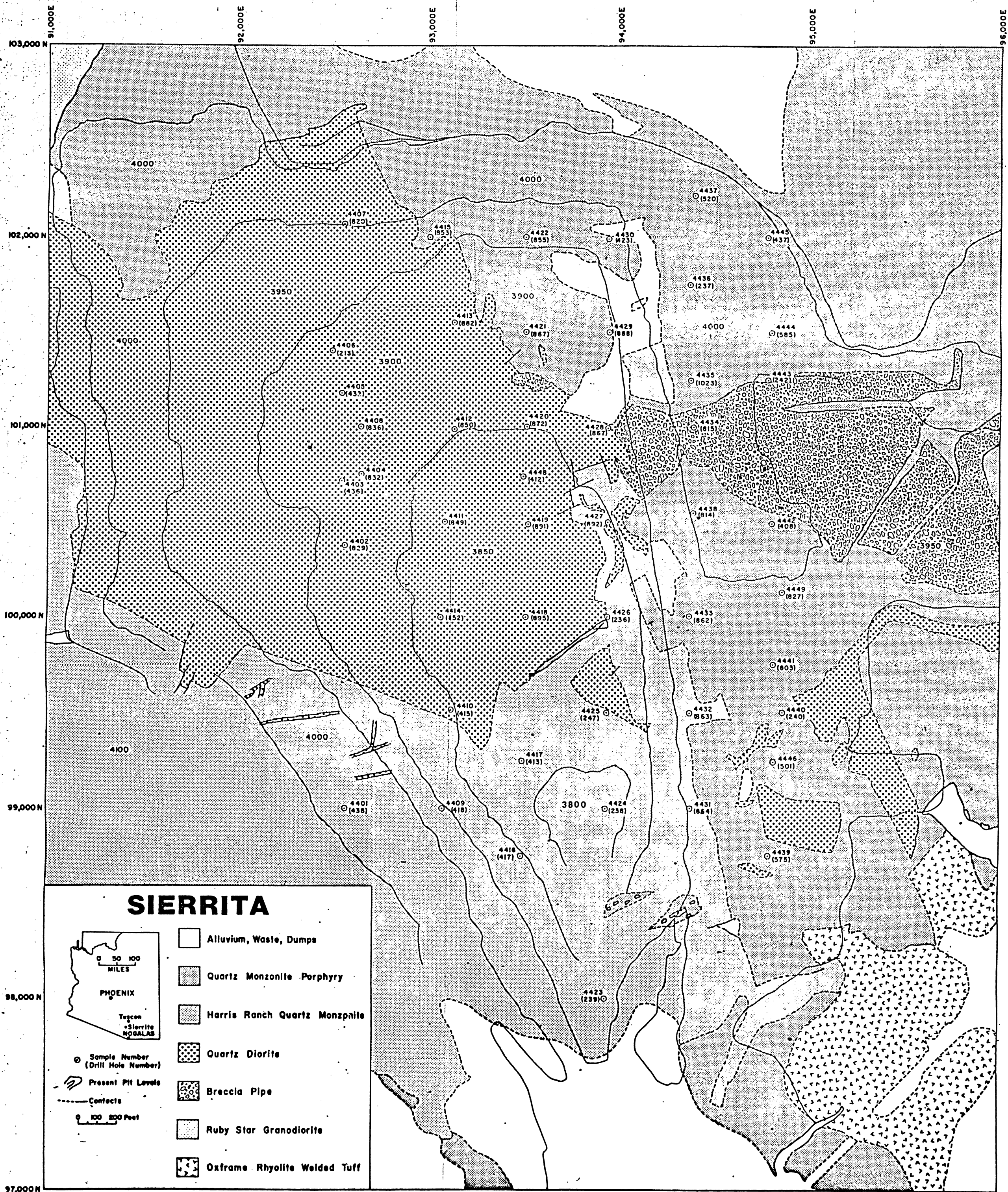
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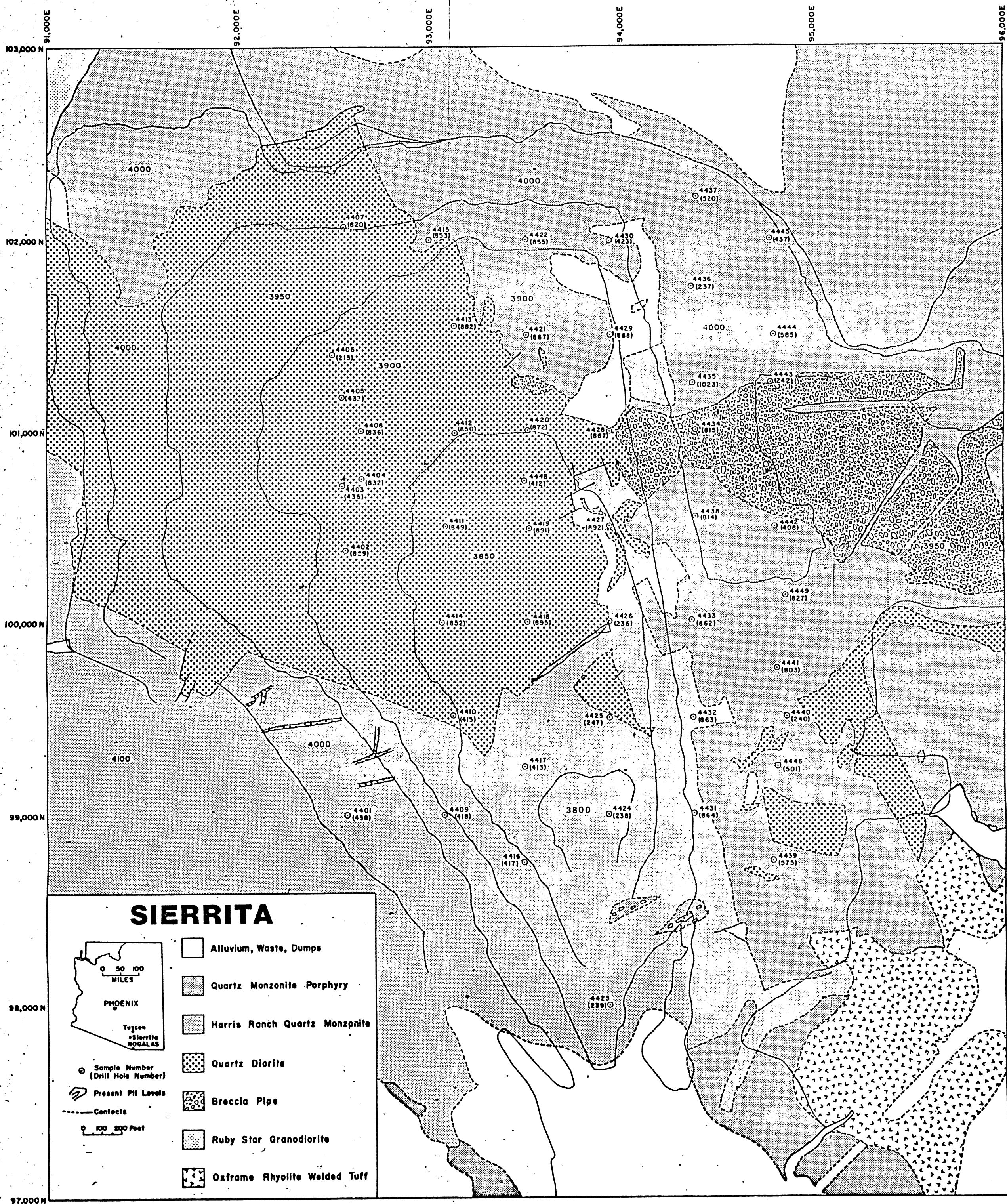
IF(O.FO.O)GO TO 500
IF(O.GF.K20)O=K20
AL203=AL203-1.082*O
SI02=SI02-3.827*O
ORTH=5.910*O
K20=K20-O
O=AL203/1.818
IF(O.LF.O)GO TO 500
IF(O.GF.CA0)O=CA0
AL203=AL203-1.818*O
SI02=SI02-2.143*O
ANOR=O*4.961
IF(O.GF.CA0)GO TO 500
