GEOCHEMISTRY OF MAJOR AND TRACE ELEMENTS OF THE "RAGGEDY MOUNTAIN GABBRO GROUP," WICHITA MOUNTAINS, SOUTHWESTERN OKLAHOMA

By

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1973

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1979

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ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my principal thesis adviser, Dr. Zuhair Al-Shaieb, for his guidance and assistance during my graduate study at Oklahoma State University. Thanks are also due to Dr. N. Green, co-adviser, for his constructive criticism and corrections of the manuscript. I also acknowledge my debt to Dr. Douglass Kent who also served on the thesis committee. Greatful acknowledgment is also extended to Dr. Lester Reed of the O.S.U. Department of Agronomy for use of the facilities and for assistance in partial x-ray fluorescence analysis of thesis samples. Further I thank Dr. Phol of the Department of Physics for access to the department's hydraulic press.

I am also thankful to my wife, Shoeleh Assadian, and my friends, Hamid Assadian, Mohamad Heidari, and Mansour Bassiri, for their help in my field trips and encouragement during the study.

Finally, I also wish to express my sincere gratitude to my parents, sisters, and brothers for their sacrifices in making it possible for me to continue my studies. I am extremely grateful for the opportunities that they have given to me.

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GMLC	Glen Mountain Layered Complex
RMGG	Raggedy Mountain Gabbro Group
IMG	Iron Mountain Gabbro (Zone G)
SAS	Statistical Analysis System

CHAPTER I

INTRODUCTION

Igneous rocks found in the Wichita Mountains (located in southwestern Oklahoma) represent the exposed portion of an uplifted massif of Cambrian mafic and silicic rocks. Rocks of the province are not confined to this uplifted block, but are also known to underlie the Marietta basin, the Ardmore basin, and the southern part of the Anadarko basin.

The single most comprehensive work on these rocks is that of Ham, Denison, and Merritt (1964). These workers have divided the igneous rocks of the Wichita province into four groups, as follows:

Wichita Granite Group

Carlton Rhyolite Group

Navajoe Mountain Basalt-Spilite Group

Raggedy Mountain Gabbro Group

Hunter (1967) showed that the Raggedy Mountain Gabbro Group (RMGG) could be divided into the layered series and a so-called intrusive group. Powell et al. (1979) in a new modified classification introduced two subdivisions for the RMGG: (1) Glen Mountain Layered complex, and (2) Roosevelt Gabbro.

Rocks of the layered complex are generally feldspathic, ranging from gabbroic and troctolitic anorthosites to nearly pure anorthosites; they exhibit igneous lamination, and rhythmic to cryptic variation.

These rocks are igneous cumulates formed in a linear, northwest-southeast trending stratiform intrusive body. Geophysical and subsurface studies indicate that this body is up to 2.5 mi (4 km) thick and occupies an area of at least 2500 square miles (Ham et al., 1964; Pruatt, 1975). This layered gabbroic intrusion was emplaced within a thick sequence of immature clastic sediments, the Tillman Metasediments, which were later metamorphosed during the intrusion of Wichita granites. With the exception of a few xenoliths found within the gabbros and granites, these metasediments are known only from the subsurface.

The present work was undertaken to determine major and trace elements variation in the Raggedy Mountain Gabbro Group.

Location of the Study Area

The study area covers the eastern, central, and western part of Raggedy Mountain Gabbro Group which is mainly located in the Cooperton, Glen Mountains, and Roosevelt quadrangles in Kiowa and Comanche counties. These quadrangles constitute the Wichita Mountains Province. Some minor outcrops, which crop out in Quanah Quadrangle in sections 23, 22, 21, 16 T.3.N. R.14.W., are not shown on the geologic maps (Plates 1-3). General location of the study area is shown in Figure 1.

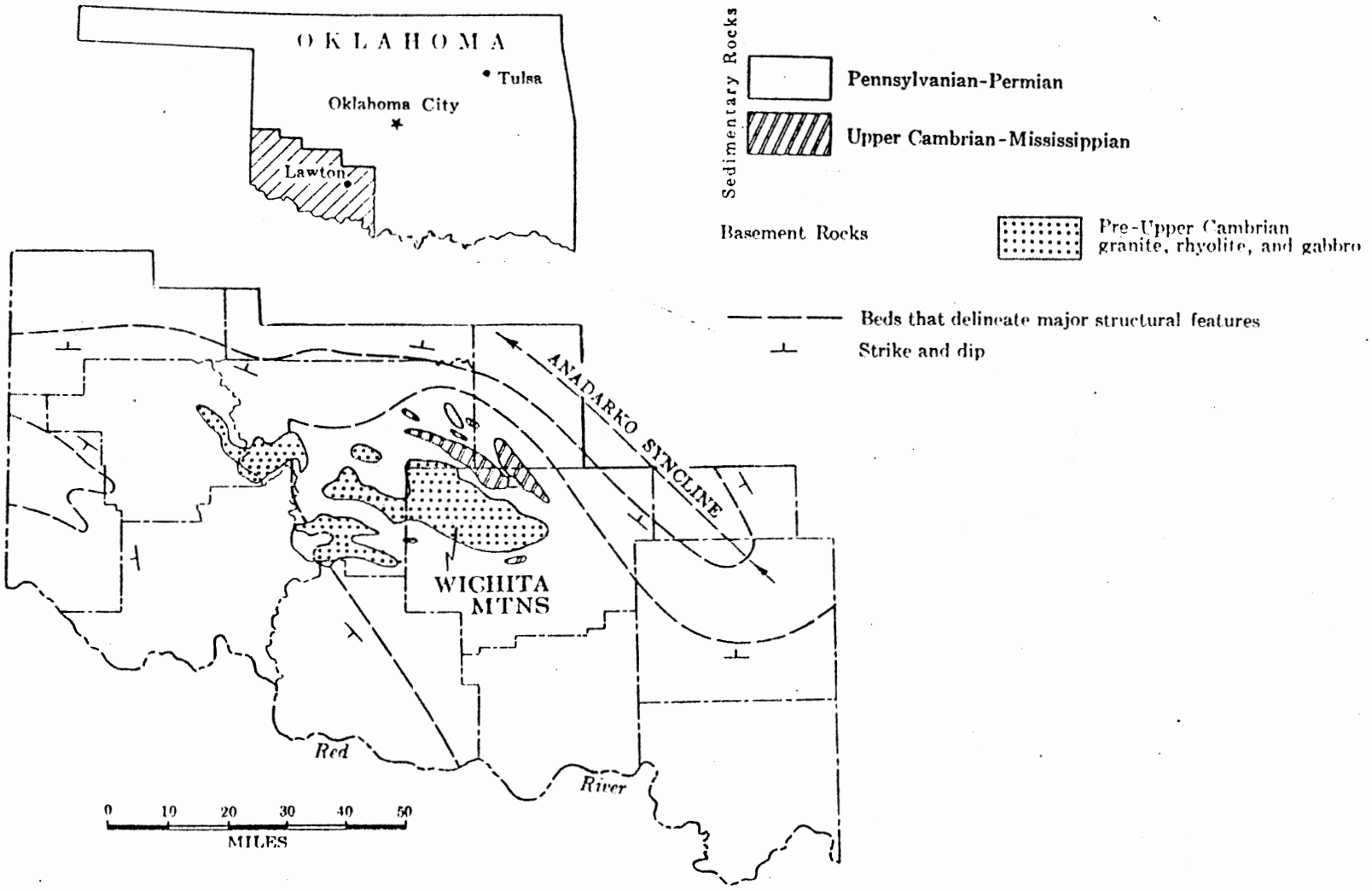

Figure 1. Index Map of Oklahoma Showing the Location of the Wichita Mountains (Area of the Study), (Modified from Ham et al., 1964.)

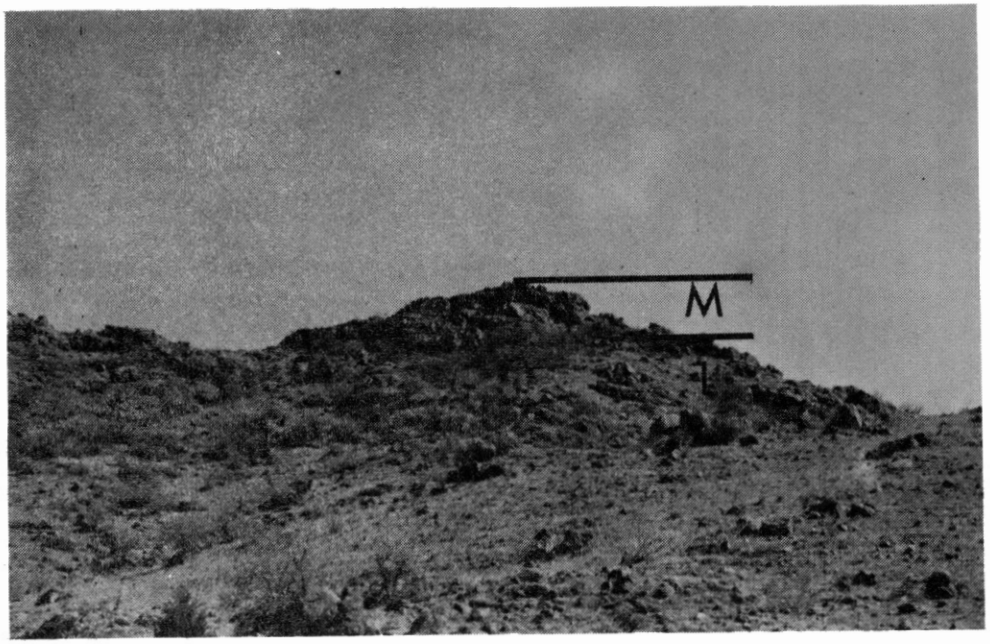

Figure 2. Zones M and L View Northeast from Middle of South Boundary of Section 15 T.4.N., R.17.W., Kiowa County

CHAPTER II

PREVIOUS WORK

The Wichita Mountains Province, located in southwestern Oklahoma, has been subject of scientific studies from the mid-nineteenth century to the present.

The igneous rocks of the area were first studied by Shumard, a member of the Marcy Expedition which traveled through the area in 1852. Comstock and Cummins (1889), Hill (1891), Vaughn (1899), and A. C. Spencer (1899) noted the presence of gabbroic rocks. H. Foster Bain (1900) suggested that name "Raggedy Mountain Gabbro Group" for gabbroic rocks in the district.

Taff (1904) studied the area while preparing a geologic map of the Arbuckle and Wichita Mountains. He identified four igneous rock units: gabbro with related anorthosite, granite with related aplites, granite porphyry with associated a porhyolite[1], and diabase dikes. His interpretation of the structure of the Wichita Mountains is still in use.

Taylor (1911, 1915), reporting some features of rocks in Wichita Mountains, referred to the "schistose" nature of the gabbro but misinterpreted the feature as being due to metamorphism. Hoffman (1930), however, concluded that the parallel orientation was due to the crystal settling at the time of crystalization and were not caused by metamorphism.

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[1]An old rhyolite in which the once glassy groundmass has devitrified (Glossary of Geology Am. Geol. Ins., 1972).

Chase (1950), understanding the layered nature of the basic rocks, prepared a detailed map of Raggedy Mountain, but his petrologic units were based on the percentage of mafic minerals present. He recognized the following rock types: anorthosite, diallage gabbro, diallage olivine gabbro, and olivine gabbro (Troctolite).

Haung and Merritt (1952, 1954) and Haung (1954) studied the petrology and mineralogy of troctolites in the province and concluded that:

> . . . the presence of spinel in troctolite and sillimanite in anorthosite indicated assimillation of aluminous material, and that the basic magmas had intrusion temperatures greater than 1100°C as evidenced by the occurrence of diopsidic lamellae in hypersthene (Haung and Merritt, 1954, p. 549).

Hamilton (1956) identified the stratiform nature of Wichita Mountain complex; he indicated that gabbroic rocks were over lain by granite.

Gilbert (1960) studied the geology of western part of Wichita Mountains, recognizing three stratigraphic zones: olivine gabbro, anorthosite gabbro, and troctolite. He prepared a geologic map more detailed than that of Chase (1950). There were, however, no distinguishable boundaries between his units, as each unit could be traced in the other units.

Hiss (1960, 1966) studied the textural relations of the ferromagnesian minerals; as a result of his study, four distinguishable zones were recognized: (1) troctolite, (2) olivine gabbro, (3) gabbro, and (4) biotite-olivine gabbro. His work showed that the composition of olivine is uniform throughout the cumulative rocks, but that orthopyroxene showed a greater chemical variation. He also noted that:

> . . . orthopyroxene symplectites and coronas with magnetite intergrowth were found in over 85 percent of the troctolites and that they represent the crystallization of the last interprecipitate and not due to thermal metamorphism as has been previously stated (p. 36).

Johnson's (1960) mineralogical study of altered rocks indicated that at least two alteration processes have contributed to the decomposition of basic igneous rocks. He considered that most of the alteration is due to weathering rather than to hydrothermal fluids; hydrothermal activity had played a secondary role.

Rotan (1960) indicated that plagioclase in most zones has a planar orientation parallel to the (101) face. He concluded that crystal settling occurred parallel to the direction of movement, and therefore, that gravitional settling inadequately explained the origin of the gabbroic rocks. Spencer (1961) designated Gilbert's stratigraphic units as K, L, and M (lower stratigraphic zone to higher, respectively) and an undefined stratigraphic zone G. The main purpose of this change was to avoid confusion with Gilbert's ill-defined zones. Spencer's zones correlate with those of Gilbert as follows:

Gilbert (1960)	Spencer (1961)
Olivine Gabbro Zone	Zone "M"
Anorthositic Gabbro Zone	Zone "L"
Troctolite Zone	Zone "K"
No Correlative	Zone "G"

Spencer's terminology has been used in all subsequent work on the Wichita Mountains.

Karn's (1961) textural work resulted in the recognition of two types of ophitic textures in the layered complex: "ophitic texture resulting from simultaneous crystallization of plagioclase and pyroxene,

and ophitic texture resulting from crystallization of an interstital liquid around already crystallized plagioclase" (p. 40).

Frech (1962) studied the basic rocks of Roosevelt and Cold Spring area. His studies confirmed that the Wichita Mountain gabbros had characteristics similar to those of other layered series known to have developed by gravity differentiation. His studies validated the zonal nature of the body established by Gilbert (1960) and Spencer (1961).

Hunter (1960, 1962, 1967, 1970) summarized and reclassified the works of Gilbert (1960) and Spencer (1961); he divided the Raggedy Mountain Gabbro Group into two groups: (1) the layered series and (2) intrusive group. This classification was a useful basis for later studies.

As a possible origin of the layered series, Scofield (1975) referred that:

> The anomalous position of highly calic plagioclase near the top of the intrusion, inferred from field relation, coupled with possible reverse cryptic layering suggests a separation of anorthosite by flotation or rafting of plagioclase (p. 732).

But the idea of plagioclase floatation and "reverse" cryptic layering was rejected by David Phelps (1975). He considered that crystal settling from a differentiating basaltic magma explained the lithologic variations of the Raggedy Mountain Gabbro Group.

Powell et al. (1979) recently reviewed and modified the litho-stratigraphic classification of the exposed igneous rocks, providing overview of the past works. The new modified classification is given in Table I.

TABLE I

LITHOSTRATIGRAPHIC CLASSIFICATION OF BASEMENT ROCKS OF THE WICHITA PROVINCE, OKLAHOMA

Age, m.y.	Group	Formation	Member	General Lithology
505±10*?		Cold Springs Breccia§		Dark gray microdiorite blocks in matrix of pink leucogranite; locally medium gray quartz monzodiorite blocks in light gray granodiorite matrix
525±25	Wichita Granite Group	Quanah Granite Lugert Granite Reformatory Granite Headquarters Granite Mount Scott Granite		Group typified by medium to fine-grained alkali feldspar granites; granophyric texture sporadically distributed within the group
525±25	Carlton Rhyolite Group			Rhyolitic lavas interbedded with minor tuffs and agglomerates
?		Otter Creek Microdiorite§		Fine-grained diorite and quartz diorite
?	Navajoe Mountain Basalt-Spilite Group			Extrusive basalts, spilites and andesites, variably altered
505-518±10* 515-535±30*	Raggedy Mountain Gabbro Group	Roosevelt Gabbros§	Glen Creek Gabbro§ Sandy Creek Gabbro§ Mount Sheridan Gabbro§	Medium-grained biotite-amphibole-bearing olivine gabbro Medium-grained biotite-amphibole-bearing gabbro ± olivine Medium-grained biotite gabbro locally fractionated to ferrogranodiorite
500-720* 1300-1500†		Glen Mountains Layered Complex§	M Zone§ L Zone§ K Zone§ G Zone§	Anorthosite, anorthositic-gabbro and troctolite with fine-ophitic augite; cumulus plagioclase, augite, olivine Anorthositic gabbro with minor troctolite; coarse-ophitic augite; cumulus plagioclase and olivine Alternating bands of anorthosite and troctolite; cumulus plagioclase, olivine Troctolite and olivine gabbro; medium-grained; cumulus plagioclase, olivine
?	Tillman Metasedimentary Group	Meers Quartzite		Meta-quartzite with microcline and sillimanite; inclusions in rocks of the Raggedy Mountain Gabbro Group and Wichita Granite Group
		Undifferentiated		Low-grade meta-graywackes and meta-argillites grading locally into mica schists and hornfelses

*These ages may reflect reheating during granite emplacement and not the primary crystallization age of the unit (see text).
†Age inferred from paleomagnetic data (see text).
§Represents modification and/or addition to lithostratigraphic classification.

Source: Powell et al. (1979).

(Relative ages shown with oldest unit at the bottom.)

CHAPTER III

METHODOLOGY

Map Preparation

Geologic maps of the study area were prepared as three plates: Plates 1 and 2 were modified after Chase (1950). These plates show, respectively, the geology of the Cooperton and Roosevelt quadrangles.

The geologic map of Glen Mountain (Plate 3) was modified after the geologic maps of Gilbert (1960) and Spencer (1961). After comparing rock units, their two maps were combined using a uniform lithologic classification that indicates the various subdivisions of Glen Mountain Layered Complex.

Sampling

Rocks sampled in the field represent almost all known outcrops of layered gabbroic rocks in the Wichita Mountains area. An attempt was made to sample as fresh material as possible.

The locations of every sample were denoted by an alphabetic character and a number (Plates 1-3). The first letter (W) stands for Wichita; and a second letter indicates the quadrangle from which the sample was obtained. Since all the sampled areas covered in this study are not shown on the geologic maps, the sample number and location were also given by quadrangle name, section number, and township.

From Quanah Mountain quadrangle samples WQ-1 through WQ-8 were taken from section 22 T.3.N. R.14.W., WQ-9 and SQ-10 are obtained from the same quadrangle but from sections 16 and 21, respectively. From Meers quadrangle: WM-109, WM-114, and WM-111 are from quarry B of Mount Sheridan, section 5, T.3.N. R.13.W.; WM-110, WM-112, and WM-113 are from Rowe Quarry, south of Meers, section 32, T.4.N. R.13.W.; WG-50 from section 5, T.3.N. R.16.W.

Samples WQ-9, WG-50, WG-81, and WR-91 were not analyzed completely, therefore were not used in this study.

Sample Preparation

All samples were first trimmed by diamond saw to remove altered surfaces. They were then crushed in a ceramic jaw crusher before milling. Each sample was powdered in a Spex Mixer Mill using Tungsten Carbid balls and cylinder; mill runs lasted 20 minutes.

Chemical Analysis

Sample Solution Procedure

One gram of sample powder (<-100) was dissolved in 25 ml of 48 percent hydroflouric acid, 10 ml of concentrated 70 percent nitric acid, and 2 ml of 70 percent perchloric acid ($HClo_4$). The solutions, left to digest for 10-12 hours in teflon beakers, were heated subsequently at 300-400^{o} F for approximately four hours until completely dried. The residue was mixed with a few milliliters of distilled water; 10 ml of 37 percent hydrochloric acid was then added to the solution which was again heated until completely re-dissolved. This solution, diluted to 100 ml with distilled water, was transferred to polyethylene bottles.

Atomic Absorption Trace Element Analysis

Copper, chromium, nickel, lead, zinc, barium, and vanadium are analyzed using a Perkin-Elmer 403 double beam atomic absorption spectrophotometer with an air-acetylene flame. Instrument settings followed the manufacturer's recommendations to assure accuracy of analytical results. Results were compared to recommended U.S.G.S. rock standard samples G-2, GSP-1, and AGU-1 (Table IV).

X-ray Fluorescence Spectrometry

Pelletizing

Three grams of rock powder (-100 mesh or finer), thoroughly mixed with 6 to 8 drops of 2 percent polyvinal alcohol binder, were transferred to a metal sleeve, and pressed with a plastic plunger. Four grams of boric acid were then inserted in the pelletizer to serve as backing for the pellet. After a steel plunger was inserted, the die was placed in a hydraulic press and held at a pressure of 8-16 tons per square inch for two minutes. These pellets were analyzed using Philips 1410 and General Electric XRD-6, SPG-3 x-ray fluorescence spectrometers. Operation conditions used are given in Table II.

Strontium and rubidium were determined on pressed powder pellets. Background and peak positions were counted for each element; the mean of two background values was subtracted from the elemental peak counts. The results were multiplied by the mass absorption coefficient for every sample calculated from the major element chemical analysis. The mass absorption coefficient corrected counts were plotted against concentration. Struntium and rubidium curves were calculated from data obtained

TABLE II

OPERATION CONDITIONS USED IN DETERMINATION OF EACH ELEMENT

Element	Peak	Crystal	Target	Detecter	Basline	Window	Collimator	Machine Model
SiO_2	K_2	PET	"	GFP[1]	-	-	C	G. E. XRD-6, SPG-3
Al_2O_3	K_2	LIF-200	"	GFP	-	-	C	G. E. XRD-6, SPG-3
FeO	K_2	LIF-200	W	SDC[2]	-	-	F	G. E. XRD-6, SPG-3
CaO	K_2	LIF-200	Cr	GFP	-	-	F	G. E. XRD-6, SPG-3
K_2O	K_2	LIF-200	Cr	GFP	-	-	F	G. E. XRD-6, SPG-3
Na_2O	K_2	RLAP	Cr	GFP	1.8	3.7	C	Philips 1410
P_2O_5	K_2	PET	Cr	GFP	1.64	4.5	C	Philips 1410
MnO	K_2	LIF-200	W	SDC	-	-	C	G. E. XRD-6, SPG-3
TiO_2	K_2	LIF-200	Cr	GFP	1.8	3.7	F	Philips 1410
MgO	K_2	TLAP	Cr	GFP	1 8	3.7	C	Philips 1410
Sr	K_2	LIF-200	Cr	GFP	1.8	3.7	F	Philips 1410
Rb	K_2	LIF-200	Cr	GFP	1.8	3.7	F	Philips 1410

[1]Gas flow proportional detector-counter.

[2]Scintillator detector-counter.

for U.S.G.S. standards (BCR-1, AGV-1, ARHCO-1, G-2, GSP-1, STM-1, RGM-1, PCC-1, and DTS-1) (Norrish and Chapell, 1967).

CHAPTER IV

GEOLOGY OF THE RAGGEDY MOUNTAIN GABBRO GROUP

The name "Raggedy Mountain Gabbro Group" is applied to all gabbroic rocks in the Wichita Mountains (Ham 1964). These rocks are exposed in Kiowa and Comanche counties where outcrop over a 150 km^2 area (Powell et al., 1979). The concordant bodies parallel to the axis of the Wichita Mountains rise 200 m above the surrounding surface; a single well indicates a minimum thickness of 8000 feet.

Powell et al. (1979) recently modified the usage of the term "Raggedy Mountain Gabbro Group" as defined by Hunter (1967, 1970). They divided the group into two formations. The "Glen Mountain Layered Complex," used for those rocks previously referred to as Hunter's "Layered Series," was given the rank of a formation; the name is derived from Glen Mountain. A description of Glen Mountain subdivisions is presented below.

Biotite gabbro which intrudes the "Glen Mountain Layered Series" was also given the rank of the formation and called "Roosevelt Gabbro." The Roosevelt Gabbro was divided into three members: (1) Glen Creek Gabbro, (2) Sandy Creek Gabbro, and (3) Mount Sheridan Gabbro. The large grain size of biotite in these rocks distinguishes them from the finer-grained biotite-bearing rocks of Glen Mountain Layered Complex. These subdivisions and modifications of "Raggedy Mountain Gabbro Group are not

defined on the basis of genetic considerations but rather on field relations and lithologic grounds" (p. 36).

Petrology and Petrography

Chase (1950), using Johansen's 1931 classification, subdivided the basic igneous rocks of the Wichita Mountains into three groups: anorthosite diallage gabbro, diallage olivine gabbro, and olivine gabbro (troctolite) with pyroxenite and magnetite rich phases. Gilbert (1960) reclassified these rocks using both mineralogy and textural features. His three petrologic units were:

Zone	Approximate Thickness Based on Exposed Thickness
Olivine Gabbro (uppermost)	200 m
Anorthositic Gabbro (middle)	300 m
Troctolite (lower most)	75 m (p. 20).

Spencer (1961) defined alphabetical code (K, L, and M) for various zones of the eastern part of the RMGG; these zones are equivalent to Gilbert's designated units. Spencer also suggests a unit (zone G) which had an uncertain stratigraphic relationship to the others. The present study area covers the area mapped by both Spencer and Gilbert, and rock units in these two areas have been correlated by comparing their geologic maps.

Gilbert (1960) (Western Portion)	Spencer (1961) (Eastern Portion)
Olivine Gabbro Zone	Zome "M"
Anorthosite Gabbro Zone	Zone "L"
Troctolite Zone	Zone "K"
	Zone "G"

These two stratigraphic sequences are assumed to be equivalent. Thus, the alphabetical symbols have been retained to designated rock units (Plate 3). Modal analysis for 25 samples selected from different zones are given in Appendix D.

The Glen Mountain Layered Complex is a stratiform, concordant body formed by gravitational accumulations of crystals. The 200 m exposed section has been considered represent only middle part of the sequence (Phelps, 1975); no outcrop contains all the recognized zones. A brief description of alphabetical zones of Glen Mountain Layered Complex follows.

Zone "K" - The exact thickness of the zone is unknown, but it is at least 36 m thick (Spencer, 1961). This unit, the lowest stratigraphic member of Glen Mountain Layered Complex, consists of anorthorsite and troctolite layers. Cumulus plagioclase constitutes 95-99 percent of the anorthosite and is associated with cumulus olivine and augite. Post cumulus corase-grained ophitic augite is widely-spaced in holocrystalline hypidiomorphic granular rocks. Igneous laminations and rhytmic layering are locally present. Olivine commonly poikilitically encloses randomly oriented plagioclase grains in troctolites (Spencer, 1961). Olivine is either rimmed by hypersthene or replaced by an orthopyroxene-magnetite symplectite (Powell et al., 1970) (Figure 5).

Zone "L" - This zone overlies by the "M" zone and has a 145 m or greater thickness. The zone contains more gabbro than the "K" zone. This zone characteristically is a coarse-grained ophitic-textured gabbro composed of closely-spaced coarse clinopyroxene, larger than 2 cm in

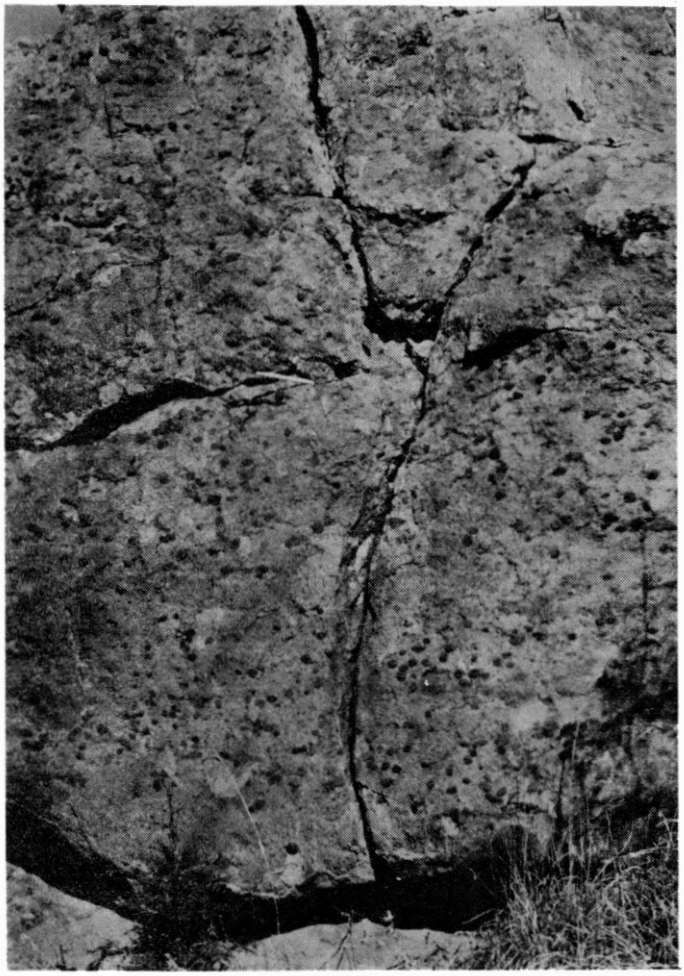

Figure 3. Fine-ophitic Pyroxene Oikocrysts (dark spots) in the Zone M of Glen Mountain Layered Complex Exposed in Southeast Corner of Section 15 T.4.N., R 17.W., Kiowa County (Pen is 15 cm in length.)

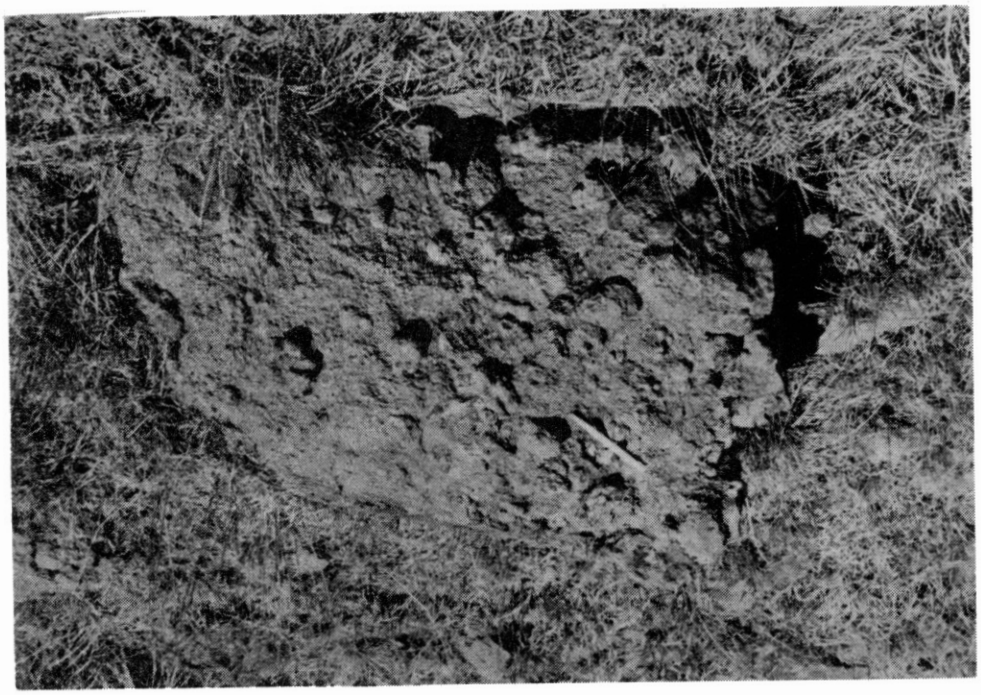

Figure 4. Medium to Large Ophitic Pyrofene Crystals (Nubes) of the Zone L Exposed in Southern Center of Section 15, T.4.N., R.17.W., Kiowa County (Pen is 15 cm in length.)

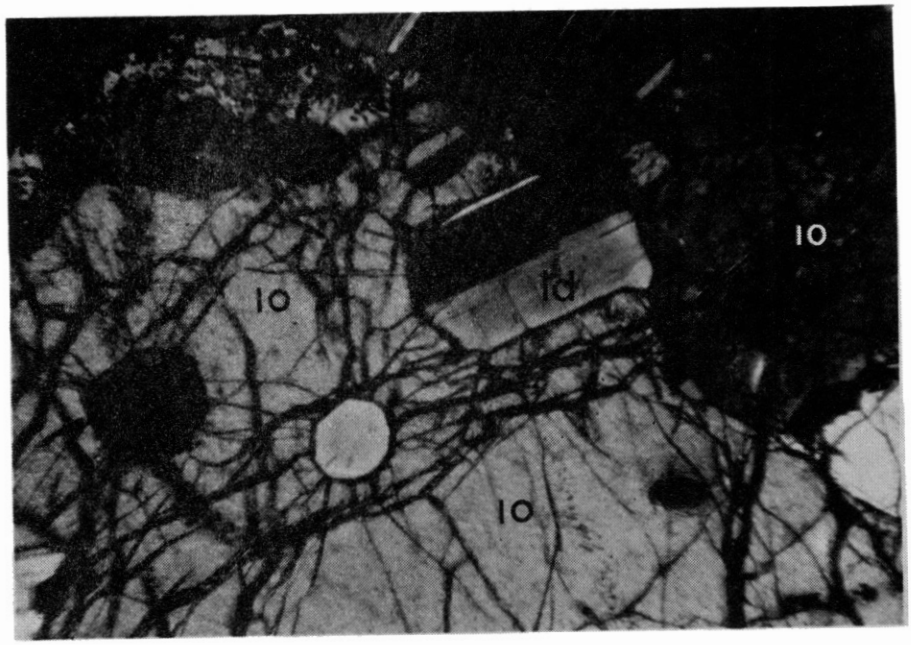

Figure 5. Troctolite from the K Zone Showing Ophitic Texture. Note the Symplectic Texture (Orthopyroxene-Magnetite) at the Lower Right Corner; Olivine (OL), Plagioclase (PL), X25, Cross Nicols

diameter. Plagioclase of similar size is enclosed in pyroxenes or in the matrix (Spencer, 1961, Powell et al., 1979) (Figure 6). Oikocryst augite is distinctive. It is best shown in weathered gabbros due to its high reflectance in sunlight. Olivine grains tend to be much smaller than those of the "K" zone; they are rimmed by symplectitic coronas. A five meter thick anomalous layer of "gabbroic anorthosite is characterized by the presence of fine ophitic pyroxen oikocrysts as well as olivine displaying analogous texture" (Powell et al., 1979, p. 25). This layer was called the L-a zone by Phelps (1975), and is overlain and underlain by the coarse-grained ophitic-textured rocks. Poikilitic post-cumulus magnetite is especially common in weathered rocks of this zone (Powell et al., 1979). Magnetite and ilmenite grains make up about 2 percent of the rock (Phelps, 1975).

Zone "M" - This uppermost zone of the Glen Mountain Layered series is exposed over 60 m; there is evidence of it being as much as 500 feet (150 m) thick. Rocks of this zone include anorthesitic olivine gabbro, gabbro anorthesite, and troctolite. The zone is characterized by a fine ophitic texture (Figure 7). Plagioclase enclosed in the augite is smaller in size than the plagioclase of matrix (Spencer, 1961). These rocks are finer grained than those in the "K" and "L" zones.

Olivine which occurs with pyroxene oikocrysts, is smaller in size (few mm) than similar grains in the other zones. Magnetite is not as abundant as in zone "L".

Banding is more prevalent in this zone than in the other zones because of the higher content of mafics. Rhytmic layering is also pronounced. Magnetite, ilmenite, olivine and augite are intercumulus phases, but plagioclase and most of olivine represent cumulus minerals (Phelps, 1975).

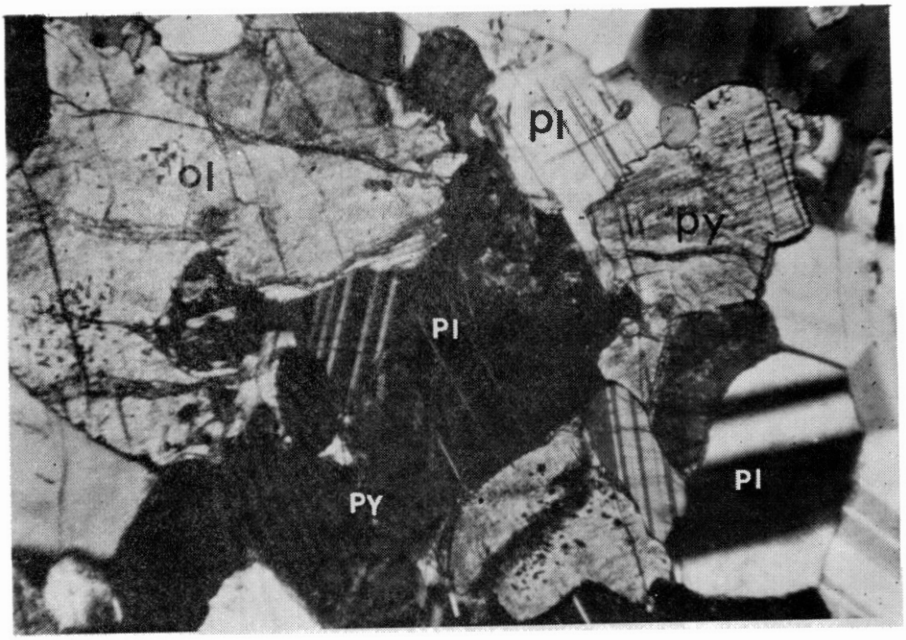

Figure 6. Gabbro With Coarse Ophitic Texture from the L Zone; Olivine (OL), Plagioclase (PL), Pyroxene (PY), X25, Cross Nicols

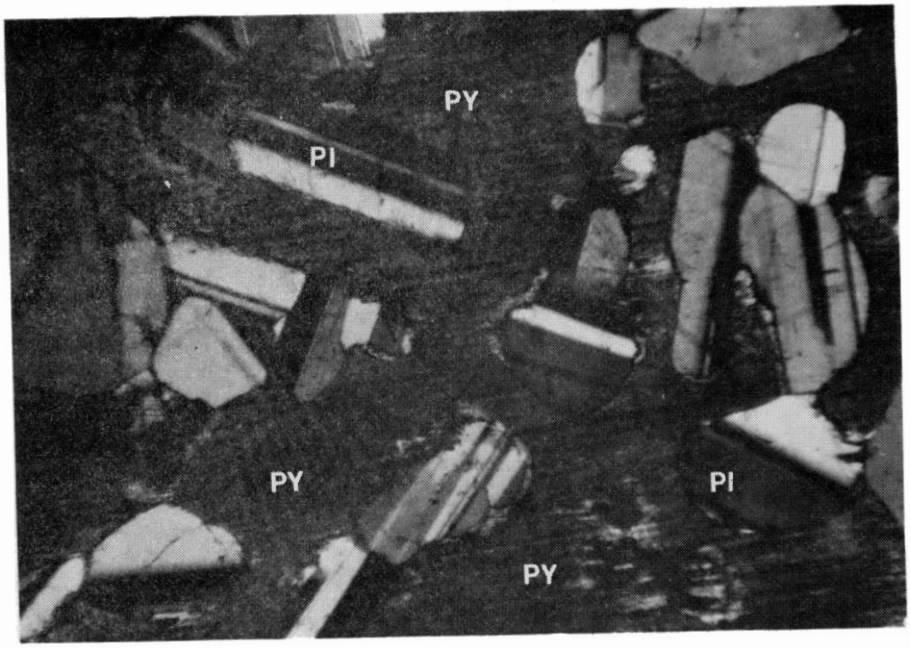

Figure 7. Troctolite With Fine Ophitic Texture from the M Zone; Olivine (OL), Pyroxene (PY), X25, Cross Nicols

Zone "G" - This zone is present in the Iron Mountains. It is composed largely of fine-to medium-grained troctolite and olivine gabbro. Stratigraphic correlation has not yet been established with any of the other zones (K, L, and M). Mineralogical similarities and olivine compositions (Fo_{67}), however, suggest that this zone might underlie the "K" zone (Spencer, 1961).

Characteristically, the troctolite contents 5-15 percent titaniferous magnetite (Spencer, 1961; Hunter, 1970). The dominant texture of these rocks is allotriomorphic, granular; the lack of an ophitic texture contrasts with rocks in the layered complex. Locally, some plagioclase grains may be partially enclosed by a 1-5 mm augite rim. Although rhythmic layering and igneous lamination are not obvious, weathering parallel to the regional dip of Glen Mountain complex may indicate minor layering within this zone (Powell et al., 1979). Olivine in this zone is more magnesian than olivine in the other zones, but it is not poikilitic and is not surrounded by orthopyroxene reaction rims.

This zone should not be considered as a zone of GMLC due to the following features: (1) lack of a ophitic texture, cryptic and rhythmic layering; (2) the absence reaction relationships common in the other zones; (2) finer-grained nature and higher content of mafic minerals and titaniferous magnetite (Figure 8); (4) lack of a general correlation with elemental variation of the other zones in GMLC (Appendix B); (5) relatively higher content of Cu, Cr, Ni, V, Mgo, Feo, Tio_2, and lower Na_2O, K_2o, Sr, Rb when compared to the other zones (Appendix A); and (6) lack of a clear stratigraphic relation to the other zones of GMLC.

Zone "G" is more likely a separate member of RMGG, which might be called Iron Mountain Gabbro.

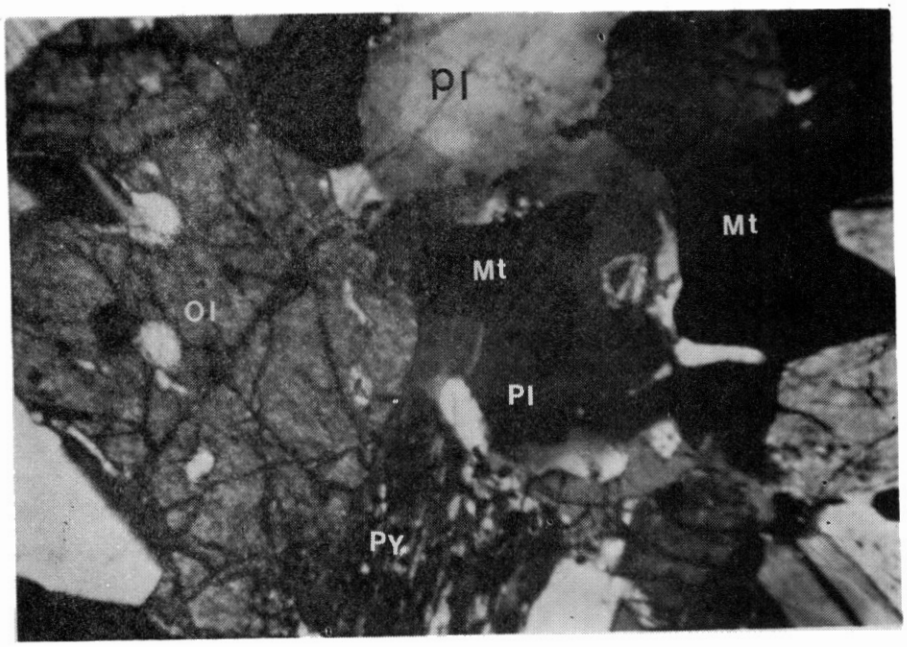

Figure 8. Gabbro of Iron Mountain Gabbro (G Zone); Olivine (OL), Pyroxene (PY), Plagioclase (PL), X25, Cross Nicols

CHAPTER V

GEOCHEMISTRY

One hundred eleven samples, representative of the Glen Mountain Layered Complex, Roosevelt and Cooperton area gabbroic rocks, were analyzed for major and trace elements (Appendix A). Average major and trace elements compositions of the GMLC and RMGG are given in Table III and Table IV, respectively. Covariance of the mineralogical and elemental concentrations was tested using the SAS computer program; correlation matrix were obtained for each zone of the Glen Mountain Layered Complex, the Roosevelt, Cooperton area, and the Raggedy Mountain Gabbro Group (Appendix B and C).