CA0=CA0-O
SI02=SI02-CA0*1.072
WOLL=2.077*CA0
500 ALBN=ALB/262.2
ORTHN=ORTH/278.4
ANORN=ANOR/278.2
Q=100/(ALBN+ORTHN+ANORN)
ALBN=Q*ALBN
ORTHN=Q*ORTHN
ANORN=Q*ANORN
WRITE(6,11)CAC03,ALBN,APAT,ORTHN,SPHE,ANORN,
1 FLUO,ALB,ORTH,ANOR,ACMI,WOLL
11 FORMAT('1',130('1-1)/T13,'WEIGHT PERCENT',T45,'MGLE PERCENT'/
1T10,19('1-1),T40,19('1-1)
1/T10,'CALCITE',T20,F9.4,T40,'ALBITE',T50,F9.4
2/T10,'APATITE',T20,F9.4,T40,'ORTHOCLASE',T50,F9.4
3/T10,'SPHENE',T20,F9.4,T40,'ANORTHITE',T50,F9.4
4/T10,'FLUORITE',T20,F9.4/T10,'ALBITE',T20,F9.4
5/T10,'ORTHOCLASE',T20,F9.4/T10,'ANORTHITE',T20,F9.4
6/T10,'ACMITE',T20,F9.4
7/T10,'WOLLASTONITE',F8.4/131('1-1))
WRITE(6,12)SI02,TIO2,AL203,FE2O3,FE0,MNO,MGO,