Major Elements

Average SiO_2 contents are 47.65 percent within the Glen Mountain Layered Complex, and 48.08 percent throughout the Raggedy Mountain Gabbro Group (Table III). Silica contents show only slight variation, varying from 44.25 percent up to 55.40 percent (Appendix A). Silica shows an overall positive correlation with Al_2O_3, but a negative correlation with FeO, and other ferromagnesiam elements (Appendix B).

The alumina content of Raggedy Mountain Gabbro Group averages 28.71 percent, whereas Al_2O_3 in the GMLC is slightly higher (29.27 percent) (Table III) due to greater amounts of plagioclase and a lower mafic mineral content in these rocks. Throughout the GMLC intrusion aluminum

TABLE III

AVERAGE ABUNDANCE VALUES OF CHEMICAL COMPOSITION COMPARED TO RAGGEDY MOUNTAIN GABBRO GROUP AND GLEN MOUNTAIN LAYERED COMPLEX

Oxides	Crustal Average[1]	Basalt[2]	Average Gabbro[2]	Anorthosite[2]	Ragg. Mtn. Gabbro Group (Average)	Glen Mtn. Layered Complex (Average) Include Zone "G"[3]	Stillwater Intrusion[5]
SiO_2 %	60.18	51.33	48.36	49.98	48.08	47.65	49.70
TiO_2 %	1.06	1 10	1.32	0.14	0.55	0.48	0.16
Al_2O_3 %	15.61	18.04	16.84	28.94	28.71	29.27	22.04
FeO %	6.71	9.10	10.40	2.23	3.39	3.02	4.68
MnO %	--	0.16	0.18	0.07	0.04	0.04	0.09
MgO %	3.56	6.01	8.06	0.84	3.72	3.47	7.03
CaO %	5.17	10.07	11.06	14.01	10.85	11.03	13.59
Na_2O %	3.91	2.76	2.26	2.73	2.90	2.84	1.79
K_2O %	3.19	0.82	0.56	0.42	0.30	0.22	0.07
P_2O_5 %	--	0.16	0.24	0.09	0.24	0.21	0.02
Total	99.70				98.83[4]	98.23[4]	100.11
Number of Samples Analyzed		56	160	8	111	59	40

[1]Crustal average is taken from Taylor, 1964.

[2]Taken from Nockolds, 1954.

[3]Separate analysis of each zone is given in Appendix A.

[4]Total before reconversion.

[5]From Wager and Brown, 1967, p. 332. (Composite of 40 samples from the Gabbro-Norite and Anorthosite Zone).

TABLE IV

AVERAGE ABUNDANCE VALUES OF TRACE ELEMENTS COMPARED TO THE RAGGEDY MOUNTAIN GABBRO GROUP AND GLEN MOUNTAIN LAYERED COMPLEX

Element	Crustal Average[1]	Basalt Average[1]	Ulterabasic Rocks[1]	Ragg. Mtn. Gabbro Group (Mean)	Glen Mtn. Layered Complex Include Zone G[3]	Stillwater Intrusion[2] a	Stillwater Intrusion[2] b
Cu ppm	55.0	100.0	10.0	39.64	35.00	52-135	18-58
Cr ppm	100.0	200.0	2000.0	28.66	29.00	578-688	9-384
Pb ppm	12.5	5.0	0.1	19.86	19.00	--	--
Zn ppm	70.0	100.0	50.0	36.52	32.00	17-45	0-9
Ni ppm	75.0	150.0	2000.0	30.58	27.00	245-339	14-140
Sr ppm	375.0	465.0	1.0	509.32	525.00	95-135	140-175
Rb ppm	90.0	30.0	--	2.25	0.73	0-18	0-5
Ba ppm	425.0	250.0	2.0	89.82	68.00	0-70	20-120
V ppm	135.0	250.0	50.0	105.76	106.00	65-133	29-68
Number of Samples Analyzed	--	--	--	111	59	7	8

[1]From Taylor, 1965.

[2](a) Range for Norite, Gabbro and (b) range for Anorthosite rocks results from Travers A. Benbow Mine and Min e Road Section (D. R. Bowes et al., 1973).

[3]For separate analyses of each zone refer to Appendix A.

TABLE V

COMPARISON OF MEASURED AND RECOMMENDED TRACE ELEMENT CONCENTRATIONS IN USGS ROCK STANDARDS

	G-2		GSP-1		AGV-1	
Elements	USGS[1]	Present Study	USGS[1]	Present Study	USGS[1]	Present Study
Cu	11.7**	11.0	33.3	33.0	59.7	59.0
Cr	7.0	12.0	12.5	13.0	12.2	12.0
Zn	85.0	85.0	98.0	100.0	84.0	84.0
Pb	31.2	30.0	51.3	50.0	35.1	40.0
Ni	5.1	1.1	12.5	12.9	18.5	18.5
Sr*	479.0	421.0	233.0	226.0	657.0	641.4
Rb*	168.0	151.9	254.0	259.6	87.0	74.9
BA	1870.0	1850.0	1300.0	1300.0	1208.0	1250.0
V	35.4	35.0	52.9	60.0	125.0	120.0

*Sr and Rb are determined by x-ray fluorescence.

**Values in parts per million

[1]Source: F. J. Flanagan, Description and Analyses of eight new USGS Rock Standards, 1976.

shows a negative correlation with FeO, MgO, MnO, TiO_2, P_2O_5, Ni, Cr, Pb and a positive correlation with SiO_2, CaO and Na_2O (Appendix B).

Iron shows the greatest variation among major elements (Appendix A). It varies from .19 percent (minimum) to 14.2 percent (maximum) with a mean of 3.39 percent in RMGG and in GMLC (Table III). The high iron and titanium contents of zone "G" are due to the increased proportion of magnetite, ilmenite and mafic minerals (Appendix A). Iron contents correlate negatively with SiO_2, Al_2O_3, and positively with MgO, Cr, Ni, Zn, V contents (Appendix B).

Sodium, with the mean of 3.47 percent in the Glen Mountain Layered Complex and 2.90 percent in Raggedy Mountain Gabbro Group, increases with increasing SiO_2 and Al_2O_3 contents (Appendix B, Table III).

The mean CaO contents in the GMLC (11.03 percent) and RMGG (10.85 percent) are similar to those of the Stillwater complex; the high CaO contents of the Wichita Mountain rocks probably reflect the Ca-rich nature of their constituent plagioclase. Calcium lacks a strong correlation with any other element in zones "K" or "L"; it does, however, exhibit a weak negative correlation with Cr, Zn, Ni, Rb, Fe, MgO, TiO_2, P_2O_5, and K_2O, and a positive correlation with Al_2O_3, and SiO_2 contents. The correlation coefficients are not strong because CaO contents show little variation between the different units.

Magnesium-rich minerals, such as olivine and pyroxene precipitate during the early stages of magmatic crystallization. Thus, MgO contents tend to decrease with increasing differentiation.

Average MgO contents are 3.72 percent in Raggedy Mountain Gabbro Group and 3.47 percent in Glen Mountain Layered Complex (Table III). These values are almost half the typical MgO content of gabbroic rocks.

The average MgO content in zone "G" is 8.93 percent (Appendix A). Usdowski and Mueller (1969) considered the gabbro border facies with MgO content of 6.84-7.67 percent to be represent undifferentiated basaltic magmas. This value falls within the range of MgO contents in undifferentiated basaltic magmas (Usdowski and Muller, 1969). The anorthosites have low MgO concentrations which reflect the high proportion of plagioclase and paucity of mafic minerals in these rocks.

Magnesium in the Wichita Mountain rocks correlates positively with Ni, Cr, Zn, V, Iron and negatively with SiO_2 and Al_2O_3. Within zone "G," MgO does not strongly correlate with the other elements (Appendix B).

AFM Diagrams

AFM ternary diagrams (Figures 9-11) for zones "K," "L," and "M" gabbros show constant patterns of chemical variations for major elements, probably reflecting similar differentiation processes for these zones. Zone "L" rocks show an enrichment in MgO which correlates with higher contents of mafic minerals than the "K" and "M" zone rocks (Figure 9).

Zone "G" is characterized by higher concentrations of MgO and Feo in accordance with its higher percentage of mafic and opaque minerals. $Na_2O + K_2O$ concentration is lower than zones "K," "L," and "M." Relative variation of elements is not the same as other zones (Figure 10) indicating that the zone "G" magma is not as differentiated, and thus, may be a separate member of RMGG.

Roosevelt and Cooperton gabbros show similar patterns of chemical variation, reflecting the same process of differentiation, and probably indicate the same formation.

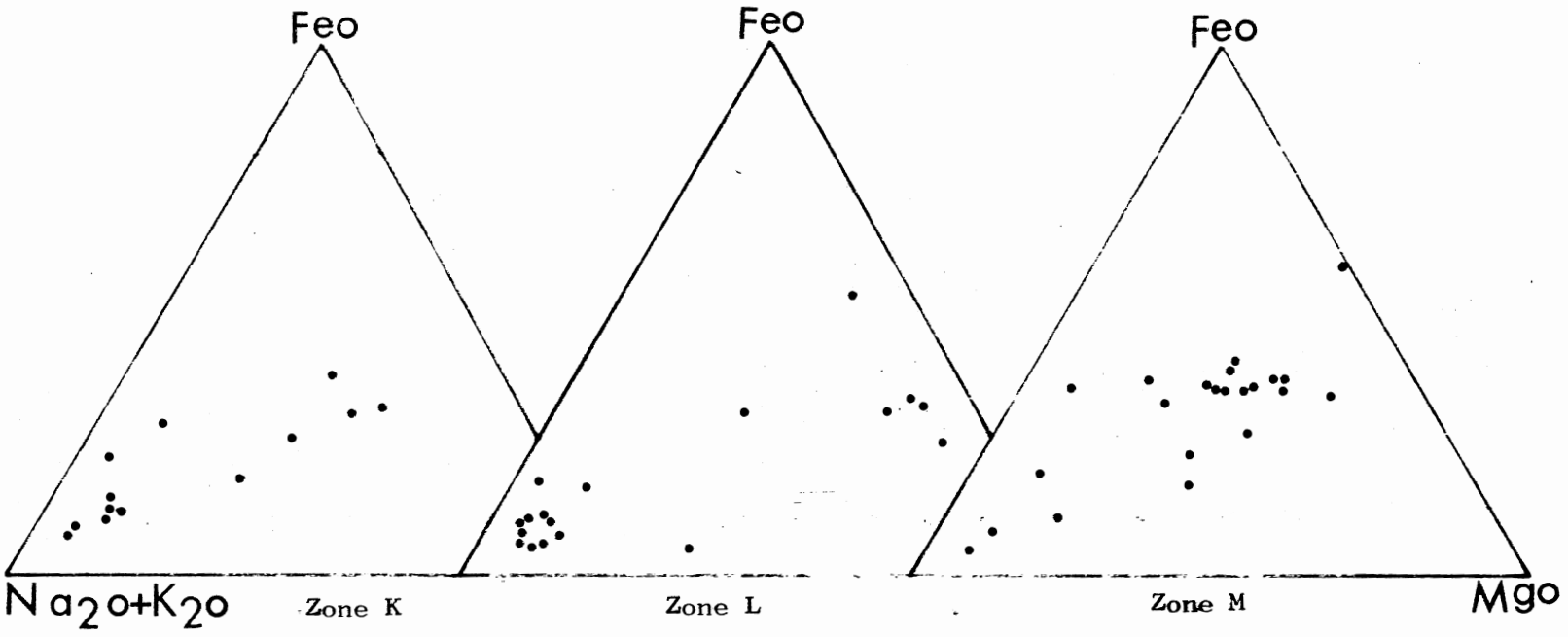

Figure 9. AFM ($Na_2O + K_2O$ - Feo - MgO) Diagrams for Zones K, L, and M

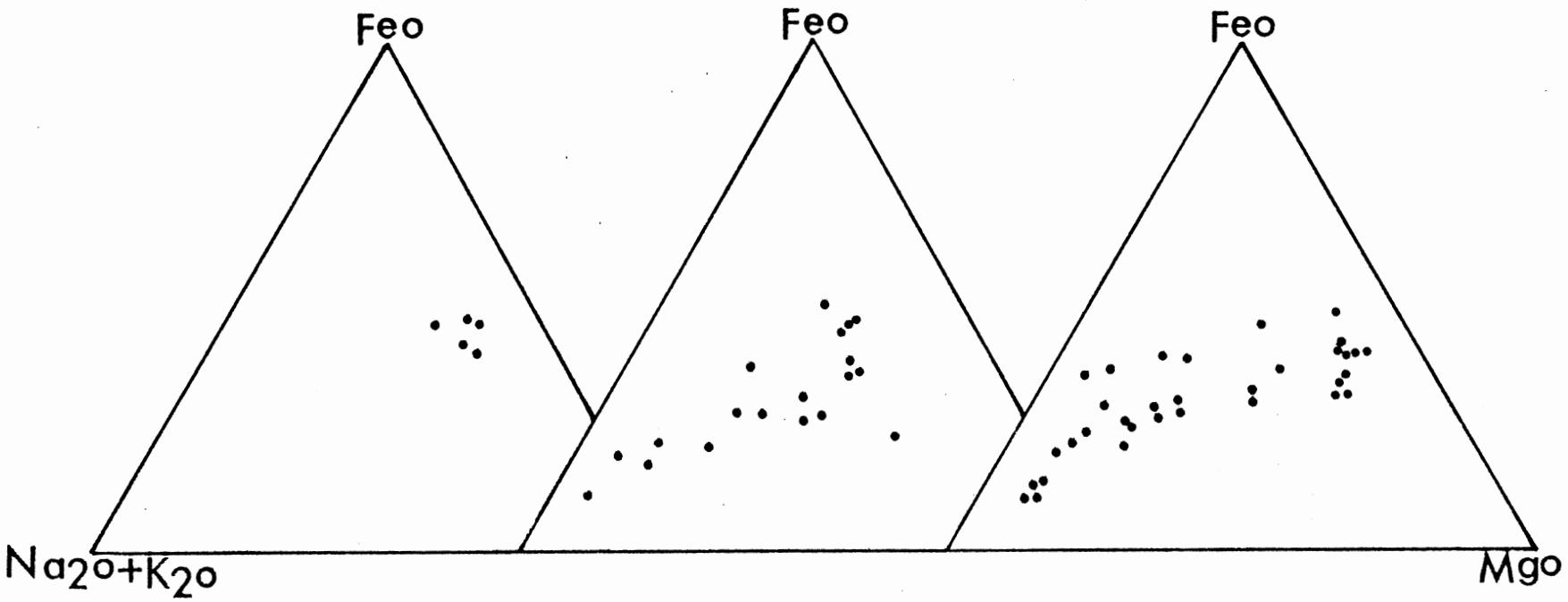

Figure 10. AFM ($Na_2O + K_2O$ - Feo - MgO) Variation Diagrams for Iron Mountain Gabbro, Roosevelt Gabbro, and Cooperton Area from Left to Right, Respectively

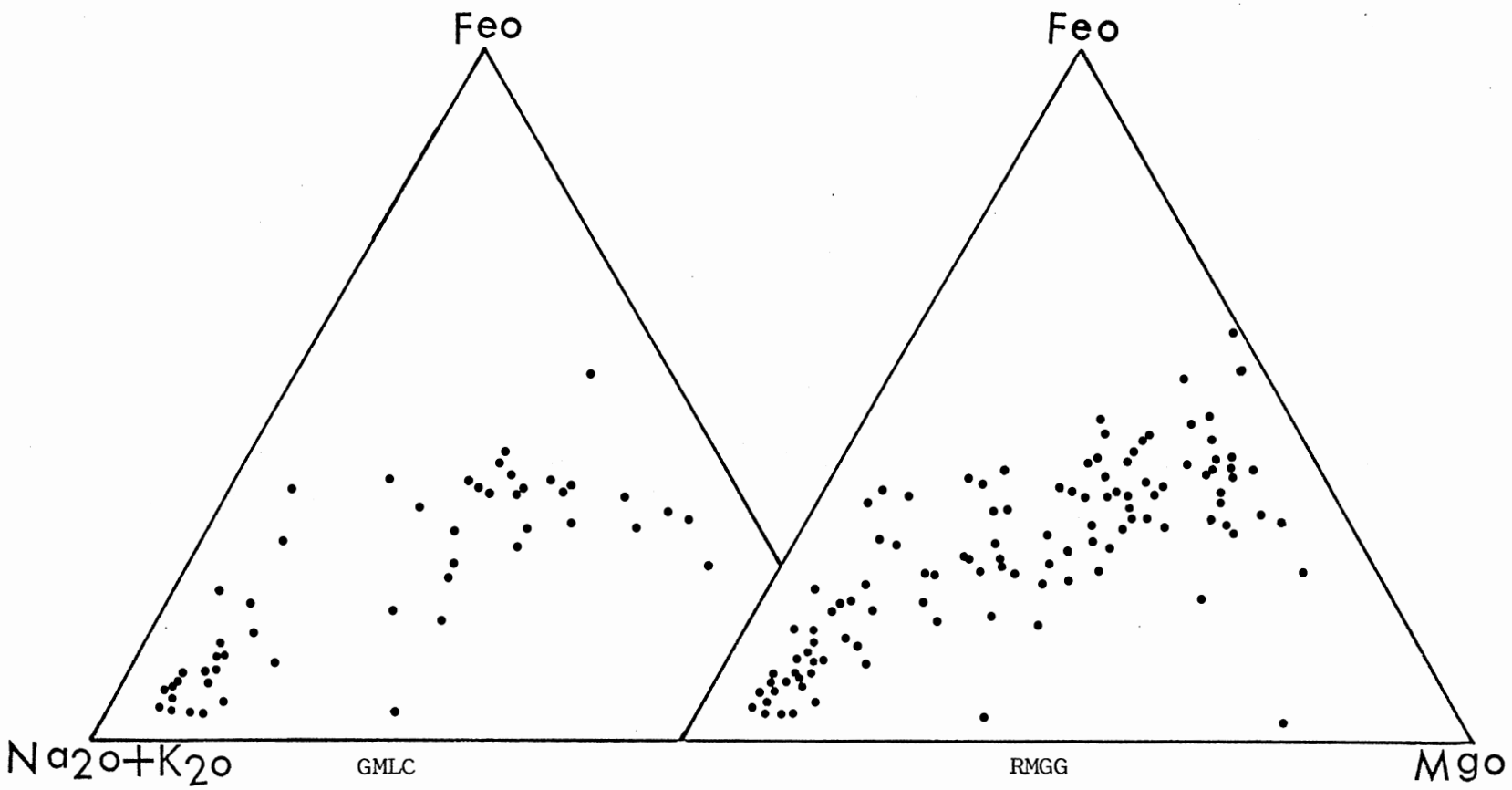

Figure 11. AFM ($Na_2O + K_2O$ - Feo - MgO) Diagrams for GMLC and RMGG

The AFM diagrams showed that RMGG is not enriched in iron because of its overall anorthositic composition.

Trace Elements

Titanium

The mean TiO_2 contents, which are 0.55 percent in Raggedy Mountain Gabbro Group and 0.48 percent in Glen Mountain Layered Complex are lower than the typical TiO^2 contents of gabbroic rocks (1.32 percent), but higher than the corresponding values for norite, anorthosite and gabbro zone of Stillwater Intrusion (Table III). The low TiO_2 contents of the RMGG reflects the low abundance of magnetite and ilmenite in these rocks. By contrast, the average TiO_2 content in the rocks or zone "G" is 2.22 percent. The higher TiO_2 concentrations reflect the presence of 5-15 percent of magnetite and ilmenite, a characteristic that distinguishes zone "G" rocks from those of the other zones within GMLC.

TiO_2 shows a positive correlation with FeO, MgO, Cr, Ni, Zn, and a negative correlation with SiO_2, Al_2O_3, and Sr for all zones but zone "G" in which there is no strong correlation between TiO_2 and the other elements (Appendix B).

Manganese

This element is present as a minor element in many minerals due to the close correspondence of its ionic radius to that of Fe, Cu, Mg and other cations. The average concentration of manganese is .04 percent within the layered complex and the Raggedy Mountain Gabbro Group (Table III).

Manganese contents increase with increasing MgO, Zn, Cr, Ni, Feo, and P_2O_5, showing the tendency for enrichment in mafic minerals, but decreases with increasing SiO_2, Al_2O_3, and Sr. Throughout the zones or province, all correlations show similar patterns of variation. Manganese has an almost uniformly strong correlation with P_2O_5, Feo, and Zn, through the province (Appendix B).

Potassium

K_2O is present in low concentration with respect to other elements in rocks of the Glen Mountain Layered Complex and Raggedy Mountain Gabbro Group. The average K_2O content is 0.30 percent in Raggedy Mountain Gabbro Group and 0.22 percent in the Glen Mountain Layered Complex (Table III). These contents are lower than the average gabbro value (.56 ppm) but higher than those reported in the gabbro-norite and anorthosite zones of Stillwater Intrusion (Table III).

Potassium shows a positive correlation with Rb and Na_2O but a negative correlation with Sr. Overall correlations between K_2O and other elements are not strong.

Phosphorus

Phosphorus is present in greater concentrations in basic than acidic rocks. It is a major constituent of apatite, in which it is associated with Ca, Fe^{3+}, Ti and Na (Fersman, 1939). This element does not show "a great variation in its relative abundance in different locations including Earth's crust, solar atmosphere, and meteorites" (Day, 1963, p. 255).

The average concentration of phosphorous in the Raggedy Mountain Gabbro Group is 0.25 percent P_2O_5 which is very close to the average

content of 0.21 percent P_2O_5 obtained for the Glen Mountain Layered Complex and the average gabbro content reported by Nockolds (1954) (Table III). Zone "G" has average of 0.15 percent P_2O_5, a value lower than the average of Raggedy Mountain Gabbro Group and Glen Mountain Layered Complex (Appendix A). P_2O_5 contents correlate positively with Cu, Cr, Zn, Ni, K, V, Mg, MnO, and FeO, and negatively with SiO_2, Al_2O_3, CaO, and Sr contents (Appendix B). Correlation coefficients are not significant for zone "G" or within the Glen Mountain Layered Complex (except zone "L"). In Roosevelt and Cooperton area gabbros, however, correlations are strong (Appendix B), associated with a general increase in P_2O_5 contents in these rocks (Appendix A).

Copper

Cu^{2+} substitutes for Fe^{2+} and Na due to similarities in valency and ionic radius. It replaces these elements in plagioclase and apatite (Taylor, 1967).

The average distribution of copper is 40 ppm in Raggedy Mountain Gabbro Group and 36 ppm in Glen Mountain Layered Complex. Zone "G" gabbros possess Cu contents (61 ppm, Appendix A) similar to those in rocks of Stillwater Intrusion (Table IV).

Copper contents show limited variation in the layered complex, and therefore, lacks of any significant correlations with other elements in zones "K," "L," "M," and "G". In contrast significant correlations occur in Cooperton Area and to a lesser extent in Roosevelt Group, where Cu correlates positively with Cr, Zn, Ni, V, Fe, MgO, TiO_2, and P_2O_5 and negatively with Sr, SiO_2, Al_2O_3, CaO, and Na_2O (Appendix B). Negative

correlation with Al_2O_3, SiO_2 shows the typical behavior of Cu in basic rocks.

Chromium

Cr^{3+} has a tendency to substitute for Fe^{3+} in pyroxene, magnetite, olivine, and ilmenite (Taylor, 1967). The highest levels of Cr enrichment are found in ulterabasic and basic rocks.

The mean chromium content of Raggedy Mountain and Glen Mountain Layered Complex rocks is about 29 ppm, lower than the average content of basaltic and similar rock types (Table IV). Throughout the province, chromium exhibits a positive correlation with Zn, Ni, V, FeO, and MnO, and a negative correlation with Al_2O_3 and TiO_2 (Appendix B).

Chromium content of Roosevelt Gabbro is also very low (10-11 ppm average) and shows no close correlation with other elements in these rocks (Appendix A and B). Zone "G" has higher Cr concentrations (92 ppm) than the other gabbros (Appendix A), but Cr contents do not correlate in these rocks with other elements as in zones "K," "L," and "M" (Appendix B). This lack of correlation represents a major difference between zone "G" and Roosevelt Gabbro with the other zones within the Glen Mountain Layered Complex.

Lead

Lead (Pb^{2+}) substitutes for Ca^{2+} and K^+, and therefore, lead should be present in plagioclase, K-feldspars, micas and apatite. A close relationship exists between Pb^{2+} and Sr^{2+}, and Pb/Sr ratios increase during fractionation (Taylor, 1967).

Lead content of Raggedy Mountain Gabbro Group and Glen Mountain Layered Complex rocks averages about 19 ppm (Table IV). Zone "G" rocks have a slightly lower Pb content (16 ppm) (Appendix A). These means are much higher than the average lead content in basalts (5 ppm, Table IV), and three times higher than the value (6 ppm) obtained by Wedepohl for gabbros (1956). In the correlation matrix (Appendix B) lead has no strong correlation with any elements within the zones of Glen Mountain Layered Complex; a very weak correlation with CaO throughout the Raggedy Mountain ($r = .21$) is not statistically significant.

Zinc

Wedepohl and Brehler (1969) indicated zinc is tetrahedrally coordinated in most chemical compounds in contrast to other bivalent cations like Mg^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, and Mn^{2+} which are usually present in octahedral coordination.

The mean concentration of zinc is 37 ppm in the rocks of Raggedy Mountain Gabbro Group; 32 ppm in Glen Mountain Layered Complex (Table IV). Zone "G" rocks have higher Zn contents (average 95 ppm; Appendix A). The high Zn content of zone "G" correlates with higher MgO, FeO and Ni contents and indicates that the Zn substitutes extensively in the lattices of silicate phases or that Zn is present in submicroscopic sulfides. The concentration values of zinc in Wichita Mountain gabbros is consistently higher than the average content in gabbro-norite and anorthositic rocks of Stillwater Intrustion (Table IV). This may be caused by concentration of Zn in iron-rich olivines (especially in zone "G") and its litophile character. Chemical modal correlation matrix showed strong correspondence with olivine and opaques (Appendix C).

Zinc shows a strong positive correlation (Appendix B) with MgO, FeO, Ni, Cr, V, and TiO_2 and correlates negatively with SiO_2 (significant in zones "K," "L," and "M") and Al_2O_3, CaO, Na_2O. Zinc shows no correlation with Pb. Zone "G" rocks do not show any of the strong correlations observed in other parts of Raggedy Mountain Gabbro Group.

Nickel

The mean nickel content of Raggedy Mountain Gabbro Group is 31 ppm and that of Glen Mountain Layered Complex is 28 ppm (Table IV). These values are much lower than the values for gabbro-norite zone of Stillwater Intrusion, being more similar to that of anorthosite zone of Stillwater Intrusion (Table IV). In comparing different zones within the Raggedy Mountain Gabbro Group itself, zone "G" contains significantly higher Ni concentrations (63 ppm, Appendix A). This value is extremely low for basic rocks and would tend to indicate extreme olivine fractionation. Primitive basic magmas (i.e., mantle derived melts) should contain between 250 and 500 ppm Ni. The higher Ni values in zone "G" might reflect a higher proportion of modal olivine; the modal-chemical correlation matrix shows strong relation between Ni and olivine (Appendix C).

Nickel shows a strong positive correlation with Cr, Zn, MgO, and iron, and a weaker positive correlation with Cr. It correlates negatively with SiO_2, Al_2O_3, CaO, and Na_2O (Appendix B).

Low Ni concentrations in the Raggedy Mountain Gabbro Group rocks may be due to their low olivine and relatively high plagioclase contents or initially low Ni concentration in the parental magmas.

Strontium

This element is usually concentrated in plagioclase, and increases with decreasing Ca during fractionation. Sr/Ca increases with decreasing anorthite content of plagioclases, as shown by analyses of Stillwater and Skaergaard intrusions (R. Berlin and C. H. B. Handerson, 1968).

Strontium contents average 409 ppm in the Raggedy Mountain Gabbro Group and 525 ppm (Table IV) in the Glen Mountain Layered Complex. There is a general decrease in average Sr contents from zones "L" to "M." Stronium concentrations remain relatively constant ($\pm$ 30 ppm) within the different zones, except zone "G" in which Sr varies from 241 to 592 ppm (Appendix A); this variation may be due to somewhat lower plagioclase contents with respect to the other zones.

The average Sr content of Wichita Mountain gabbros is similar to the value for basalt (465 ppm) given by Taylor (1965), but is much higher than the values obtained for gabbro-norite and anorthosite zones of Stillwater Intrusion (Table IV).

Modal-chemical correlation matrix shows a strong positive correlation with plagiclase, but a negative correlation with pyroxene, opaque, and biotite.

Sr shows a negative correlation with K_2O and CaO in Roosevelt Gabbro and the zone "G;" this correlation may reflect the crystallization of biotite in the Roosevelt Gabbro, and pyroxene in zone "G." Sr shows no significant correlation with CaO in Glen Mountain Layered Complex, but correlates positively with CaO and significant in Roosevelt and Cooperton Gabbro. Negative correlation is noticed for Sr with SiO_2 along with positive for Al_2O_3 and Na_2O (Appendix B).

Rubidium

Rubidium is an element that exhibits a strong association with K. This affinity is due to very similar electronegativities and ionic radii (r = 1.47). Rubidium accumulates in the late stage of magmatic crystallization, where it is concentrated in micas and K-feldspars (Taylor, 1967; Heier and Billings, 1969).

The mean rubidium concentration in Raggedy Mountain Gabbros is 2 ppm, which is much lower than the average basaltic (30 ppm) and Stillwater Intrusion (0-18 ppm) contents (Table IV). Glen Mountains Layered Complex including zone "G" has an average Rb content of 1 ppm. Rb in zone "G" was below detection. The average K/Rb ratio for the layered complex is about 2442 ppm; this abnormally high ratio primarily reflects the usually low concentration of Rb. The Rb concentrations on the Roosevelt Gabbros (average 6 ppm, Appendix B) may be related to the presence of biotite in the rocks. This relationship is supported by a positive correlation between Rb and biotite in modal-chemical correlation matrix (Appendix C).

Rb does not show a significant correlation with other elements within Glen Mountain Layered Complex, and correlates positively only with K_2O and Ba in Cooperton Area and Roosevelt Gabbros. There is also a weakly negative correlation with Sr, Al_2O_3, and CaO in the later rocks (Appendix B).

Barium

Barium is very similar in size to K^+ and only substitutes for K^+ in early-formed K minerals.

Mean Barium content is 90 ppm in the Raggedy Mountain Gabbro Group and 69 ppm (Table IV) in the Glen Mountain Layered Complex (including zone "G"). Barium in the zone "G," however, shows lower concentrations (10-70 ppm) and greater variation compared to the other zones (Appendix A). Highest Ba contents occur in the Roosevelt Gabbro, probably due to the higher biotite content of these rocks. Barium exhibits a positive but non-significant correlation with biotite (Appendix C). The difference in Ba contents between the Roosevelt Gabbro and GMLC suggests that these rocks formed from chemically distinct magmas or that the parental magmas underwent different fractionation processes.

Barium shows positive correlation with K_2O, and to a lesser extent, SiO_2; it has a negative correlation with CaO, Al_2O_3, and Sr. This correlation cannot be extended throughout the RMGG, since there is no strong correlation between Ba and other elements in the zone "G."

Vanadium

Vanadium (V^{3+}) usually substitutes for ferric iron in minerals due to its very similar ionic radius (0.61A°). Vanadium is present in pyroxenes, magnetite, ilmenite, amphibole, and biotite as a minor element (Taylor, 1967; Evans and Landergren, 1969).

The average vanadium content of both the Raggedy Mountain Gabbro Group and the Glen Mountain Layered Complex is about 160 ppm (Table IV); V contents are similar to those in gabbro-norite zone of Stillwater Intrusion (range 65-133 ppm; Table IV).

Vanadium in zone "G" averages 455 ppm (Appendix A). This high value can be related to the abundance of titaniferous magnetite and

ilmenite (5-15 percent), and pyroxenes (20-30 %) in this zone. Their strong positive correlation is evident in modal-chemical correlation matrix (Appendix C).

Vanadium shows positive correlations (Appendix B) with Cu, Cr, Zn, Ni, Fe_o, MgO, TiO_2, P_2O_5, and MnO; it correlates negatively with Sr, Al_2O_3 and CaO, within both GMLC and RMGG: Vanadium in zone "G" does not show any strong correlation except (negative) with MnO. The pattern of correlation is consistent with the geochemical behavior of vanadium.

CHAPTER VI

CONCLUSIONS

The following are the principal results derived from Geochemical and Petrological analyses of the Raggedy Mountain Gabbro Group:

(1) Raggedy Mountain Gabbro Group consists of gabbroic rocks transitional from Anorthosite to Troctolite to gabbro.

(2) Variation of elements in individual members zones is distinctive and reflect mineralogic differences between these members.

(3) Iron and magnesium increase in value from anorthosite to troctolite. Ni, Cr, Fe, Mg and, to a lesser extent, Mn concentrations decrease with increasing silica content in the RMGG. Zn, Ni, Cr, Fe show a positive correlation with the mafic minerals; Cu shows no significant correlation with any other elements in GMLC.

(4) Statistical treatment of the chemical and modal data show strong positive correlation between:

(a) Plagioclase and Al_2O_3, CaO, and Na_2O;

(b) Olivine and Ni, Cr (may be due to presence of Cr-spinel inclusions in olivine), Zn, Fe, and Mg;

(c) Biotite and Cu, Cr, Ni, Fe, Mg, V, P; and,

(d) Magnetite, Ilmenite, Fe, V, Zn, and Ti.

(5) "G" zone of the layered series is suggest to be separate member of the RMGG. This suggestion is based on petrological, petrographical, and chemical observations. The lack of ophitic texture,

cryptic and rhytmic layering, and mineralogical reaction relationships present in the other zones of GMLC, the higher modal content of olivine, pyroxene, and titaniferous magnetite, high concentration of Mg, Fe, Cr, Ni, Cu, V, and lower Na_2O, K_2O, Sr, and Rb contents compared to the other GMLC zones imply a different degree of differentiation. The lack of elemental correlation such as found in the "K," "L," and "M" zones is strong evidence that the "G" zone may be a different member of RMGG. It is proposed zone "G" should be renamed Iron Mountain Gabbro to distinguish from the zones of GMLC.

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APPENDIXES

APPENDIX A

CHEMICAL ANALYSES OF GMLC BY ZONE, ROOSEVELT GABBRO, AND COOPERTON AREA

ZONE "K"

TABLE VI

MINIMUM, MEAN, AND MAXIMUM VALUES
OF THE MAJOR AND TRACE ELEMENTS
OF THE ZONE "K"

Variables		Minimum	Mean (13)[3]	Maximum
SiO_2	%	46.25	47.73	49.50
Al_2O_3	%	28.0	32.63	34.80
FeO[1]	%	0.30	1.45	4.50
MgO	%	0.21	1.45	4.30
CaO	%	10.00	11.24	11.75
Na_2O	%	2.10	2.90	3.36
K_2O	%	0.16	0.24	0.91
TiO_2	%	0.07	0.14	0.30
P_2O_5	%	0.13	0.18	0.23
MnO	%	0.02	0.03	0.04
Cu	ppm	5	13	21
Cr	ppm	2	4	9
Zn	ppm	10	17	30
Pb	ppm	10	17	25
Ni	ppm	12	19	33
Ba	ppm	40	59	110
Sr	ppm	496	574	764
Rb	ppm	nd	.07	1
V	ppm	10	36	70
K/RB	ppm	--	2370	7471
Total[2]		97.08	98.02	98.95

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

[3]Number of analyses.

TABLE VII

CHEMICAL COMPOSITION OF MAJOR AND TRACE ELEMENTS OF THE ZONE "K"

VARIABLES		Sample No. WG-40	WG-47	WG-45	WG-44	WG-43	WG-42	WG-48
SiO_2	%	47.20	47.00	48.50	49.50	47.90	46.50	46.50
Al_2O_3	%	33.90	43.80	33.00	33.40	33.20	30.00	31.00
FeO[1]	%	1.10	1.10	0.70	0.30	0.65	4.50	3.00
MgO	%	1.68	0.24	0.43	0.21	0.52	4.00	3.84
CaO	%	11.75	11.50	11.75	11.40	11.30	10.00	11.00
Na_2O	%	2.83	3.26	3.26	3.04	3.12	2.99	2.61
K_2O	%	0.17	0.22	0.20	0.17	0.91	0.17	0.16
TiO_2	%	0.07	0.09	0.19	0.07	0.17	0.09	0.09
P_2O_5	%	0.22	0.20	0.18	0.15	0.15	0.17	0.23
MnO	%	0.02	0.03	0.20	0.02	0.02	0.03	0.04
Cu	ppm	21	8	13	17	21	18	10
Cr	ppm	3	2	3	2	5	3	4
Zn	ppm	18	13	12	17	14	30	22
Pb	ppm	10	10	20	20	20	10	20
Ni	ppm	20	12	14	12	14	33	33
Ba	ppm	50	50	60	60	50	60	70
Sr	ppm	509	609	565	590	764	580	576
Rb	ppm	nd	nd	nd	nd	nd	nd	1
V	ppm	20	20	50	40	60	20	40
K/Rb	ppm	--	--	--	--	--	--	1328
Total[2]		98.95	98.44	98.23	98.28	97.94	98.46	98.48

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

(Location of the samples are shown in Plate No. 3)

TABLE VII (Continued)

VARIABLES		Sample No. WG-41	WG-67	WG-45	WG-49	WG-54	WG-104
SiO_2	%	48.50	48.00	48.25	46.25	48.25	48.25
Al_2O_3	%	34.00	32.00	34.00	33.00	34.00	28.00
FeO[1]	%	0.40	1.60	0.40	1.65	0.50	3.00
MgO	%	0.27	0.54	0.38	2.04	0.42	4.30
CaO	%	11.30	11.50	11.10	11.00	11.10	11.50
Na_2O	%	3.36	3.06	2.68	2.45	2.95	2.10
K_2O	%	0.20	0.22	0.17	0.18	0.16	0.16
TiO_2	%	0.92	0.29	0.09	0.30	0.07	0.15
P_2O_5	%	0.20	0.17	0.15	0.13	0.18	0.23
MnO	%	0.04	0.02	0.02	0.02	0.04	0.02
Cu	ppm	5	16	17	12	8	6
Cr	ppm	3	7	7	8	3	9
Zn	ppm	12	20	15	17	10	21
Pb	ppm	20	20	20	20	10	25
Ni	ppm	14	14	12	24	18	30
Ba	ppm	70	70	40	40	40	110
Sr	ppm	563	602	546	496	547	515
Rb	ppm	nd	nd	nd	nd	nd	nd
V	ppm	30	70	30	70	10	20
K/Rb	ppm	--	--	--	--	--	--
Total[2]		98.36	97.41	97.24	97.08	97.67	97.72

ZONE "L"

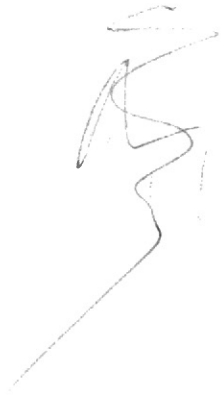

TABLE VIII

MINIMUM, MEAN, AND MAXIMUM VALUES
OF THE MAJOR AND TRACE ELEMENTS
OF THE ZONE "L"

Variables		Minimum	Mean (18)[3]	Maximum
SiO_2	%	44.30	48.31	51.00
Al_2O_3	%	14.40	28.78	34.80
FeO[1]	%	0.19	2.33	14.20
MgO	%	0.23	3.35	12.00
CaO	%	8.40	11.06	13.50
Na_2O	%	1.46	2.96	3.91
K_2O	%	0.17	0.23	0.40
TiO_2	%	0.08	0.36	2.35
P_2O_5	%	0.13	0.24	0.61
MnO	%	0.02	0.07	0.80
Cu	ppm	9	43	268
Cr	ppm	3	36	160
Zn	ppm	9	26	123
Pb	ppm	1	20	45
Ni	ppm	14	24	98
Ba	ppm	40	89	160
Sr	ppm	289	518	726
Rb	ppm	nd	1	8
V	ppm	20	79	480
K/Rb	ppm	--	1909	415
Total[2]		95.06	97.74	99.72

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

[3]Number of analyses.

TABLE IX

CHEMICAL COMPOSITION AND TRACE ELEMENTS OF THE ZONE "L"

VARIABLES		Sample No. WG-70	WG-69	WG-79	WG-98	WG-72	WG-55	WG-77
SiO_2	%	47.00	49.00	48.25	49.50	48.30	47.50	49.00
Al_2O_3	%	34.80	32.00	34.00	34.00	34.00	33.00	33.20
FeO^1	%	0.40	0.90	0.75	0.40	0.30	0.19	0.40
FeO	%	0.18	0.40	0.33	0.18	0.13	0.08	0.11
MgO	%	0.37	0.72	0.23	0.27	0.33	0.32	0.29
CaO	%	11.00	11.00	11.20	10.00	11.50	11.00	10.60
NaO_2	%	2.93	3.68	3.24	3.17	3.75	3.39	3.43
K_2O	%	0.30	0.25	0.20	0.19	0.17	0.19	0.40
T_1O_2	%	0.10	0.13	0.09	0.24	0.08	0.22	0.15
P_2O_5	%	0.24	0.20	0.21	0.17	0.23	0.17	0.21
MnO	%	0.02	0.04	0.02	0.02	0.02	0.02	0.02
Cu	ppm	30	13	21	9	9	168	17
Cr	ppm	3	6	3	3	3	3	3
Zn	ppm	23	10	10	10	9	15	17
Pb	ppm	20	20	20	20	20	20	10
Ni	ppm	16	14	14	16	14	38	14
Ba	ppm	70	140	56	100	45	40	110
Sr	ppm	682	525	576	610	524	587	552
Rb	ppm	nd	nd	5	nd	nd	nd	4
V	ppm	30	40	20	20	30	30	30
K/Rb	ppm	--	--	332	--	--	--	830
Total[2]		97.72	97.93	98.20	97.96	96.69	95.91	97.70

[1]Total Iron expressed as FeO.