12 CA0,NA2O,K2O,P2O5,BEC,SRO,CR2O3,F,CL,S03,S,CO2,ZRO2
FORMAT('1-RESIDUALS'/1X,20(1X,F5.2))
GO TO 100
901 WRITE(6,13)
13 FORMAT('1',20('*'),'END OF DATA',20('*'))
CALL EXIT
END

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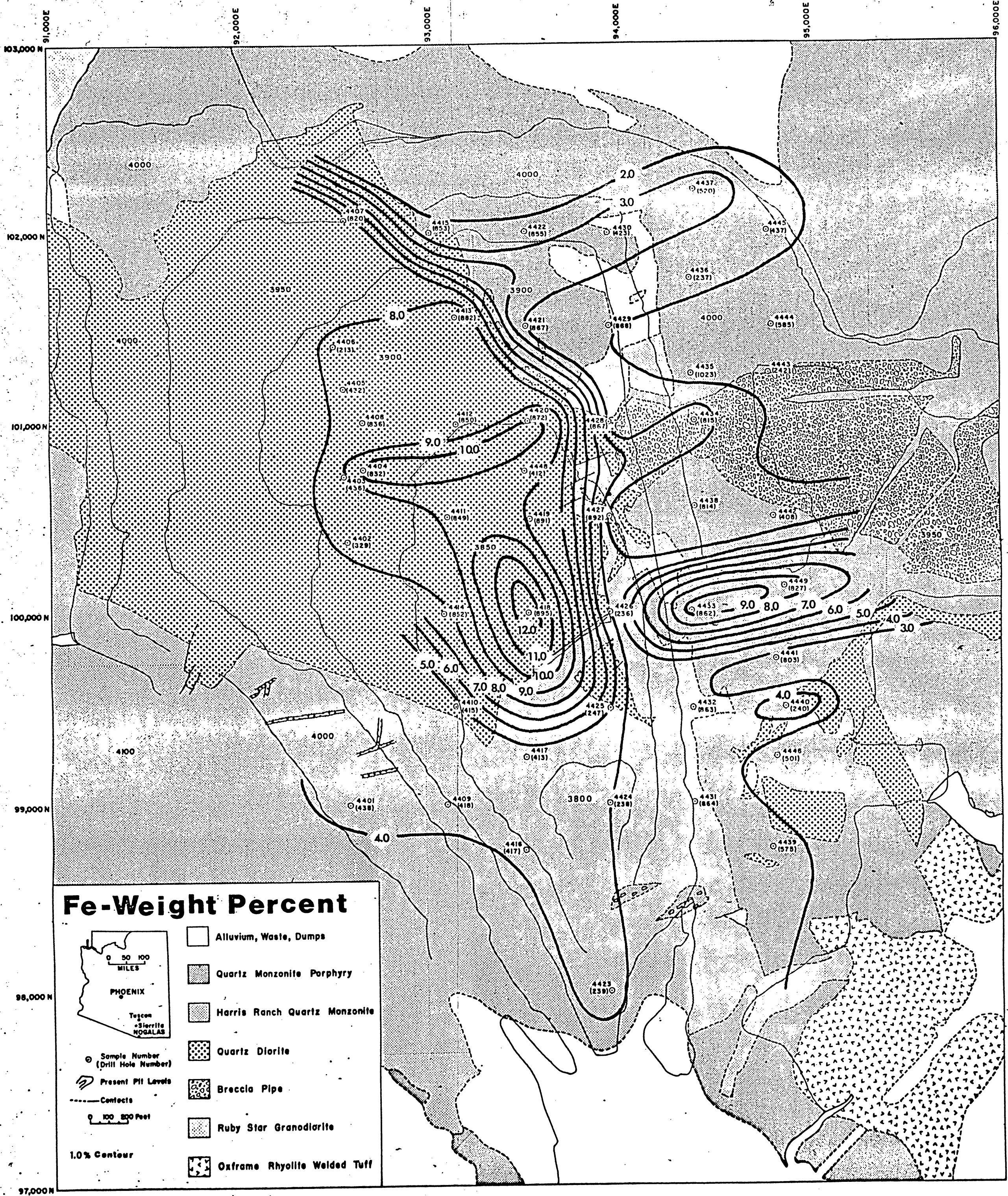
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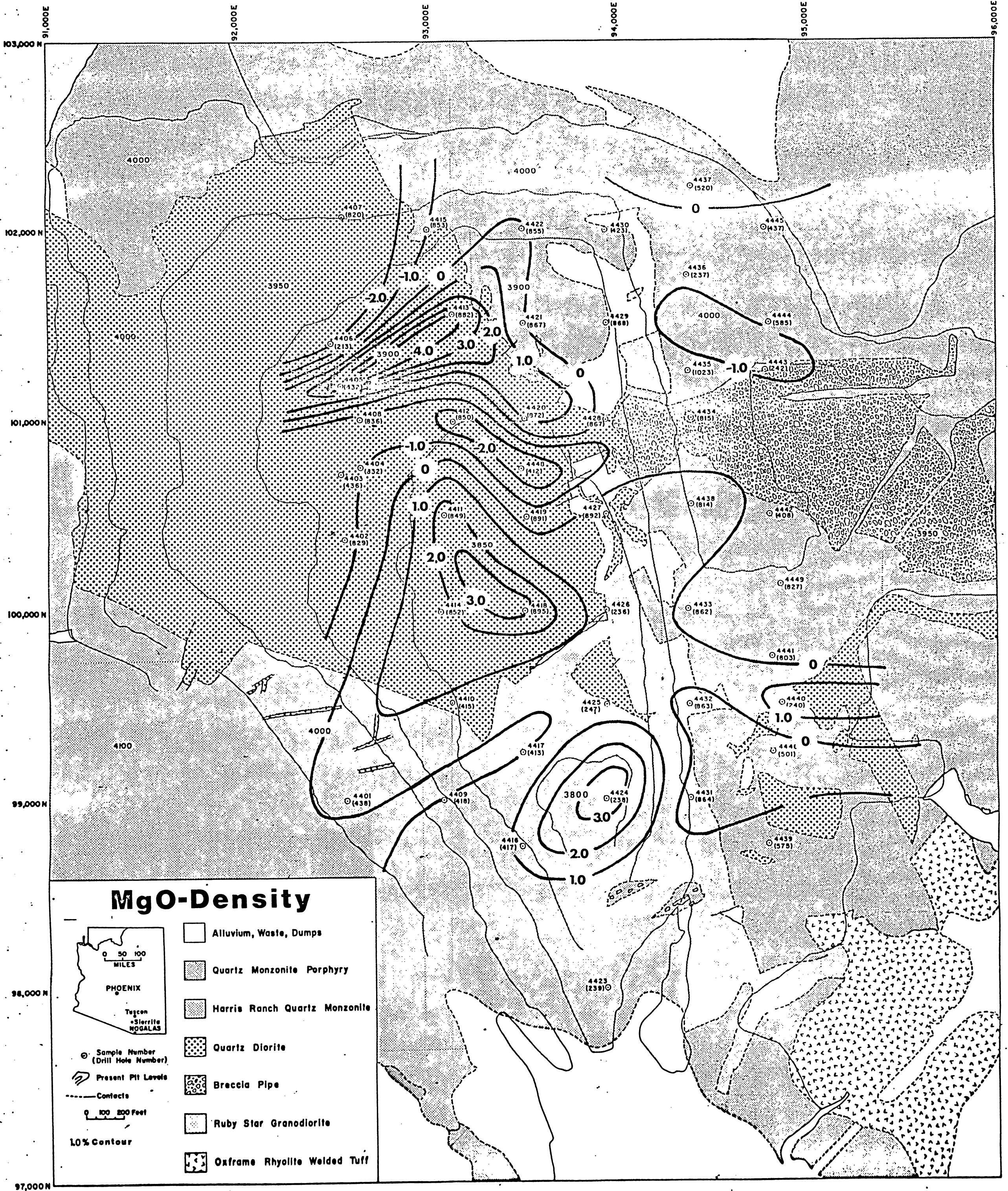
C.U.