[2]Total before reconversion

(Location of samples are shown in Plate No. 3)

TABLE IX (Continued)

VARIABLES		Sample No. WG-71	WG-68	W-99	W-73	W-36	W-39	WG-105
SiO_2	%	50.00	47.00	48.50	49.20	44.30	48.00	44.20
Al_2O_3	%	31.30	34.50	30.00	31.40	16.00	32.00	23.00
FeO^1	%	0.25	0.19	0.23	0.28	14.20	0.40	4.80
FeO	%	0.11	0.08	0.10	0.12	6.39	0.18	2.16
MgO	%	2.03	0.52	0.52	0.66	10.00	0.50	8.24
CaO	%	10.20	11.00	11.00	11.50	8.40	11.40	10.40
NaO_2	%	3.12	3.49	3.91	3.49	2.35	3.53	2.54
K_2O	%	0.25	0.19	0.23	0.23	0.26	0.23	0.24
T_1O_2	%	0.19	0.31	0.37	0.14	2.35	0.15	0.46
P_2O_5	%	0.13	0.17	0.25	0.16	0.61	0.24	0.24
MnO	%	0.02	0.02	0.04	0.02	0.80	0.02	0.08
Cu	ppm	14	38	27	33	142	28	11
Cr	ppm	19	7	7	25	160	3	99
Zn	ppm	18	24	18	14	123	15	36
Pb	ppm	20	20	20	20	20	20	25
Ni	ppm	16	18	14	14	98	14	18
Ba	ppm	95	70	90	60	100	60	100
Sr	ppm	483	604	513	540	403	726	401
Rb	ppm	nd	nd	2	nd	nd	nd	nd
V	ppm	60	100	40	50	480	40	160
K/Rb	ppm	--	--	954	--	--	--	--
Total[2]		97.40	97.39	95.06	97.13	99.37	96.47	98.20

TABLE IX (Continued)

VARIABLES		Sample No. WG-106	C_2Clot	C_3Clot	C_4Clot
SiO_2	%	48.00	51.00	47.50	49.40
Al_2O_3	%	30.80	14.40	19.00	20.80
FeO^1	%	2.40	6.00	4.50	5.50
FeO	%	1.08	2.70	2.02	1.12
MgO	%	2.52	11.50	12.00	9.40
CaO	%	10.50	13.50	12.80	12.20
Na_2O	%	2.87	1.46	1.47	1.50
K_2O	%	0.21	0.20	0.19	0.21
TiO_2	%	0.22	0.53	0.49	0.43
P_2O_5	%	0.20	0.31	0.28	0.25
MnO	%	0.04	0.04	0.04	0.03
Cu	ppm	63	16	30	20
Cr	ppm	3	157	48	103
Zn	ppm	19	35	43	30
Pb	ppm	15	20	45	20
Ni	ppm	24	35	36	21
Ba	ppm	115	110	160	75
Sr	ppm	600	298	289	418
Rb	ppm	nd	8	nd	nd
V	ppm	60	100	110	25
K/Rb	ppm	--	--	--	--
Total[2]		97.76	98.95	98.27	99.72

ZONE "M"

TABLE X

MINIMUM, MEAN, AND MAXIMUM VALUES
OF THE MAJOR AND TRACE ELEMENTS
OF THE ZONE "M"

Variables		Minimum	Mean (22)[3]	Maximum
SiO_2	%	45.00	47.35	49.50
Al_2O_3	%	19.00	29.81	35.20
FeO[1]	%	0.20	3.40	13.00
MgO	%	0.22	3.28	10.20
CaO	%	8.40	11.19	12.50
Na_2O	%	2.13	2.75	3.56
K_2O	%	0.16	0.21	0.35
TiO_2	%	0.06	0.30	0.74
P_2O_5	%	0.12	0.22	0.34
MnO	%	0.20	0.03	0.07
Cu	ppm	8	35	88
Cr	ppm	3	21	84
Zn	ppm	12	29	77
Pb	ppm	20	21	20
Ni	ppm	14	25	99
Ba	ppm	20	61	125
Sr	ppm	399	532	671
Rb	ppm	nd	1	5
V	ppm	20	74	160
K/Rb	ppm	--	1743	581
Total[2]		97.22	98.56	99.97

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

[3]Number of analyses.

TABLE XI

CHEMICAL COMPOSITION OF MAJOR AND TRACE ELEMENTS OF THE ZONE "M"

VARIABLES		Sample No. WG-37	WG-62	WG-59	WG-61	WG-66	WG-35	WG-76
SiO_2	%	48.00	47.75	45.00	45.75	48.00	47.50	47.50
Al_2O_3	%	29.50	24.50	19.00	29.60	31.00	32.40	33.00
FeO[1]	%	3.95	4.58	13.00	3.40	3.10	1.00	0.95
MgO	%	4.00	5.18	10.20	2.92	2.28	0.50	1.99
CaO	%	10.10	12.00	8.40	11.80	10.00	12.20	11.80
Na_2O	%	2.71	2.27	2.13	2.82	3.56	3.25	2.40
K_2O	%	0.25	0.27	0.19	0.22	0.34	0.19	0.16
TiO_2	%	0.37	0.74	0.51	0.46	0.41	0.11	0.07
P_2O_5	%	0.19	0.32	0.17	0.22	0.22	0.21	0.12
MnO	%	0.02	0.07	0.06	0.02	0.05	0.02	0.03
Cu	ppm	43	45	21	22	51	18	14
Cr	ppm	36	43	72	10	16	10	5
Zn	ppm	39	49	77	30	30	15	13
Pb	ppm	20	30	20	20	20	20	20
Ni	ppm	27	18	99	22	20	16	20
Ba	ppm	60	45	80	60	120	90	40
Sr	ppm	500	441	510	622	573	523	517
Rb	ppm	4	nd	5	nd	4	nd	nd
V	ppm	120	140	120	90	90	40	20
K/Rb	ppm	518	--	315	--	456	--	--
Total[2]		99.11	97.69	98.68	97.21	98.96	97.38	98.02

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

(Location of the samples are shown in Plate No. 3)

TABLE XI (Continued)

VARIABLES		Sample No. WG-78	WG-38	WG-103	WG-60	WG-102	WG-80	WG-74
SiO_2	%	47.50	47.00	47.25	46.00	48.00	47.50	47.50
Al_2O_3	%	31.50	26.50	28.60	30.00	26.00	32.00	31.00
FeO[1]	%	1.60	4.30	4.50	3.97	5.00	3.00	3.60
MgO	%	2.32	5.00	3.43	3.12	5.30	2.40	3.25
CaO	%	12.00	12.00	11.00	11.00	10.50	11.00	11.22
Na_2O	%	2.79	2.43	2.40	2.56	2.65	2.50	2.95
K_2O	%	0.17	0.20	0.18	0.27	0.35	0.23	0.17
TiO_2	%	0.18	0.50	0.34	0.66	0.32	0.58	0.09
P_2O_5	%	0.25	0.25	0.19	0.34	0.26	0.15	0.15
MnO	%	0.03	0.03	0.03	0.04	0.04	0.02	0.03
Cu	ppm	64	36	73	88	20	36	16
Cr	ppm	31	79	35	5	9	12	8
Zn	ppm	15	33	23	58	39	35	13
Pb	ppm	20	20	20	20	20	20	30
Ni	ppm	18	24	22	20	29	22	22
Ba	ppm	60	100	40	70	40	30	30
Sr	ppm	525	402	671	534	495	515	575
Rb	ppm	3	nd	nd	nd	0.30	nd	nd
V	ppm	70	140	130	160	50	130	20
K/Rb	ppm	470	--	--	--	--	--	--
Total[2]		98.35	98.22	98.26	97.96	98.52	99.97	99.38

TABLE XI (Continued)

VARIABLES		Sample No. WG-83	WG-74	WG-101	WG-84	WG-82	WG-34	WG-90	WG-107
SiO_2	%	27.90	47.00	49.50	47.50	46.50	47.75	47.50	47.90
Al_2O_3	%	40.60	31.00	1.70	35.20	29.60	34.80	32.40	32.61
FeO[1]	%	6.40	2.85	35.20	0.20	4.00	0.35	2.80	0.55
MgO	%	9.18	4.05	0.31	0.22	4.00	0.30	1.41	0.80
CaO	%	11.42	11.22	9.80	12.00	11.00	12.00	11.50	12.50
Na_2O	%	2.54	3.04	2.38	2.83	2.92	2.91	2.99	3.10
K_2O	%	0.18	0.19	0.21	0.18	0.19	0.19	0.20	0.18
TiO_2	%	0.64	0.12	0.13	0.05	0.09	0.09	0.11	0.07
P_2O_5	%	0.22	0.16	0.29	0.19	0.23	0.22	0.21	0.23
MnO	%	0.40	0.02	0.05	0.02	0.04	0.02	0.02	0.02
Cu	ppm	34	13	35	73	22	20	32	8
Cr	ppm	84	5	3	3	3	3	4	3
Zn	ppm	44	16	17	21	30	24	22	13
Pb	ppm	20	20	20	20	20	20	20	25
Ni	ppm	24	25	18	16	29	14	20	21
Ba	ppm	80	50	61	30	40	45	20	125
Sr	ppm	399	560	605	548	520	516	545	623
Rb	ppm	nd	2	nd	nd	nd	nd	2	nd
V	ppm	190	40	20	20	20	20	20	20
K/Rb	ppm	--	788	--	--	--	--	830	--
Total[2]		47.00	99.66	99.18	98.40	95.58	98.64	99.15	97.96

IRON MOUNTAIN GABBRO

(ZONE "G")

TABLE XII

MINIMUM, MEAN, AND MAXIMUM VALUES
OF THE MAJOR AND TRACE ELEMENTS
OF IRON MOUNTAIN GABBRO
(ZONE G)

Variables		Minimum	Mean (6)[3]	Maximum
SiO_2	%	44.25	46.62	49.41
Al_2O_3	%	18.50	21.50	26.50
FeO[1]	%	0.56	7.14	10.00
MgO	%	5.60	8.93	11.80
CaO	%	9.50	9.89	10.40
Na_2O	%	2.36	2.76	3.30
K_2O	%	0.16	0.19	0.24
TiO_2	%	0.27	2.22	4.16
P_2O_5	%	0.11	0.15	0.18
MnO	%	0.02	0.06	0.12
Cu	ppm	15	61	145
Cr	ppm	20	92	270
Zn	ppm	58	95	140
Pb	ppm	10	16	20
Ni	ppm	25	63	105
Ba	ppm	10	51	70
Sr	ppm	241	412	592
Rb	ppm	nd	0.25	1
V	ppm	70	455	680
K/Rb	ppm	--	6309	1992
Total[2]		98.72	99.48	100.36

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

[3]Number of analyses.

TABLE XIII

CHEMICAL COMPOSITION OF MAJOR AND TRACE ELEMENTS OF THE IRON MOUNTAIN GABBRO (ZONE "G")

VARIABLES		Sample No. WG-83	WG-64	WG-65	WG-56	WG-57	WG-58
SiO_2	%	47.20	58.50	49.41	45.11	45.25	44.25
Al_2O_3	%	18.50	19.10	19.90	22.00	26.50	23.00
FeO[1]	%	7.60	7.80	0.56	10.00	6.90	10.00
MgO	%	9.00	8.20	11.80	10.00	5.60	9.00
CaO	%	10.40	10.00	10.14	9.50	9.80	9.50
Na_2O	%	2.72	2.89	3.30	2.36	2.72	2.61
K_2O	%	0.16	0.19	0.24	0.19	0.19	0.19
TiO_2	%	3.50	3.51	4.16	0.27	1.63	0.27
P_2O_5	%	0.15	0.13	0.17	0.18	0.11	0.17
MnO	%	0.04	0.04	0.04	0.12	0.02	0.10
Cu	ppm	15	135	145	17	38	17
Cr	ppm	20	47	44	105	270	69
Zn	ppm	140	114	114	72	72	58
Pb	ppm	10	10	20	20	20	20
Ni	ppm	25	40	44	105	70	94
Ba	ppm	10	50	65	60	70	55
Sr	ppm	290	345	241	491	514	592
Rb	ppm	nd	nd	nd	nd	1	nd
V	ppm	680	620	620	70	660	80
K/Rb	ppm	--	--	--	--	1577	--
Total[2]		99.27	100.36	99.72	99.74	98.72	99.10

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

(Location of the samples are shown in Plate No. 3)

ROOSEVELT GABBRO

TABLE XIV

MINIMUM, MEAN, AND MAXIMUM VALUES
OF THE MAJOR AND TRACE ELEMENTS
OF THE ROOSEVELT GABBRO

Variables		Minimum	Mean (19)[3]	Maximum
SiO_2	%	46.60	49.68	55.40
Al_2O_3	%	12.97	27.84	35.00
FeO	%	0.40	3.41	9.29
MgO	%	0.35	3.40	7.42
CaO	%	7.67	10.65	12.70
Na_2O	%	2.10	2.90	3.62
K_2O	%	0.17	0.46	1.63
TiO_2	%	0.09	0.78	3.74
P_2O_5	%	0.14	0.32	1.08
MnO	%	0.02	0.05	0.35
Cu	ppm	8	34	157
Cr	ppm	2	10	45
Zn	ppm	8	41	133
Pb	ppm	10	21	30
Ni	ppm	12	24	37
Ba	ppm	10	143	625
Sr	ppm	229	500	631
Rb	ppm	nd	5	33
V	ppm	20	125	520
K/Rb	ppm	--	763	410
Total[2]		98.42	99.53	101.31

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

[3]Number of analyses.

TABLE XV

CHEMICAL COMPOSITION OF MAJOR AND TRACE ELEMENTS OF THE ROOSEVELT GABBRO

VARIABLES		Sample No.							
		WR-88	WR-86	WM-109	WG-110	WM-111	WO-26	WO-27	WR-89
SiO_2	%	49.60	50.50	55.40	51.10	54.00	49.40	48.20	49.10
Al_2O_3	%	33.90	32.00	12.07	14.00	14.00	30.20	30.40	33.06
FeO[1]	%	0.40	1.00	9.29	9.14	8.13	2.05	2.29	0.80
MgO	%	0.35	0.71	5.70	7.42	6.80	3.15	2.91	0.38
CaO	%	10.70	11.60	7.67	9.25	7.69	11.19	11.50	12.24
Na_2O	%	3.62	3.12	3.11	3.10	3.10	3.15	2.91	3.28
K_2O	%	0.30	0.20	1.62	1.07	1.48	0.19	0.17	0.22
TiO_2	%	0.12	0.16	3.27	3.74	2.47	0.10	0.10	0.09
P_2O_5	%	0.23	0.21	0.77	1.08	0.71	0.18	0.18	0.20
MnO	%	0.02	0.04	0.35	0.08	0.04	0.02	0.02	0.02
Cu	ppm	10	20	40	157	65	10	14	16
Cr	ppm	3	4	6	4	38	4	4	4
Zn	ppm	15	14	133	131	121	17	22	8
Pb	ppm	20	20	20	25	20	20	20	30
Ni	ppm	16	18	12	29	24	25	33	16
Ba	ppm	60	60	625	390	500	60	30	50
Sr	ppm	544	571	229	333	287	557	576	595
Rb	ppm	2	nd	29	14	27	nd	nd	2
V	ppm	60	60	440	520	310	60	30	40
K/Rb	ppm	1245	--	463	634	455	--	--	913
Total[2]		99.25	99.54	100	99.98	98.42	99.64	98.79	99.40

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

(Location of samples are shown in Plate No. 2)

TABLE XV (Continued)

VARIABLES		Sample No. WR-87	WR-95	WR-92	WR-96	WR-97	WR-94	WR-93	WR-85
SiO_2	%	48.20	49.75	48.00	49.60	49.40	46.40	47.22	50.00
Al_2O_3	%	27.40	32.40	30.00	33.20	33.20	29.20	32.70	35.00
FeO[1]	%	4.03	1.60	4.00	1.40	1.00	4.00	2.17	0.50
MgO	%	4.40	1.59	4.80	1.58	1.25	5.05	3.45	0.49
CaO	%	11.50	10.50	10.00	12.70	10.90	10.90	10.80	11.83
Na_2O	%	2.80	2.40	2.84	2.32	2.96	2.85	2.86	2.10
K_2O	%	0.19	0.20	0.27	0.17	0.18	0.19	0.20	0.20
TiO_2	%	0.59	0.13	0.27	0.17	0.12	0.31	0.10	0.13
P_2O_5	%	0.23	0.16	0.22	0.14	0.16	0.19	0.21	0.15
MnO	%	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.07
Cu	ppm	105	11	22	19	21	35	12	13
Cr	ppm	45	3	6	11	10	8	6	3
Zn	ppm	25	20	34	16	12	36	20	12
Pb	ppm	20	20	10	20	30	30	20	20
Ni	ppm	31	24	33	20	18	37	29	18
Ba	ppm	10	60	50	20	30	50	20	50
Sr	ppm	540	595	552	631	585	529	511	595
Rb	ppm	nd	1	nd	nd	nd	nd	nd	nd
V	ppm	160	40	60	70	40	60	60	30
K/Rb	ppm	--	1660	--	--	--	--	--	--
Total[2]		99.38	99.26	100.42	101.31	99.19	99.13	99.73	100.47

COOPERTON AREA

TABLE XVI

MINIMUM, MEAN, AND MAXIMUM VALUES
OF THE MAJOR AND TRACE ELEMENTS
OF THE COOPERTON AREA

Variables		Minimum	Mean (33)[3]	Maximum
SiO_2	%	45.50	47.92	50.00
Al_2O_3	%	16.20	28.20	35.50
FeO	%	0.35	4.05	12.00
MgO	%	0.30	4.33	13.40
CaO	%	8.80	10.66	12.00
Na_2O	%	1.47	3.00	4.52
K_2O	%	0.18	0.35	0.67
TiO_2	%	0.08	0.05	1.55
P_2O_5	%	0.14	0.28	0.72
MnO	%	0.02	0.04	0.22
Cu	ppm	11	49	195
Cr	ppm	3	37	171
Zn	ppm	7	41	100
Pb	ppm	10	19	30
Ni	ppm	14	39	122
Ba	ppm	50	96	190
Sr	ppm	282	486	666
Rb	ppm	nd	3	17
V	ppm	30	93	200
K/Rb	ppm	--	968	327
Total[2]		98.29	99.41	102.23

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

[3]Number of analyses.

TABLE XVII

CHEMICAL COMPOSITION OF MAJOR AND TRACE ELEMENTS OF THE COOPERTON AREA

VARIABLES		Sample No. WQ-1	WQ-2	WQ-31	WQ-7	WQ-4	WQ-6	WQ-14
SiO_2	%	48.50	49.50	49.50	49.90	48.50	48.35	46.50
Al_2O_3	%	31.00	30.20	32.00	30.30	32.50	33.20	18.20
FeO[1]	%	3.25	2.30	0.80	2.95	1.35	1.70	9.00
MgO	%	1.45	2.31	0.54	0.52	0.70	1.27	11.30
CaO	%	10.60	9.90	10.80	10.10	10.80	10.90	9.50
Na_2O	%	3.35	3.49	4.03	4.52	3.52	3.51	1.96
K_2O	%	0.37	0.54	0.53	0.47	0.34	0.41	0.62
TiO_2	%	0.31	0.46	0.18	0.52	0.36	0.34	1.22
P_2O_5	%	0.28	0.16	0.28	0.28	0.19	0.20	0.36
MnO	%	0.03	0.03	0.02	0.04	0.02	0.04	0.09
Cu	ppm	44	45	20	18	47	11	133
Cr	ppm	4	4	30	3	3	4	119
Zn	ppm	34	27	18	42	24	28	13
Pb	ppm	10	20	20	20	30	20	10
Ni	ppm	14	14	14	16	16	16	105
Ba	ppm	150	140	110	140	80	130	100
Sr	ppm	594	522	564	578	438	425	378
Rb	ppm	7	8	9	17	4	nd	2
V	ppm	80	80	40	100	70	80	140
K/Rb	ppm	438	560	488	230	705	--	2490
Total[2]		99.12	98.89	98.69	99.61	98.29	99.93	98.75

[1]Total Iron expressed as FeO.

[2]Total before reconversion.

(Location of the samples are shown in Plate No. 1)

TABLE XVII (Continued)

VARIABLES		Sample No. WQ-8	WC-13	WC-15	WQ-10	WQ-5	WC-11	WC-16
SiO_2	%	49.50	45.50	45.61	46.25	47.20	46.10	47.90
Al_2O_3	%	28.00	16.20	18.00	25.30	32.20	18.60	16.80
FeO[1]	%	4.80	12.00	10.00	5.00	3.16	8.90	8.60
MgO	%	3.30	11.00	11.40	7.99	1.74	11.60	10.40
CaO	%	10.60	8.80	9.80	10.50	11.44	9.60	9.69
Na_2)	%	2.31	1.93	2.55	2.63	3.03	2.36	2.53
K_2O	%	0.34	0.67	0.44	0.21	0.22	0.41	0.55
TiO_2	%	0.56	1.55	1.31	0.50	0.45	1.01	1.47
P_2O_5	%	0.28	0.64	0.33	0.14	0.25	0.46	0.72
MnO	%	0.03	0.08	0.08	0.03	0.04	0.07	0.04
Cu	ppm	37	54	195	33	50	154	87
Cr	ppm	14	115	171	25	8	165	127
Zn	ppm	37	100	87	54	30	80	90
Pb	ppm	20	20	20	20	20	10	20
Ni	ppm	18	88	109	33	24	105	83
Ba	ppm	100	110	70	70	100	110	140
Sr	ppm	527	379	359	581	457	338	350
Rb	ppm	7	2	7	nd	nd	2	5
V	ppm	120	190	160	80	90	150	200
K/Rb	ppm	403	2490	521	--	--	830	913
Total[2]		99.76	98.37	99.52	98.55	99.74	99.12	98.71

TABLE XVII (Continued)

VARIABLES		Sample No. WC-12	WC-33	WC-17	WC-24	WC-23	WC-52	WC-30
SiO_2	%	46.00	47.40	48.90	48.70	49.73	47.95	5.00
Al_2O_3	%	17.39	30.00	31.00	31.70	33.50	35.50	32.20
FeO[1]	%	10.60	2.95	2.50	2.26	0.62	0.40	1.65
MgO	%	4.54	1.34	1.14	1.01	0.27	0.18	0.74
CaO	%	12.00	3.70	0.71	1.95	0.41	0.40	1.31
Na_2O	%	2.10	3.10	3.29	4.07	3.50	3.00	3.34
K_2O	%	0.45	0.23	0.48	0.20	0.24	0.18	0.40
TiO_2	%	1.22	0.20	0.35	0.28	0.18	0.11	0.12
P_2O_5	%	0.38	0.27	0.25	0.19	0.23	0.16	0.29
MnO	%	0.05	0.02	0.02	0.02	0.22	0.02	0.02
Cu	ppm	147	50	17	22	13	21	37
Cr	ppm	128	14	5	4	4	4	4
Zn	ppm	93	30	33	16	11	10	30
Pb	ppm	20	30	20	20	20	30	20
Ni	ppm	114	25	22	18	16	18	20
Ba	ppm	50	70	110	90	90	60	110
Sr	ppm	324	460	501	601	666	524	574
Rb	ppm	nd	nd	3	nd	nd	1	2
V	ppm	160	90	80	60	70	60	60
K/Rb	ppm	--	--	1328	--	--	1492	1660
Total[2]		99.29	99.10	99.23	99.47	99.35	99.55	99.54

TABLE XVII (Continued)