157.72
.H5
plate 1

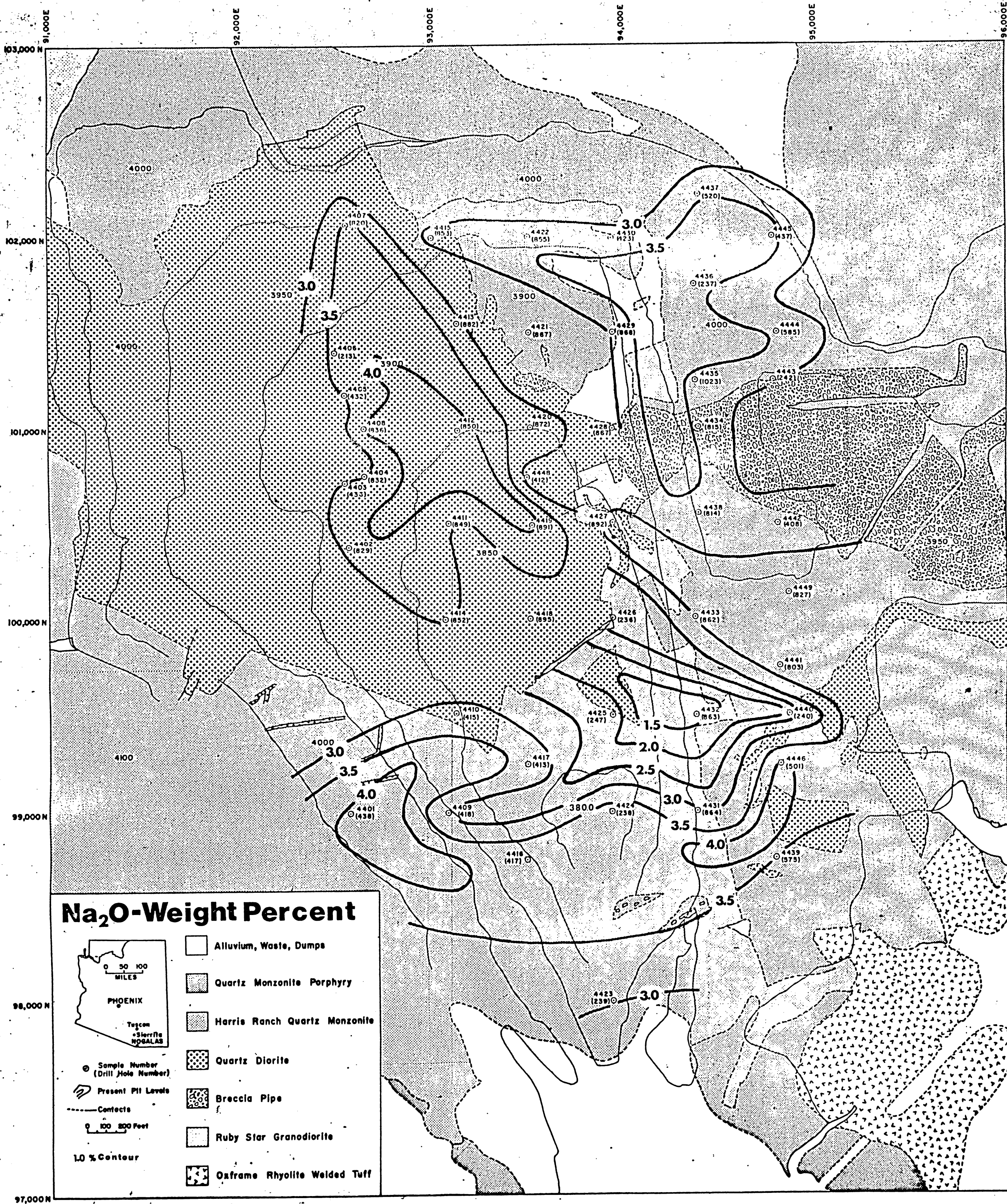


C.U.