VARIABLES		Sample No. WC-53	WC-19	WC-20	WC-31	WC-51	WC-28	WC-18
SiO_2	%	46.40	48.20	48.00	48.73	48.60	48.90	47.30
Al_2O_3	%	21.60	32.80	32.50	34.50	33.80	33.06	28.20
FeO[1]	%	7.55	2.10	1.90	0.80	1.27	1.12	4.10
MgO	%	10.60	1.79	0.80	0.38	1.25	0.58	4.48
CaO	%	9.89	11.20	11.60	11.97	11.02	11.73	11.30
Na_2O	%	2.73	3.00	3.53	2.73	3.43	3.43	2.70
K_2O	%	0.27	0.30	0.36	0.19	0.26	0.32	0.31
TiO_2	%	0.47	0.37	0.45	0.15	0.13	0.19	0.51
P_2O_5	%	0.19	0.23	0.28	0.16	0.19	0.20	0.28
MnO	%	0.04	0.02	0.02	0.02	0.02	0.02	0.06
Cu	ppm	18	16	22	21	24	22	17
Cr	ppm	57	22	3	3	3	3	31
Zn	ppm	75	37	26	26	22	20	32
Pb	ppm	20	20	20	10	20	20	20
Ni	ppm	90	16	18	16	18	24	25
Ba	ppm	90	70	100	60	65	120	90
Sr	ppm	426	480	466	567	567	623	497
Rb	ppm	nd	1	nd	nd	nd	1	2
V	ppm	100	100	80	30	30	90	110
K/Rb	ppm	--	2490	--	--	--	2490	1286
Total[2]		99.75	100.02	99.45	99.64	99.98	99.56	99.24

TABLE XVII (Continued)

VARIABLES		Sample No. WG-22	WC-32	WC-24	WC-21	WC-108
SiO_2	%	46.11	49.71	48.50	48.00	45.50
Al_2O_3	%	26.60	32.00	34.80	29.50	17.50
FeO[1]	%	5.00	2.10	0.35	3.18	10.00
MgO	%	8.25	1.63	0.30	3.69	13.40
CaO	%	11.00	12.00	11.80	11.00	9.00
Na_2O	%	2.16	3.68	2.85	2.96	1.74
K_2O	%	0.26	0.23	0.19	0.36	0.47
TiO_2	%	0.48	0.56	0.08	0.64	1.36
P_2O_5	%	1.22	0.30	0.15	0.39	0.20
MnO	%	0.04	0.02	0.02	0.02	0.05
Cu	ppm	15	34	19	45	140
Cr	ppm	7	5	3	20	152
Zn	ppm	80	26	7	36	87
Pb	ppm	20	20	10	20	15
Ni	ppm	25	16	14	18	122
Ba	ppm	60	65	50	100	190
Sr	ppm	440	494	597	466	282
Rb	ppm	nd	nd	nd	4	4
V	ppm	80	70	60	75	140
K/Rb	ppm	--	--	--	747	975
Total[2]		100.13	102.23	99.05	99.75	99.23

APPENDIX B

CORRELATION MATRIX OF CHEMICAL ANALYSES FOR EACH ZONE OF GMLC, ROOSEVELT GABBRO, COOPERTON AREA, GMLC, AND RMGG

ZONE "K"

	CU	CR	ZN	PB	NI	BA	SR	RB	V	SIO2	AL2O3	FE2O3
CU	1.00000 0.0000	-0.06038 0.8447	0.27390 0.3652	-0.18353 0.5435	-0.14551 0.6182	-0.39691 0.1793	0.35582 0.2272	-0.17570 0.5659	0.29870 0.3215	-0.04150 0.8929	0.12504 0.6744	-0.03631 0.9063
CR	-0.06038 0.8447	1.00000 0.0000	0.21256 0.4852	0.62016 0.0237	0.43991 0.1304	0.32173 0.2837	-0.21378 0.4831	-0.00736 0.9769	0.39847 0.1775	-0.11530 0.7076	-0.47841 0.0965	0.21670 0.4770
ZN	0.27390 0.3652	0.21256 0.4852	1.00000 0.0000	-0.01803 0.9534	0.76736 0.0022	0.48289 0.1723	-0.12013 0.6359	0.27516 0.3629	-0.02174 0.9439	-0.46832 0.1065	-0.76012 0.0026	0.90470 0.0001
PB	-0.18353 0.5435	0.62016 0.0237	-0.01803 0.9534	1.00000 0.0000	-0.00691 0.9821	0.52292 0.0667	0.05691 0.8688	0.15409 0.6153	0.58508 0.0546	0.37624 0.2130	-0.36785 0.2162	-0.07510 0.8073
NI	-0.14551 0.6182	0.43991 0.1304	0.76736 0.0022	-0.00691 0.9821	1.00000 0.0000	0.42845 0.1441	-0.31546 0.2931	0.01487 0.9716	-0.13499 0.6232	-0.60709 0.0278	-0.79666 0.0011	0.90580 0.0001
BA	-0.39691 0.1793	0.32173 0.2837	0.48289 0.1723	0.52292 0.0667	0.42845 0.1441	1.00000 0.0000	-0.11176 0.7162	0.17109 0.5763	-0.09415 0.7596	0.19961 0.6515	-0.38413 0.1950	-0.35978 0.2273
SR	0.35582 0.2272	-0.21378 0.4831	-0.12013 0.6359	0.05691 0.8688	-0.31546 0.2931	-0.11176 0.7162	1.00000 0.0000	0.00897 0.9768	0.31268 0.2983	0.13861 0.6515	0.14706 0.6316	-0.16160 0.5979
RB	-0.17570 0.5659	-0.00736 0.9769	0.27516 0.3629	0.15408 0.6153	0.01487 0.9718	0.17109 0.5763	0.00897 0.9768	1.00000 0.0000	0.04586 0.8817	-0.38413 0.1950	-0.25550 0.3995	0.35942 0.2278
V	0.29870 0.3215	0.39847 0.1775	-0.02174 0.9439	0.58508 0.0546	-0.13499 0.6232	-0.09415 0.7596	0.31268 0.2983	0.04586 0.8817	1.00000 0.0000	-0.05958 0.8467	0.03334 0.9139	-0.13223 0.6667
SIO2	-0.04150 0.8929	-0.11530 0.7076	-0.46832 0.1065	0.37624 0.2130	-0.60709 0.0278	0.19961 0.5132	0.13861 0.6515	-0.38413 0.1950	-0.05958 0.8467	1.00000 0.0000	0.18219 0.5514	-0.61660 0.0248
AL2O3	0.12504 0.6744	-0.47841 0.0962	-0.76012 0.0026	-0.36785 0.2162	-0.79666 0.0011	-0.78349 0.0015	0.14706 0.6316	-0.25550 0.3995	0.03334 0.9139	0.18219 0.5514	1.00000 0.0000	-0.82607 0.0005
FE2O3	-0.03631 0.9063	0.21670 0.4770	0.90470 0.0001	-0.07510 0.8074	0.90580 0.0001	0.46035 0.1134	-0.16160 0.5979	0.35942 0.2278	-0.13223 0.6667	-0.61660 0.0248	-0.82607 0.0005	1.00000 0.0000
FEO	-0.28261 0.3495	-0.26281 0.5064	0.18597 0.5474	-0.42410 0.1487	0.14627 0.6335	0.06340 0.8370	0.07642 0.8040	0.67877 0.7981	-0.29375 0.3306	-0.48259 0.0945	-0.04493 0.8841	0.35825 0.2293
MGO	-0.11380 0.7112	0.33394 0.2648	0.80956 0.0008	0.09053 0.7687	0.97556 0.0001	0.53903 0.0573	-0.31178 0.2997	0.45215 0.1208	-0.18700 0.5407	-0.55184 0.0506	-0.86459 0.0001	0.91565 0.0001
CAO	-0.09146 0.7663	0.01359 0.9648	-0.60194 0.0295	0.26766 0.3766	-0.56704 0.0433	0.15573 0.6114	-0.01349 0.9651	-0.16377 0.5929	0.14962 0.6256	0.47754 0.0989	0.33059 0.2699	-0.63207 0.0205
NA2O	0.12561 0.6826	-0.73785 0.0040	-0.40937 0.1648	-0.36480 0.2204	-0.62388 0.0227	-0.35978 0.2273	0.49884 0.0827	-0.24271 0.4243	0.04399 0.8865	0.27283 0.3671	0.61620 0.0245	-0.44561 0.1268
K2O	0.41055 0.1568	0.03916 0.8989	-0.19401 0.5254	0.14505 0.6349	-0.24927 0.4115	-0.15343 0.6168	0.87676 0.0001	-0.11663 0.7044	0.38009 0.2002	0.05453 0.8596	0.12626 0.6811	-0.21327 0.4842
TIO2	0.06679 0.8284	0.64034 0.0184	0.08772 0.8770	0.44900 0.1238	-0.04030 0.8960	0.05621 0.8553	0.01701 0.9560	-0.16851 0.5812	0.84513 0.0003	-0.18326 0.5490	-0.16386 0.5927	0.05379 0.8814
P2O5	-0.45501 0.1182	-0.11733 0.7027	0.20945 0.4922	-0.05700 0.8533	0.47184 0.1016	0.63428 0.0199	-0.28695 0.3418	0.47658 0.0997	-0.52082 0.0680	-0.14688 0.6321	-0.40591 0.1688	0.37558 0.2060
MNO	-0.58342 0.0363	-0.42977 0.1427	-0.11421 0.7103	-0.35506 0.2339	0.26728 0.3773	-0.02279 0.9411	-0.09301 0.7625	0.47603 0.1001	-0.50900 0.0757	-0.15402 0.6154	0.67303 0.0126	-0.11141 0.7171

	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	-0.11380	-0.09146	0.12561	0.41655	0.06679	-0.45501	-0.58342
	0.7112	0.7663	0.6826	0.1568	0.8284	0.1182	0.0363
CR	0.33394	0.01359	-0.73785	0.03916	0.64034	-0.11733	-0.42977
	0.2648	0.9648	0.0040	0.8989	0.0184	0.7027	0.1427
ZN	0.80956	-0.60194	-0.40937	-0.19401	0.04772	0.20945	-0.11421
	0.0008	0.0295	0.1648	0.5254	0.8770	0.4922	0.7103
PB	0.09053	0.26766	-0.36480	0.14565	0.44900	-0.05700	-0.35506
	0.7687	0.3766	0.2204	0.6349	0.1238	0.8533	0.2339
NI	0.97556	-0.56704	-0.62388	-0.24927	-0.04030	0.47184	0.26728
	0.0001	0.0433	0.0227	0.4115	0.8960	0.1036	0.3773
BA	0.53903	0.15573	-0.35978	-0.15343	0.05621	0.63428	-0.02279
	0.0573	0.6114	0.2273	0.6168	0.8553	0.0199	0.9411
SR	-0.31178	-0.01349	0.49889	0.87676	0.01701	-0.28695	-0.09301
	0.2997	0.9651	0.0827	0.0001	0.9560	0.3418	0.7625
RB	0.45215	-0.16377	-0.24271	-0.11663	-0.16891	0.47658	0.47603
	0.1208	0.5929	0.4243	0.7044	0.5812	0.0997	0.1001
V	-0.18700	0.14962	0.04399	0.38009	0.84513	-0.52082	-0.50900
	0.5407	0.6256	0.8865	0.2002	0.0003	0.0680	0.0757
SIO2	-0.55184	0.47754	0.27283	0.05453	-0.18326	-0.14688	-0.15402
	0.0506	0.0989	0.3671	0.8596	0.5490	0.6321	0.6154
AL2O3	-0.86459	0.33059	0.61620	0.12626	-0.16386	-0.40591	0.07303
	0.0001	0.2699	0.0249	0.6811	0.5927	0.1688	0.8126
FE2O3	0.91585	-0.63207	-0.44581	-0.21327	0.05379	0.37558	0.11141
	0.0001	0.0205	0.1268	0.4842	0.8614	0.2060	0.7171
FEO	0.18300	-0.11654	0.08642	-0.11951	-0.12427	0.30713	0.13402
	0.5496	0.7046	0.7789	0.6974	0.6859	0.3074	0.6625
MGO	1.00000	-0.48137	-0.69150	-0.23128	-0.01597	0.50450	0.11213
	0.0000	0.0958	0.0088	0.4471	0.9587	0.0787	0.7153
CAO	-0.48137	1.00000	0.11690	0.07070	0.14016	0.23084	-0.32280
	0.0958	0.0000	0.7037	0.8185	0.6479	0.4480	0.2820
NA2O	-0.69150	0.11690	1.00000	0.25009	-0.17601	-0.23771	0.15499
	0.0088	0.7037	0.0000	0.4099	0.5652	0.4342	0.5901
K2O	-0.23128	0.07070	0.25009	1.00000	0.15574	-0.33007	-0.25110
	0.4471	0.8185	0.4099	0.0000	0.6114	0.2707	0.4079
TIO2	-0.01597	0.14016	-0.17601	0.15574	1.00000	-0.39336	-0.52085
	0.9587	0.6479	0.5652	0.6114	0.0000	0.1836	0.0680
P2O5	0.50450	0.23084	-0.23771	-0.33007	-0.39336	1.00000	0.41466
	0.0787	0.4480	0.4342	0.2707	0.1836	0.0000	0.1539
MNO	0.11213	-0.32280	0.15499	-0.25110	-0.52085	0.41466	1.00000
	0.7153	0.2820	0.5901	0.4079	0.0680	0.1589	0.0000

ZONE "L"

	CU	CR	ZN	PB	NI	BA	SR	RB	V	SIO2	AL2O3	FE2O3
CU	1.00000 0.0000	0.66943 0.7843	0.31767 0.1989	-0.64694 0.0534	0.57384 0.0125	-0.36349 0.2200	0.67853 0.0768	-0.19227 0.4447	0.38566 0.2111	-0.49623 0.0362	-0.84733 0.0521	0.21598 0.3804
CR	0.66943 0.7843	1.00000 0.0000	0.75323 0.0003	0.17867 0.4796	0.49385 0.0627	0.24869 0.3237	-0.75068 0.0003	0.29238 0.2562	0.69345 0.0014	-0.08291 0.7436	-0.93300 0.0001	0.89248 0.0001
ZN	0.31767 0.1989	0.75323 0.0003	1.00000 0.0000	0.22647 0.4251	0.53374 0.0001	0.25158 0.3141	-0.48555 0.0411	-0.06267 0.8067	0.96759 0.0001	-0.64698 0.0037	-0.71256 0.0005	0.93847 0.0001
PB	-0.64694 0.0534	0.17867 0.4796	0.22647 0.4251	1.00000 0.0000	0.15618 0.5362	0.41179 0.0895	-0.52659 0.0268	-0.21453 0.3926	0.13661 0.5678	-0.15928 0.5279	-0.42231 0.0806	0.20615 0.4072
NI	0.57384 0.0125	0.49385 0.0627	0.53374 0.0001	0.15618 0.5362	1.00000 0.0000	0.18317 0.5177	-0.41767 0.0846	-0.03405 0.8933	0.55442 0.0001	-0.64123 0.0041	-0.63519 0.0046	0.87176 0.0001
BA	-0.36349 0.2200	0.24869 0.3237	0.25158 0.3141	0.41179 0.0895	0.18317 0.5177	1.00000 0.0000	-0.53634 0.0217	0.10594 0.6757	0.22277 0.3743	0.10001 0.6930	-0.45157 0.0600	0.31975 0.1958
SR	0.67853 0.0768	-0.75068 0.0003	-0.48555 0.0411	-0.52659 0.0268	-0.41767 0.0846	-0.53633 0.0217	1.00000 0.0000	-0.29168 0.2412	-0.42432 0.0793	-0.14370 0.5694	0.86191 0.0001	-0.63490 0.0046
RB	-0.19227 0.4447	0.29238 0.2562	-0.06267 0.8067	-0.21453 0.3926	-0.03405 0.8933	0.10594 0.6757	-0.29168 0.2412	1.00000 0.0000	-0.09875 0.6967	0.43180 0.0736	-0.25835 0.3006	0.06374 0.8016
V	0.38566 0.2111	0.69345 0.0014	0.96759 0.0001	0.13661 0.5678	0.55442 0.0001	0.22277 0.3743	-0.42432 0.0793	-0.09875 0.6967	1.00000 0.0000	-0.66243 0.0027	-0.62041 0.0001	0.88406 0.0001
SIO2	-0.49623 0.0362	-0.08291 0.7436	-0.64698 0.0037	-0.15928 0.5279	-0.64123 0.0041	0.10001 0.6930	-0.14370 0.5694	0.43180 0.0736	-0.66243 0.0027	1.00000 0.0000	0.05836 0.8181	-0.43928 0.0682
AL2O3	-0.84733 0.0521	-0.93300 0.0001	-0.71256 0.0009	-0.42231 0.0806	-0.63519 0.0046	-0.45157 0.0600	0.86191 0.0001	-0.25835 0.3906	-0.62041 0.0001	0.05836 0.8181	1.00000 0.0000	-0.86104 0.0001
FE2O3	0.21598 0.3804	0.89248 0.0001	0.93827 0.0001	0.20815 0.4072	0.87176 0.0001	0.31975 0.1958	-0.63490 0.0046	0.06374 0.8016	0.88406 0.0001	-0.43928 0.0682	-0.86104 0.0001	1.00000 0.0000
FEO	0.24421 0.3288	0.85275 0.0001	0.95386 0.0001	0.21887 0.3829	0.50182 0.0001	0.34984 0.1547	-0.60804 0.0074	0.08627 0.7276	0.93125 0.0001	-0.48763 0.0401	-0.82238 0.0001	0.98060 0.0001
MGO	-0.00492 0.9845	0.87891 0.0001	0.65061 0.0031	0.53883 0.0210	0.56020 0.0156	0.49164 0.0382	-0.87087 0.0001	0.17724 0.4817	0.55301 0.0173	-0.06369 0.8018	-0.97075 0.0001	0.81252 0.0001
CAO	-0.27681 0.2661	0.07722 0.7807	-0.39414 0.1656	0.37790 0.1241	-0.37778 0.1242	0.06382 0.8014	-0.32326 0.1907	0.42111 0.0819	-0.50321 0.0333	0.54207 0.0261	-0.23543 0.3476	-0.21049 0.4109
NA2O	0.03575 0.8880	-0.76452 0.0002	-0.48855 0.0397	-0.46432 0.0417	-0.41697 0.0852	-0.43034 0.0746	0.73621 0.0005	-0.21635 0.3865	-0.33379 0.1758	-0.05712 0.8219	0.85441 0.0001	-0.87126 0.0001
K2O	0.04099 0.8531	0.15868 0.5294	0.42179 0.0813	-0.36059 0.1192	0.31732 0.1995	0.15380 0.5423	0.04872 0.8478	0.05173 0.8385	0.40952 0.0915	-0.28546 0.2509	-0.05812 0.8188	0.26389 0.2536
TIO2	0.30839 0.2131	0.73147 0.0006	0.98006 0.0001	0.11179 0.6588	0.93066 0.0001	0.22189 0.3782	-0.44849 0.0619	-0.04349 0.8540	0.96600 0.0001	-0.61007 0.0072	-0.87149 0.0023	0.92250 0.0001
P2O5	0.25210 0.3129	0.72786 0.0006	0.93422 0.0001	0.12523 0.6205	0.88055 0.0001	0.19827 0.4303	-0.42713 0.0771	0.09308 0.7134	0.88456 0.0001	-0.60985 0.0072	-0.69194 0.0015	0.91070 0.0001
MNO	0.36507 0.1318	0.60436 0.0079	0.94054 0.0001	-0.00832 0.9801	0.91989 0.0001	0.12554 0.6196	-0.28608 0.2463	-0.10887 0.6672	0.95320 0.0001	-0.68421 0.0017	-0.51156 0.0304	0.84928 0.0001

	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	-0.00492	-0.27681	0.03575	0.04699	0.30839	0.25210	0.36907
	0.9845	0.2661	0.8880	0.8531	0.2131	0.3129	0.1318
CR	0.87891	0.07722	-0.76452	0.15868	0.73147	0.72786	0.60430
	0.0001	0.7607	0.0002	0.5294	0.0006	0.0006	0.0079
ZN	0.65661	-0.39414	-0.43855	0.42179	0.98006	0.93422	0.94054
	0.0031	0.1056	0.0397	0.0813	0.0001	0.0001	0.0001
PB	0.53883	0.37790	-0.48432	-0.38059	0.11179	0.12523	-0.00632
	0.0210	0.1221	0.0417	0.1192	0.6588	0.6205	0.9801
NI	0.56020	-0.37778	-0.41697	0.31732	0.93066	0.88655	0.91989
	0.0156	0.1222	0.0852	0.1995	0.0001	0.0001	0.0001
BA	0.49164	0.06382	-0.43034	0.15380	0.22189	0.19827	0.12554
	0.0382	0.8014	0.0746	0.5423	0.3762	0.4303	0.6196
SR	-0.87087	-0.32326	0.73621	0.04872	-0.44849	-0.42713	-0.28808
	0.0001	0.1907	0.0005	0.8478	0.0619	0.0771	0.2463
RB	0.17724	0.42111	-0.21635	0.05173	-0.04349	0.09308	-0.10887
	0.4817	0.0818	0.3885	0.8385	0.8640	0.7134	0.6572
V	0.55301	-0.50321	-0.33379	0.40952	0.96600	0.88456	0.95320
	0.0173	0.0333	0.1758	0.0915	0.0001	0.0001	0.0001
SIO2	-0.06369	0.54207	-0.05712	-0.28546	-0.61007	-0.60985	-0.68421
	0.8018	0.0201	0.8219	0.2509	0.0072	0.0072	0.0017
AL2O3	-0.97075	-0.23543	0.85441	-0.05812	-0.67149	-0.69194	-0.51050
	0.0001	0.3470	0.0001	0.8188	0.0023	0.0015	0.0304
FE2O3	0.81252	-0.21089	-0.67126	0.28389	0.92250	0.91070	0.84928
	0.0001	0.4009	0.0023	0.2536	0.0001	0.0001	0.0001
FEO	0.76480	-0.26786	-0.59485	0.31443	0.93921	0.92472	0.88241
	0.0002	0.2825	0.0092	0.2038	0.0001	0.0001	0.0001
MGO	1.00000	0.28644	-0.92556	-0.02280	0.58537	0.60361	0.41357
	0.0000	0.2492	0.0001	0.9284	0.0107	0.0080	0.0880
CAO	0.28644	1.00000	-0.39631	-0.49148	-0.46085	-0.28626	-0.59497
	0.2492	0.0000	0.1035	0.0383	0.0543	0.2495	0.0092
NA2O	-0.92556	-0.39631	1.00000	0.08801	-0.39503	-0.43207	-0.22250
	0.0001	0.1035	0.0000	0.7284	0.1047	0.0734	0.3749
K2O	-0.02280	-0.49148	0.08801	1.00000	0.39910	0.39108	0.48148
	0.9284	0.0383	0.7284	0.0000	0.1009	0.1085	0.0431
TIO2	0.58537	-0.46085	-0.39503	0.39910	1.00000	0.93696	0.96988
	0.0107	0.0543	0.1047	0.1009	0.0000	0.0001	0.0001
P2O5	0.60361	-0.28626	-0.43207	0.39108	0.93696	1.00000	0.91260
	0.0080	0.2495	0.0734	0.1085	0.0001	0.0000	0.0001
MNO	0.41357	-0.59497	-0.22250	0.48148	0.96988	0.91260	1.00000
	0.0880	0.0092	0.3749	0.0431	0.0001	0.0001	0.0000

ZONE "M"

	CU	CR	ZN	PB	NI	dA	SR	RB	Y	SIO2	AL2O3	FE2O3
CU	1.00000	0.10729	0.22672	-0.16572	-0.19929	-0.07449	0.06128	0.05769	0.46634	-0.03194	0.04311	-0.02704
	0.0000	0.6346	0.3236	0.4502	0.3739	0.7418	0.7865	0.7987	0.0217	0.8878	0.8489	0.9049
CR	0.10729	1.00000	0.54552	-0.01154	0.09787	0.30927	-0.60311	0.24631	0.69762	-0.21059	-0.81900	0.67657
	0.6346	0.0000	0.0086	0.9594	0.6321	0.1613	0.0030	0.2692	0.0003	0.3408	0.0001	0.0005
ZN	0.22672	0.54552	1.00000	-0.04977	0.07508	0.15064	-0.42494	0.24910	0.68544	-0.55054	-0.77198	0.83045
	0.3236	0.0086	0.0000	0.8259	0.6006	0.5034	0.0487	0.1919	0.0004	0.0079	0.0001	0.0001
PB	-0.16572	-0.01154	-0.04977	1.00000	-0.10729	-0.09407	-0.00986	-0.23598	-0.01466	0.13733	-0.09959	-0.06258
	0.4502	0.9594	0.8259	0.0000	0.6346	0.6771	0.9653	0.2904	0.9436	0.5422	0.6592	0.9909
NI	-0.19929	0.09787	0.07508	-0.10729	1.00000	0.12557	-0.11137	0.56140	0.22527	-0.59114	-0.64735	0.86106
	0.3739	0.6321	0.6006	0.6346	0.0000	0.5776	0.6217	0.0066	0.3135	0.0038	0.0011	0.0001
dA	-0.07449	0.30927	0.15064	-0.09407	0.12557	1.00000	-0.07201	0.18775	0.32345	-0.00098	-0.16870	0.08734
	0.7418	0.1613	0.5034	0.6771	0.5776	0.0000	0.7501	0.4028	0.1420	0.9966	0.4530	0.6991
SR	0.06128	-0.60311	-0.42494	-0.00986	-0.11137	-0.07201	1.00000	-0.02040	-0.36161	0.01041	0.51055	-0.29065
	0.7865	0.0030	0.0487	0.9653	0.6217	0.7501	0.0000	0.9282	0.0797	0.9633	0.0152	0.1894
RB	0.05769	0.24631	0.24910	-0.23598	0.56140	0.18775	-0.02040	1.00000	0.16413	-0.19531	-0.24323	0.44101
	0.7987	0.2692	0.1919	0.2904	0.0066	0.4028	0.9282	0.0000	0.4655	0.3837	0.2754	0.0399
Y	0.46634	0.69762	0.68944	-0.04466	0.22527	0.32345	-0.36161	0.16413	1.00000	-0.31621	-0.05195	0.55870
	0.0217	0.0003	0.0004	0.8436	0.3135	0.1420	0.0797	0.4655	0.0000	0.1517	0.0010	0.0009
SIO2	-0.03194	-0.21059	-0.55054	0.13733	-0.59114	-0.00098	0.01041	-0.19531	-0.31621	1.00000	0.42562	-0.54788
	0.8878	0.3408	0.0079	0.5422	0.0038	0.9966	0.9633	0.3837	0.1517	0.0000	0.0483	0.0083
AL2O3	0.04311	-0.81900	-0.77198	-0.09959	-0.64735	-0.16870	0.51055	-0.24323	-0.05195	0.42562	1.00000	-0.89655
	0.8489	0.0001	0.0001	0.6592	0.0011	0.4530	0.0152	0.2754	0.0010	0.0483	0.0000	0.0001
FE2O3	-0.02704	0.67657	0.83045	-0.06258	0.86106	0.08734	-0.29065	0.44101	0.55870	-0.54788	-0.89655	1.00000
	0.9049	0.0005	0.0001	0.9909	0.0001	0.6991	0.1894	0.0359	0.0069	0.0083	0.0001	0.0000
FEO	-0.05021	0.67397	0.82424	0.02062	0.87032	0.12818	-0.27054	0.43679	0.54861	-0.54573	-0.89999	0.99694
	0.8244	0.0006	0.0001	0.9274	0.0001	0.5697	0.2233	0.0421	0.0082	0.0086	0.0001	0.0001
MGO	-0.08217	0.78832	0.74437	0.03745	0.69138	0.09467	-0.51354	0.30158	0.59635	-0.44193	-0.90636	0.91127
	0.7162	0.0001	0.0001	0.8686	0.0004	0.6771	0.0145	0.1726	0.0034	0.0395	0.0001	0.0001
CAO	-0.04250	-0.20050	-0.51374	0.23322	-0.68145	-0.06147	-0.09306	-0.59377	-0.21125	0.11602	0.35858	-0.66273
	0.8510	0.3710	0.0145	0.2962	0.0005	0.7858	0.6804	0.0036	0.3453	0.6071	0.1013	0.0008
NA2O	-0.09923	-0.49018	-0.65264	-0.04609	-0.41368	0.20151	0.41442	0.09283	-0.44112	0.17180	0.48386	-0.45584
	0.6604	0.0206	0.0076	0.8366	0.0556	0.3685	0.0552	0.6811	0.0399	0.4446	0.0225	0.0189
K2O	0.19342	-0.06537	0.39879	-0.01805	-0.01105	0.19409	-0.11629	0.22048	0.31194	0.12192	-0.19085	0.17882
	0.3884	0.7726	0.0660	0.9365	0.9611	0.3868	0.6863	0.3241	0.1576	0.5888	0.3548	0.4259
TIO2	0.35826	0.61603	0.77757	0.07837	0.62973	0.28706	-0.44413	0.09939	0.93718	-0.28990	-0.66825	0.58152
	0.1016	0.0023	0.0001	0.7268	0.3037	0.1952	0.0384	0.6599	0.0001	0.1906	0.0004	0.0045
P2O5	0.41818	0.09055	0.34299	0.11752	-0.19709	0.15437	-0.19591	-0.22397	0.31429	0.11321	-0.14221	0.01718
	0.0528	0.6886	0.1181	0.6025	0.3793	0.4926	0.3823	0.3163	0.1543	0.6159	0.5278	0.9395
MNO	0.11070	0.37678	0.64510	0.30623	0.46033	0.04821	-0.27668	0.19951	0.33001	-0.08519	-0.58049	0.60271
	0.6238	0.0839	0.0012	0.1657	0.0311	0.8313	0.2136	0.3734	0.1336	0.7062	0.0040	0.0030

	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	-0.08217	-0.04250	-0.09923	0.19342	0.35826	0.41818	0.11070
	0.7162	0.8510	0.6604	0.3884	0.1016	0.0528	0.6238
CR	0.78832	-0.20050	-0.49018	-0.06537	0.61603	0.09055	0.37676
	0.0001	0.3710	0.0206	0.7726	0.0023	0.6886	0.0839
ZN	0.74437	-0.51374	-0.55264	0.39879	0.77757	0.34299	0.64510
	0.0001	0.0145	0.0076	0.0660	0.0001	0.1181	0.0012
PB	0.03745	0.23322	-0.04669	-0.01805	0.07837	0.11752	0.30623
	0.8686	0.2962	0.8366	0.9365	0.7288	0.6025	0.1657
NI	0.69138	-0.68145	-0.41368	-0.01105	0.22973	-0.19709	0.46033
	0.0004	0.0005	0.0556	0.9611	0.3037	0.3793	0.0311
BA	0.09407	-0.06147	0.20151	0.19409	0.28706	0.15437	0.04821
	0.6771	0.7858	0.3685	0.3868	0.1952	0.4928	0.8313
SR	-0.51354	-0.09306	0.41442	-0.11629	-0.44413	-0.19591	-0.27608
	0.0145	0.6804	0.0552	0.6063	0.0384	0.3823	0.2136
RB	0.30158	-0.59377	0.09283	0.22048	0.09939	-0.22397	0.19951
	0.1726	0.0036	0.6811	0.3241	0.6599	0.3163	0.3734
V	0.59635	-0.21125	-0.44112	0.31194	0.93718	0.31429	0.33001
	0.0034	0.3453	0.0399	0.1576	0.0001	0.1543	0.1336
SIO2	-0.44193	0.11602	0.17180	0.12192	-0.28990	0.11321	-0.03519
	0.0395	0.6071	0.4449	0.5888	0.1906	0.6159	0.7062
AL2O3	-0.96836	0.35858	0.48386	-0.19089	-0.68625	-0.14221	-0.56049
	0.0001	0.1013	0.0225	0.3948	0.0004	0.5278	0.0046
FE2O3	0.91127	-0.66272	-0.49584	0.17882	0.58152	0.01718	0.60271
	0.0001	0.0008	0.0189	0.4259	0.0045	0.9395	0.0030
FEO	0.90883	-0.64936	-0.48527	0.16936	0.57167	0.01993	0.59678
	0.0001	0.0011	0.0221	0.4512	0.0054	0.9299	0.0034
MGO	1.00000	-0.44100	-0.50404	0.12276	0.61692	0.01492	0.53401
	0.0000	0.0399	0.0168	0.5863	0.0022	0.9475	0.0105
CAO	-0.44100	1.00000	0.27784	-0.35025	-0.22770	0.03962	-0.51947
	0.0399	0.0000	0.2106	0.1100	0.3081	0.8610	0.0132
NA2O	-0.50404	0.27784	1.00000	0.09040	-0.48499	-0.18064	-0.46012
	0.0168	0.2106	0.0000	0.6891	0.0222	0.4211	0.0312
K2O	0.12276	-0.35025	0.09040	1.00000	0.46276	0.43979	0.37752
	0.5863	0.1100	0.6891	0.0000	0.0301	0.0405	0.0832
TIO2	0.61692	-0.22770	-0.48499	0.46276	1.00000	0.41171	0.48642
	0.0022	0.3081	0.0222	0.0301	0.0000	0.0569	0.0217
P2O5	0.01492	0.03962	-0.18064	0.43979	0.41171	1.00000	0.45402
	0.9475	0.8610	0.4211	0.0405	0.0569	0.0000	0.0338
MNO	0.53401	-0.51947	-0.46012	0.37752	0.48642	0.45402	1.00000
	0.0105	0.0132	0.0312	0.0832	0.0217	0.0338	0.0000

ZONE "G"

	CU	CR	ZN	PB	NI	BA	SR	RB	V	SIO2	AL2O3	FE2O3
CU	1.00000	-0.27273	0.41305	-0.17360	-0.50120	0.29074	-0.63646	-0.18387	0.48772	0.85934	-0.40801	-0.71922
	0.0000	0.0616	0.4156	0.7422	0.3111	0.5680	0.1742	0.7273	0.3264	0.0283	0.4219	0.1072
CR	-0.27273	1.00000	-0.58067	0.49927	0.39265	0.57955	0.54796	0.94998	0.06338	-0.49527	0.92156	0.11426
	0.6110	0.0000	0.2269	0.3133	0.4413	0.2280	0.2603	0.0037	0.8051	0.3178	0.0090	0.8294
ZN	0.41305	-0.58067	1.00000	-0.77054	-0.93021	-0.68785	-0.92688	-0.35027	0.72452	0.80715	-0.81610	-0.46142
	0.4156	0.2269	0.0000	0.0729	0.0671	0.1309	0.0678	0.4961	0.1034	0.0522	0.0476	0.3570
PB	-0.17360	0.49927	-0.77054	1.00000	0.73697	0.77690	0.52469	0.31623	-0.51154	-0.46022	0.69854	-0.12410
	0.7422	0.3133	0.0729	0.0000	0.0947	0.0691	0.2652	0.5415	0.2996	0.3584	0.1226	0.8148
NI	-0.50120	0.39265	-0.93021	0.73697	1.00000	0.56217	0.65385	0.10621	-0.88766	-0.80264	0.63070	0.54248
	0.3111	0.4413	0.0671	0.0947	0.0000	0.2456	0.0305	0.8413	0.0182	0.0549	0.1794	0.2661
BA	0.29074	0.57955	-0.68785	0.77690	0.56217	1.00000	0.40034	0.41576	-0.25554	-0.15965	0.64474	-0.21059
	0.5680	0.2280	0.1309	0.0691	0.2456	0.0000	0.4316	0.4123	0.6250	0.7626	0.1669	0.6888
SR	-0.63646	0.54796	-0.92688	0.52469	0.65385	0.40034	1.00000	0.35696	-0.69656	-0.93973	0.77428	0.71712
	0.1742	0.2603	0.0078	0.2652	0.0305	0.4316	0.0000	0.4873	0.1241	0.0053	0.0707	0.1087
RB	-0.18387	0.94998	-0.35027	0.31623	0.10621	0.41576	0.35696	1.00000	0.34012	-0.32420	0.81813	-0.03431
	0.7273	0.0037	0.4961	0.5415	0.8413	0.4123	0.4873	0.0000	0.5095	0.5307	0.0466	0.9466
V	0.48772	0.06338	0.72452	-0.51154	-0.88766	-0.25554	-0.69656	0.34012	1.00000	0.68390	-0.24093	-0.60356
	0.3264	0.8051	0.1034	0.2996	0.0182	0.6250	0.1241	0.5095	0.0000	0.1341	0.6456	0.2046
SIO2	0.85934	-0.49527	0.80715	-0.46022	-0.80264	-0.15965	-0.93973	-0.32420	0.68390	1.00000	-0.70588	-0.76794
	0.0283	0.3178	0.0522	0.3584	0.0549	0.7626	0.0053	0.5307	0.1341	0.0000	0.1170	0.0745
AL2O3	-0.40801	0.92156	-0.81610	0.69854	0.63070	0.64474	0.77428	0.81813	-0.24093	-0.70588	1.00000	0.23233
	0.4219	0.0090	0.0476	0.1226	0.1794	0.1669	0.0707	0.0466	0.6456	0.1170	0.0000	0.6578
FE2O3	-0.71922	0.11426	-0.46142	-0.12410	0.54248	-0.21059	0.71712	-0.03431	-0.60356	-0.76794	0.23233	1.00000
	0.1072	0.8294	0.3570	0.8148	0.2661	0.6888	0.1087	0.9466	0.2046	0.0745	0.6578	0.0000
FEO	-0.71894	0.11301	-0.46094	-0.12451	0.54232	-0.21113	0.71662	-0.03561	-0.60398	-0.76748	0.23125	1.00000
	0.1074	0.8312	0.3576	0.8142	0.2663	0.6880	0.1091	0.9466	0.2042	0.0748	0.6593	0.0001
MGO	0.33234	-0.73583	0.28265	0.12595	-0.05202	-0.06925	-0.48371	-0.79657	-0.24846	0.44562	-0.62107	-0.42869
	0.5198	0.0955	0.5873	0.8121	0.9220	0.8963	0.3310	0.0579	0.6350	0.3758	0.1882	0.3401
CAO	0.37895	-0.39961	0.95509	-0.66753	-0.97021	-0.62541	-0.88528	-0.12257	0.85126	0.70181	-0.63584	-0.56759
	0.4588	0.4325	0.0030	0.1474	0.0013	0.1842	0.0190	0.8171	0.0315	0.0783	0.1748	0.2900
NA2O	0.84468	-0.26264	0.52618	-0.09447	-0.66830	0.12028	-0.72330	-0.07274	0.65426	0.84285	-0.35727	-0.92475
	0.0343	0.6151	0.2836	0.8587	0.1468	0.8265	0.1043	0.8911	0.1586	0.0351	0.4869	0.0083
K2O	0.69984	-0.62110	-0.03632	0.55000	0.04264	0.68726	-0.27121	-0.06345	0.03935	0.45685	0.02587	-0.76438
	0.1216	0.9683	0.8560	0.2582	0.9361	0.1314	0.6032	0.9053	0.9410	0.3624	0.9612	0.0767
TIO2	0.71929	-0.41500	0.89509	-0.57281	-0.94587	-0.33764	-0.94081	-0.10886	0.85256	0.94562	-0.65112	-0.74189
	0.1071	0.4132	0.0159	0.2348	0.0043	0.5128	0.0052	0.7563	0.0310	0.0045	0.1613	0.0913
P2O5	-0.08533	-0.59834	-0.08795	0.32436	0.35863	-0.03240	-0.05044	-0.76157	-0.65216	-0.02477	-0.36048	-0.02402
	0.8723	0.2096	0.8684	0.5305	0.4851	0.9514	0.9244	0.0785	0.1604	0.9628	0.4749	0.9640
MNO	-0.47414	-0.18889	-0.57426	0.40110	0.80962	0.13044	0.55207	-0.40607	-0.97333	-0.58317	0.07320	0.58826
	0.3421	0.7200	0.2333	0.4306	0.0509	0.8054	0.2560	0.3515	0.0011	0.2244	0.8904	0.2194

	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	0.33234	0.37895	0.84468	0.69984	0.71929	-0.08533	-0.47414
	0.5198	0.4588	0.0343	0.1216	0.1071	0.8723	0.3421
CR	-0.73583	-0.39961	-0.26264	-0.02116	-0.41500	-0.59834	-0.18889
	0.0955	0.4325	0.6151	0.9683	0.4132	0.2096	0.7200
ZN	0.28265	0.95509	0.52618	-0.09632	0.89509	-0.08795	-0.57426
	0.5873	0.0030	0.2836	0.8560	0.0159	0.8684	0.2333
PB	0.12595	-0.66753	-0.09447	0.55000	-0.57281	0.32436	0.40110
	0.8121	0.1474	0.8587	0.2582	0.2348	0.5305	0.4306
NI	-0.05202	-0.97021	-0.06830	0.04264	-0.94587	0.35863	0.80962
	0.9220	0.0013	0.1468	0.9361	0.0043	0.4851	0.0509
BA	-0.06925	-0.82541	0.12028	0.68726	-0.33764	-0.03240	0.13044
	0.8963	0.1842	0.8205	0.1314	0.5128	0.9514	0.8054
SR	-0.48371	-0.88528	-0.72330	-0.27121	-0.94081	-0.05044	0.55207
	0.3310	0.0190	0.1043	0.6032	0.0052	0.9244	0.2560
RB	-0.79657	-0.12257	-0.07274	-0.06325	-0.16806	-0.76157	-0.46607
	0.0579	0.8171	0.8911	0.9053	0.7503	0.0785	0.3515
V	-0.24846	0.85126	0.65426	0.03935	0.85256	-0.65216	-0.97333
	0.6350	0.0315	0.1586	0.9410	0.0310	0.1604	0.0011
SIO2	0.44562	0.76181	0.84285	0.45685	0.94502	-0.02477	-0.58317
	0.3758	0.0783	0.0351	0.3624	0.0045	0.9628	0.2244
AL2O3	-0.62107	-0.63584	-0.35727	0.02587	-0.65112	-0.36648	0.07320
	0.1882	0.1748	0.4869	0.9612	0.1613	0.4749	0.8904
FE2O3	-0.42889	-0.56759	-0.92475	-0.76438	-0.74189	-0.02402	0.58826
	0.3961	0.2400	0.0083	0.0767	0.0913	0.9640	0.2194
FEO	-0.42783	-0.56740	-0.92461	-0.76426	-0.74164	-0.02302	0.58884
	0.3974	0.2402	0.0083	0.0768	0.0915	0.9655	0.2188
MGO	1.00000	0.14320	0.35592	0.53402	0.25108	0.88064	0.36373
	0.0000	0.7867	0.4887	0.2751	0.6313	0.0205	0.4785
CAO	0.14320	1.00000	0.61382	-0.06029	0.91545	-0.24130	-0.74600
	0.7867	0.0000	0.1949	0.9097	0.0104	0.6451	0.0886
NA2O	0.35592	0.61382	1.00000	0.69170	0.83003	-0.08337	-0.66576
	0.4887	0.1949	0.0000	0.1279	0.0409	0.8752	0.1489
K2O	0.53402	-0.06029	0.69170	1.00000	0.26170	0.30837	-0.08022
	0.2751	0.9097	0.1279	0.0000	0.6164	0.5521	0.8799
TIO2	0.25108	0.91545	0.83003	0.26170	1.00000	-0.21948	-0.76830
	0.6313	0.0104	0.0409	0.6164	0.0000	0.6761	0.0743
P2O5	0.88064	-0.24130	-0.08337	0.30837	-0.21948	1.00000	0.73851
	0.0205	0.6451	0.8752	0.5521	0.6761	0.0000	0.0936
MNO	0.36373	-0.74600	-0.66576	-0.08022	-0.76830	0.73951	1.00000
	0.4785	0.0886	0.1489	0.8799	0.0743	0.0936	0.0000