157.72
H5
plate
(dup.)

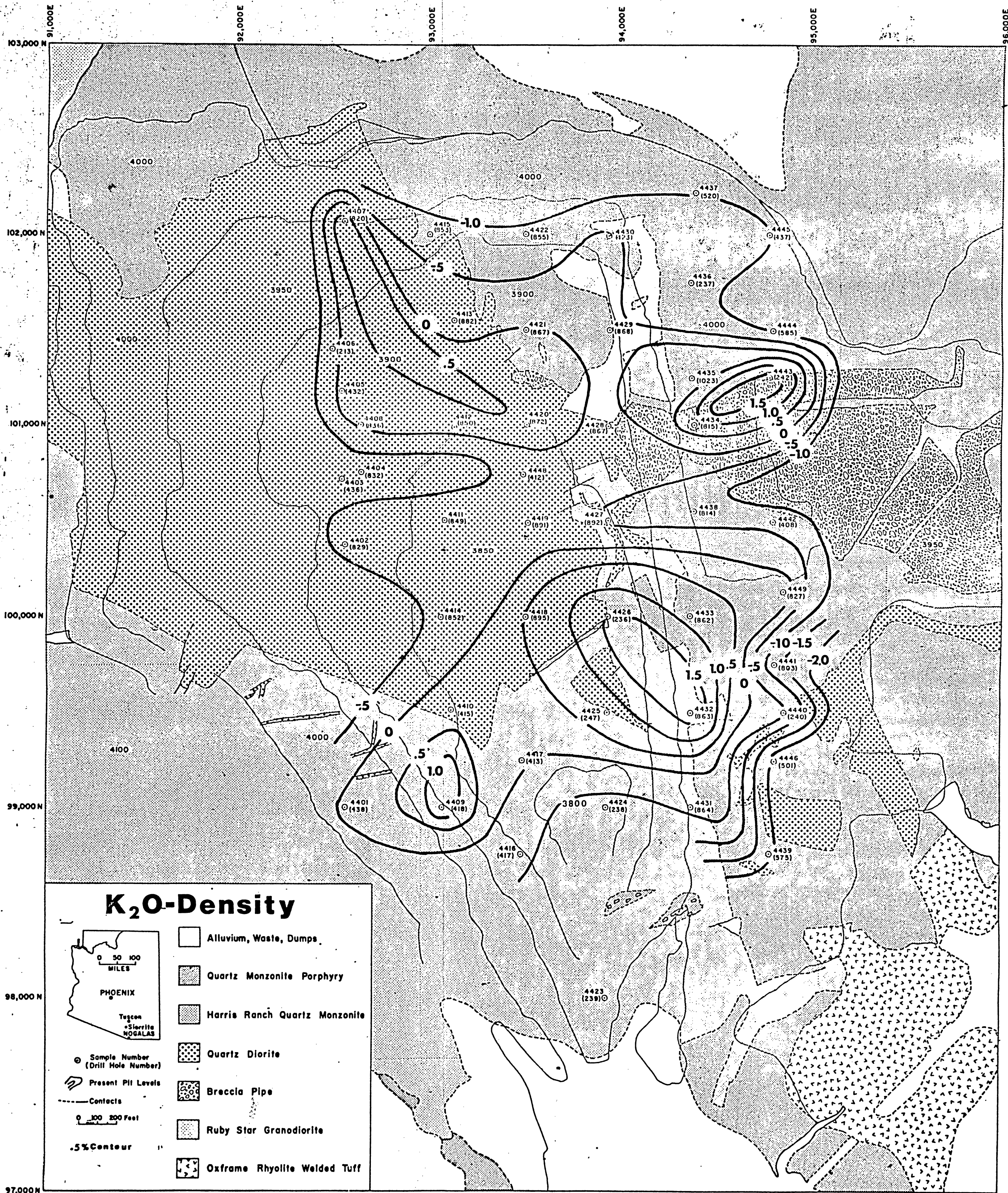


C.V.
157.72
H5
plate 9

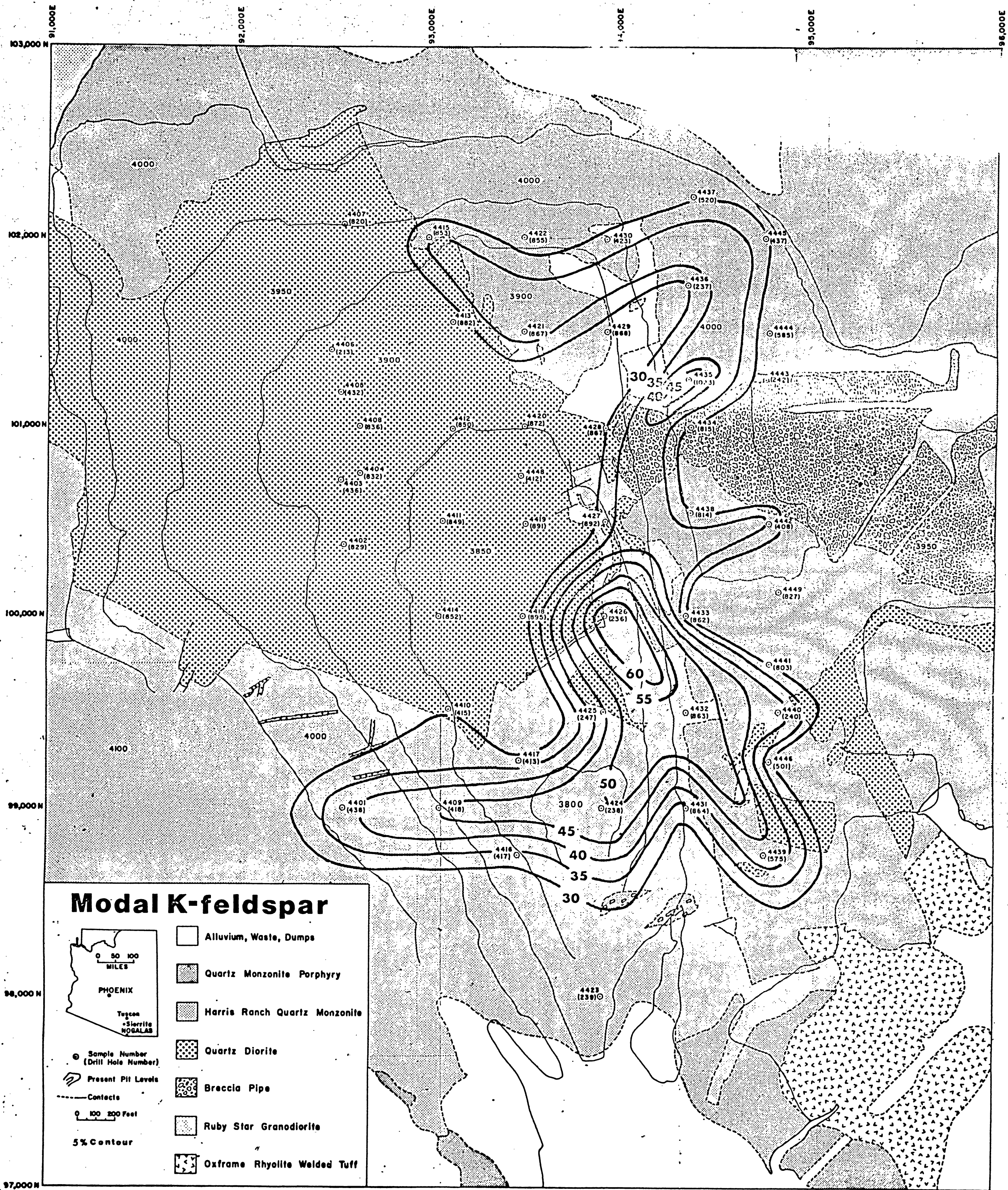




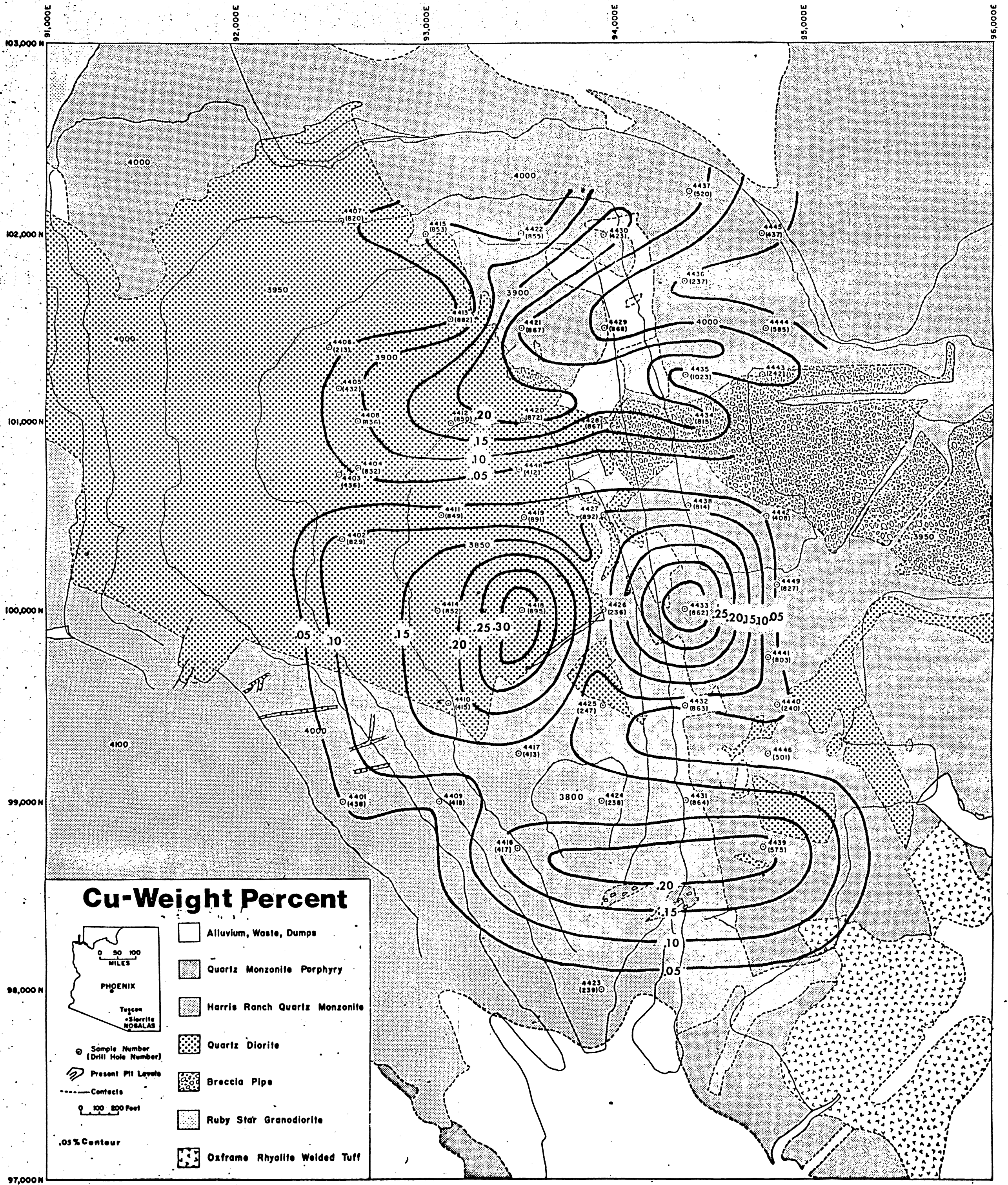
C.U.
157.72
H5
plate 5



C.U.
157.72
H5
plate 4



C.U.
157.72
H5
plate 2



C.U.
157.72
.H5
plate 11