ROOSEVELT GABBRO

	CU	CR	ZN	PB	NI	BA	SR	RB	V	SIO2	AL2O3	FE2O3
CU	1.00000 0.0000	0.52845 0.0200	0.64004 0.0014	0.12726 0.6036	0.28500 0.2368	0.50639 0.0269	-0.64650 0.0027	0.53230 0.0190	0.79078 0.0001	0.33352 0.1629	-0.70090 0.0008	0.72225 0.0005
CR	0.52845 0.0200	1.00000 0.0000	0.33299 0.0980	-0.07343 0.7851	0.18822 0.4403	0.36484 0.1246	-0.53581 0.0181	0.46426 0.0452	0.35104 0.1406	0.32570 0.1736	-0.48941 0.0334	0.46947 0.0426
ZN	0.64004 0.0014	0.33249 0.0980	1.00000 0.0000	-0.04142 0.8663	-0.02540 0.9178	0.95964 0.0001	-0.94343 0.0001	0.94537 0.0001	0.94925 0.0001	0.77633 0.0001	-0.98264 0.0001	0.97064 0.0001
PB	0.12726 0.6036	-0.07343 0.7851	-0.04142 0.8663	1.00000 0.0000	-0.12075 0.6224	-0.05125 0.8349	0.06931 0.7780	-0.03389 0.8904	0.02037 0.9340	-0.08958 0.7153	0.04365 0.8590	-0.08507 0.7291
NI	0.28500 0.2368	0.18822 0.4403	-0.02540 0.9178	-0.12075 0.6224	1.00000 0.0000	-0.24558 0.3109	0.04697 0.8486	-0.20960 0.3891	-0.06754 0.7834	-0.53576 0.0181	-0.01034 0.9665	0.14530 0.5528
BA	0.50639 0.0269	0.36484 0.1246	0.95964 0.0001	-0.05125 0.8349	-0.24558 0.3109	1.00000 0.0000	-0.93428 0.0001	0.98245 0.0001	0.88016 0.0001	0.87552 0.0001	-0.94969 0.0001	0.90345 0.0001
SR	-0.64650 0.0027	-0.53581 0.0181	-0.94343 0.0001	0.06931 0.7780	0.04697 0.8486	-0.93428 0.0001	1.00000 0.0000	-0.93201 0.0001	-0.89215 0.0001	-0.73716 0.0003	0.96529 0.0001	-0.93914 0.0001
RB	0.53230 0.0190	0.46426 0.0452	0.94537 0.0001	-0.03389 0.8904	-0.20960 0.3891	0.98245 0.0001	-0.93201 0.0001	1.00000 0.0000	0.85568 0.0001	0.86328 0.0001	-0.94431 0.0001	0.89385 0.0001
V	0.79078 0.0001	0.35104 0.1406	0.94925 0.0001	0.02037 0.9340	-0.06754 0.7834	0.88016 0.0001	-0.89215 0.0001	0.85568 0.0001	1.00000 0.0000	0.74243 0.0003	-0.93048 0.0001	0.91866 0.0001
SIO2	0.33352 0.1629	0.32570 0.1736	0.77633 0.0001	-0.08958 0.7153	-0.53576 0.0181	0.87552 0.0001	-0.73716 0.0003	0.86328 0.0001	0.74243 0.0003	1.00000 0.0000	-0.75256 0.0002	0.65614 0.0023
AL2O3	-0.70090 0.0008	-0.48941 0.0334	-0.98264 0.0001	0.04369 0.8590	-0.01034 0.9665	-0.94969 0.0001	0.96529 0.0001	-0.94431 0.0001	-0.93048 0.0001	-0.75256 0.0002	1.00000 0.0000	-0.97840 0.0001
FE2O3	0.72225 0.0005	0.46947 0.0426	0.97064 0.0001	-0.08507 0.7291	0.14530 0.5528	0.90345 0.0001	-0.93914 0.0001	0.89385 0.0001	0.91866 0.0001	0.65614 0.0023	-0.97840 0.0001	1.00000 0.0000
FEO	0.72262 0.0005	0.46889 0.0429	0.97063 0.0001	-0.08502 0.7293	0.14483 0.5541	0.90354 0.0001	-0.93913 0.0001	0.89390 0.0001	0.91868 0.0001	0.65613 0.0023	-0.97833 0.0001	1.00000 0.0000
MGO	0.64816 0.0027	0.46524 0.0447	0.79033 0.0001	-0.14103 0.5047	0.41672 0.0759	0.68102 0.0013	-0.81493 0.0001	0.67536 0.0015	0.70735 0.0007	0.32155 0.1795	-0.83576 0.0001	0.87407 0.0001
CAO	-0.45980 0.0476	-0.40066 0.0891	-0.90146 0.0001	0.10226 0.5069	0.03381 0.8907	-0.90330 0.0001	0.89752 0.0001	-0.89951 0.0001	-0.78572 0.0001	-0.75769 0.0002	0.88261 0.0001	-0.87022 0.0001
NA2O	0.13774 0.5739	0.00595 0.9807	0.23535 0.3321	0.19155 0.4321	-0.13044 0.5945	0.24845 0.3051	-0.27559 0.2534	0.25334 0.2953	0.27499 0.2545	0.26954 0.2644	-0.24621 0.3096	0.18001 0.4609
K2O	0.52643 0.0206	0.45060 0.0529	0.95482 0.0001	-0.06898 0.7790	-0.20980 0.3887	0.98924 0.0001	-0.94076 0.0001	0.99767 0.0001	0.86655 0.0001	0.87192 0.0001	-0.94840 0.0001	0.90499 0.0001
TIO2	0.74823 0.0002	0.36671 0.1225	0.98278 0.0001	0.01697 0.9450	-0.08695 0.7234	0.93758 0.0001	-0.92229 0.0001	0.92566 0.0001	0.98086 0.0001	0.77856 0.0001	-0.96447 0.0001	0.94595 0.0001
P2O5	0.76773 0.0001	0.30347 0.2066	0.96024 0.0001	0.02404 0.9222	-0.05482 0.8236	0.89948 0.0001	-0.88960 0.0001	0.88396 0.0001	0.96785 0.0001	0.71398 0.0006	-0.93967 0.0001	0.91702 0.0001
MNO	0.18056 0.4595	-0.04677 0.8492	0.60845 0.0057	-0.05318 0.8288	-0.42925 0.0667	0.68423 0.0012	-0.61728 0.0049	0.57967 0.0093	0.63273 0.0036	0.66130 0.0020	-0.57294 0.0103	0.56716 0.0113

	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	0.64816	-0.45980	0.13774	0.52643	0.74823	0.76773	0.18056
	0.0027	0.0476	0.5739	0.0206	0.0002	0.0001	0.4595
CR	0.46524	-0.40066	0.00595	0.45060	0.36671	0.30347	-0.04677
	0.0447	0.0891	0.9807	0.0529	0.1225	0.2066	0.8492
ZN	0.79033	-0.90146	0.23535	0.95482	0.98278	0.96024	0.60885
	0.0001	0.0001	0.3321	0.0001	0.0001	0.0001	0.0057
PB	-0.14103	0.16226	0.19155	-0.06898	0.01697	0.02404	-0.05318
	0.5647	0.5069	0.4321	0.7790	0.9450	0.9222	0.8288
NI	0.41672	0.03381	-0.13044	-0.20980	-0.08695	-0.05482	-0.42925
	0.0759	0.8907	0.5945	0.3887	0.7234	0.8236	0.0667
BA	0.68102	-0.90330	0.24845	0.98924	0.93758	0.89948	0.68423
	0.0013	0.0001	0.3051	0.0001	0.0001	0.0001	0.0012
SR	-0.81493	0.89752	-0.27559	-0.94076	-0.92229	-0.88960	-0.61728
	0.0001	0.0001	0.2534	0.0001	0.0001	0.0001	0.0049
RB	0.67536	-0.89951	0.25334	0.99707	0.92566	0.88396	0.57967
	0.0015	0.0001	0.2953	0.0001	0.0001	0.0001	0.0093
V	0.70735	-0.78572	0.27499	0.86655	0.98086	0.96785	0.63273
	0.0007	0.0001	0.2545	0.0001	0.0001	0.0001	0.0036
SIO2	0.32155	-0.75769	0.26954	0.87192	0.77856	0.71338	0.66130
	0.1795	0.0002	0.2644	0.0001	0.0001	0.0006	0.0020
AL2O3	-0.83576	0.88261	-0.24621	-0.94840	-0.96447	-0.93967	-0.57294
FE2O3	0.87407	-0.87022	0.18001	0.90239	0.94595	0.91702	0.56716
	0.0001	0.0001	0.4609	0.0001	0.0001	0.0001	0.0113
FEO	0.87402	-0.87024	0.17988	0.90304	0.94601	0.91703	0.56761
	0.0001	0.0001	0.4612	0.0001	0.0001	0.0001	0.0112
MGO	1.00000	-0.70902	0.04108	0.68240	0.73494	0.73595	0.32170
	0.0000	0.0007	0.8674	0.0013	0.0003	0.0003	0.1792
CAO	-0.70902	1.00000	-0.37051	-0.91767	-0.84199	-0.80575	-0.54605
	0.0007	0.0000	0.1184	0.0001	0.0001	0.0001	0.0156
NA2O	0.04108	-0.37051	1.00000	0.26069	0.23763	0.28444	0.09581
	0.8674	0.1184	0.0000	0.2811	0.3273	0.2379	0.6964
K2O	0.68240	-0.91767	0.26069	1.00000	0.93038	0.88786	0.61332
	0.0013	0.0001	0.2811	0.0000	0.0001	0.0001	0.0052
TIO2	0.73494	-0.84199	0.23763	0.93038	1.00000	0.98312	0.61718
	0.0003	0.0001	0.3273	0.0001	0.0000	0.0001	0.0049
P2O5	0.73595	-0.80575	0.28444	0.88786	0.98312	1.00000	0.53441
	0.0003	0.0001	0.2379	0.0001	0.0001	0.0000	0.0184
MNO	0.32170	-0.54605	0.09581	0.61332	0.61718	0.53441	1.00000
	0.1792	0.0156	0.6964	0.0052	0.0049	0.0184	0.0000

COOPERTON AREA

	CU	CR	ZN	PB	NI	BA	SR	RB	V	SIO2	AL2O3	FE2O3
CU	1.00000 0.0000	0.90193 0.0001	0.58405 0.0004	-0.25739 0.1482	0.85091 0.0001	0.13494 0.4540	-0.72543 0.0001	0.06737 0.7094	0.69657 0.0001	-0.61595 0.0001	-0.77803 0.0001	0.76891 0.0001
CR	0.90193 0.0001	1.00000 0.0000	0.76305 0.0001	-0.28641 0.1061	0.96114 0.0001	0.19677 0.2724	-0.80108 0.0001	0.02611 0.8953	0.85285 0.0001	-0.73583 0.0001	-0.92491 0.0001	0.91420 0.0001
ZN	0.58405 0.0004	0.76305 0.0001	1.00000 0.0000	-0.08166 0.6514	0.76607 0.0001	0.17110 0.3411	-0.72632 0.0001	0.07613 0.6737	0.77937 0.0001	-0.72037 0.0001	-0.84921 0.0001	0.86321 0.0001
PB	-0.25739 0.1482	-0.28641 0.1061	-0.08166 0.6514	1.00000 0.0000	-0.26988 0.1288	-0.21815 0.2226	0.01468 0.9354	-0.06876 0.6614	-0.11088 0.5390	0.11453 0.5257	0.22470 0.2047	-0.22698 0.2040
NI	0.85091 0.0001	0.96114 0.0001	0.76607 0.0001	-0.26988 0.1288	1.00000 0.0000	0.16937 0.3460	-0.80347 0.0001	-0.06046 0.7182	0.80346 0.0001	-0.77353 0.0001	-0.93630 0.0001	0.92915 0.0001
BA	0.13494 0.4540	0.19677 0.2724	0.17110 0.3411	-0.21815 0.2226	0.16937 0.3460	1.00000 0.0000	-0.16137 0.3696	0.48556 0.0042	0.26348 0.1385	0.08238 0.6486	-0.22825 0.2014	0.20679 0.2482
SR	-0.72543 0.0001	-0.80108 0.0001	-0.72632 0.0001	0.01468 0.9354	-0.80347 0.0001	-0.16137 0.3696	1.00000 0.0000	0.06457 0.7211	-0.77012 0.0001	0.73902 0.0001	0.78309 0.0001	-0.79515 0.0001
RB	0.06739 0.7094	0.02611 0.8953	0.07613 0.6737	-0.06876 0.6614	-0.06046 0.7182	0.48556 0.0042	0.06457 0.7211	1.00000 0.0000	0.16732 0.3520	0.30425 0.0852	-0.05294 0.7698	0.03443 0.8491
V	0.69657 0.0001	0.85285 0.0001	0.77937 0.0001	-0.11088 0.5390	0.80346 0.0001	0.26348 0.1385	-0.77012 0.0001	0.16732 0.3520	1.00000 0.0000	-0.62380 0.0001	-0.89397 0.0001	0.90197 0.0001
SIO2	-0.61595 0.0001	-0.73583 0.0001	-0.72037 0.0001	0.11453 0.5257	-0.77353 0.0001	0.08238 0.6486	0.73902 0.0001	0.30425 0.0852	-0.62380 0.0001	1.00000 0.0000	0.75078 0.0001	-0.79515 0.0001
AL2O3	-0.77803 0.0001	-0.92491 0.0001	-0.84921 0.0001	0.22470 0.2047	-0.93630 0.0001	-0.22825 0.2014	0.78309 0.0001	-0.05294 0.7698	-0.89397 0.0001	0.75078 0.0001	1.00000 0.0000	-0.98462 0.0001
FE2O3	0.76891 0.0001	0.91420 0.0001	0.86321 0.0001	-0.22698 0.2040	0.92915 0.0001	0.20679 0.2482	-0.79515 0.0001	0.03443 0.8491	0.90197 0.0001	-0.79842 0.0001	-0.98462 0.0001	1.00000 0.0000
FEO	0.76895 0.0001	0.91419 0.0001	0.86321 0.0001	-0.22634 0.2053	0.92910 0.0001	0.20677 0.2483	-0.79542 0.0001	0.03442 0.8492	0.90218 0.0001	-0.79845 0.0001	-0.98461 0.0001	1.00000 0.0000
MGO	0.76008 0.0001	0.90240 0.0001	0.84453 0.0001	-0.22142 0.2156	0.93524 0.0001	0.12271 0.4963	-0.79161 0.0001	-0.09323 0.6058	0.81097 0.0001	-0.85115 0.0001	-0.95941 0.0001	0.95801 0.0001
CAO	-0.62530 0.0001	-0.73618 0.0001	-0.66927 0.0001	0.17919 0.3184	-0.75494 0.0001	-0.45035 0.0085	0.53844 0.0012	-0.28010 0.1141	-0.71837 0.0001	0.48353 0.0044	0.81044 0.0001	-0.80032 0.0001
NA2O	-0.56843 0.0006	-0.69081 0.0001	-0.62856 0.0001	0.28205 0.1110	-0.71066 0.0001	0.07086 0.6951	0.65911 0.0001	0.30913 0.0800	-0.63937 0.0001	0.78074 0.0001	0.72368 0.0001	-0.75090 0.0001
K2O	0.45006 0.0086	0.53241 0.0014	0.41081 0.0176	-0.17340 0.3345	0.49917 0.0031	0.57841 0.0004	-0.48619 0.0041	0.48386 0.0043	0.61135 0.0002	-0.17738 0.3224	-0.57496 0.0003	0.56409 0.0006
TIO2	0.77797 0.0001	0.90168 0.0001	0.78868 0.0001	-0.20253 0.2583	0.86225 0.0001	0.29289 0.0981	-0.81227 0.0001	0.13371 0.4582	0.92646 0.0001	-0.86945 0.0001	-0.93181 0.0001	0.93371 0.0001
P2O5	0.43149 0.0122	0.60181 0.0002	0.57334 0.0005	-0.09389 0.6033	0.58587 0.0027	0.23326 0.1914	-0.52753 0.0016	0.13667 0.4482	0.75725 0.0001	-0.29018 0.1014	-0.64477 0.0001	0.62786 0.0001
MNO	0.27470 0.1218	0.36325 0.0377	0.15036 0.4036	-0.16415 0.3613	0.34240 0.0511	0.08236 0.6487	-0.07230 0.6993	-0.06790 0.7073	0.35528 0.0425	-0.18097 0.3135	-0.32618 0.0693	0.36798 0.0412

	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	0.76008	-0.62530	-0.56843	0.45006	0.77797	0.43149	0.27470
	0.0001	0.0001	0.0006	0.0086	0.0001	0.0122	0.1218
CR	0.90240	-0.73618	-0.69081	0.53241	0.90168	0.60181	0.36325
	0.0001	0.0001	0.0001	0.0014	0.0001	0.0002	0.0377
ZN	0.84453	-0.66527	-0.62856	0.41081	0.78868	0.57334	0.15036
	0.0001	0.0001	0.0001	0.0176	0.0001	0.0005	0.4036
PB	-0.22142	0.17919	0.28265	-0.17340	-0.20253	-0.09389	-0.16415
	0.2156	0.3184	0.1110	0.3345	0.2583	0.6033	0.3613
NI	0.93524	-0.75494	-0.71066	0.49917	0.86225	0.50587	0.34240
	0.0001	0.0001	0.0001	0.0031	0.0001	0.0027	0.0511
BA	0.12271	-0.45035	0.07086	0.57841	0.29289	0.23326	0.08236
	0.4963	0.0085	0.6951	0.0004	0.0981	0.1914	0.6487
SR	-0.79161	0.53844	0.65911	-0.48639	-0.81227	-0.52753	-0.07230
	0.0001	0.0012	0.0001	0.0041	0.0001	0.0016	0.6893
RB	-0.09323	-0.28030	0.30913	0.48386	0.13371	0.13667	-0.06790
	0.6058	0.1141	0.0800	0.0043	0.4582	0.4482	0.7073
V	0.81097	-0.71837	-0.63937	0.61135	0.92646	0.76725	0.35528
	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0425
SIO2	-0.85115	0.48353	0.78074	-0.17738	-0.66945	-0.29018	-0.18097
	0.0001	0.0044	0.0001	0.3234	0.0001	0.1014	0.3135
AL2O3	-0.96941	0.81644	0.72368	-0.59406	-0.93181	-0.64477	-0.32018
	0.0001	0.0001	0.0001	0.0003	0.0001	0.0001	0.0693
FE2O3	0.95801	-0.80032	-0.75090	0.56408	0.93371	0.62786	0.30798
	0.0001	0.0001	0.0001	0.0006	0.0001	0.0001	0.0812
FEO	0.95787	-0.79978	-0.75111	0.56449	0.93375	0.62809	0.30786
	0.0001	0.0001	0.0001	0.0006	0.0001	0.0001	0.0813
MGO	1.00000	-0.75864	-0.79248	0.43675	0.86355	0.50861	0.29552
	0.0000	0.0001	0.0001	0.0110	0.0001	0.0025	0.0950
CAO	-0.75864	1.00000	0.41901	-0.66694	-0.74979	-0.49486	-0.37511
	0.0001	0.0000	0.0152	0.0001	0.0001	0.0034	0.0315
NA2O	-0.79248	0.41901	1.00000	-0.21860	-0.65878	-0.35630	-0.21711
	0.0001	0.0152	0.0000	0.2216	0.0001	0.0418	0.2249
K2O	0.43675	-0.66694	-0.21860	1.00000	0.66722	0.61870	0.18272
	0.0110	0.0001	0.2216	0.0000	0.0001	0.0001	0.3088
TIO2	0.86355	-0.74979	-0.65878	0.66722	1.00000	0.73200	0.31455
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0746
P2O5	0.50861	-0.49486	-0.35630	0.61870	0.73200	1.00000	0.23066
	0.0025	0.0034	0.0418	0.0001	0.0001	0.0000	0.1966
MNO	0.29552	-0.37511	-0.21711	0.18272	0.31455	0.23066	1.00000
	0.0950	0.0315	0.2249	0.3088	0.0746	0.1966	0.0000

GLEN MOUNTAIN

LAYERED COMPLEX

	CU	CR	ZN	PB	NI	BA	SR	RB	V	SIO2	AL2O3	FE2O3	FEO
CU	1.00000 0.0000	0.12532 0.3443	0.37577 0.0034	-0.03849 0.7723	0.23911 0.0681	-0.08922 0.5016	-0.18064 0.1719	-0.07303 0.5825	0.39570 0.0019	-0.09821 0.4593	-0.20438 0.1205	0.12735 0.3365	0.09175 0.4895
CR	0.12532 0.3443	1.00000 0.0000	0.51086 0.0001	0.12478 0.3464	0.61770 0.0001	0.21366 0.1042	-0.45414 0.0003	0.23558 0.0725	0.54910 0.0001	-0.25687 0.0495	-0.67861 0.0001	0.66199 0.0001	0.58076 0.0001
ZN	0.37577 0.0034	0.51086 0.0001	1.00000 0.0000	-0.10945 0.4092	0.53008 0.0001	-0.06386 0.6309	-0.62837 0.0001	-0.01289 0.9228	0.87858 0.0001	-0.35738 0.0055	-0.77665 0.0001	0.72899 0.0001	0.66394 0.0001
PB	-0.03849 0.7723	0.12478 0.3464	-0.10945 0.4092	1.00000 0.0000	0.04349 0.7436	0.34574 0.0073	-0.14041 0.2888	-0.05706 0.6677	-0.14806 0.2631	0.00026 0.9984	-0.17756 0.1785	0.03998 0.7637	-0.05234 0.6938
NI	0.23919 0.0681	0.61770 0.0001	0.53008 0.0001	0.04349 0.7436	1.00000 0.0000	0.06042 0.6494	-0.24958 0.0566	0.12385 0.3500	0.39301 0.0021	-0.64385 0.0001	-0.61781 0.0001	0.83107 0.0001	0.76609 0.0001
BA	-0.08922 0.5016	0.21366 0.1042	-0.06386 0.6309	0.34574 0.0073	0.06042 0.6494	1.00000 0.0000	-0.17644 0.1813	0.19693 0.1349	-0.06294 0.6358	0.20363 0.1230	-0.21839 0.0966	0.05040 0.7046	0.02285 0.8636
SR	-0.18064 0.1710	-0.45414 0.0003	-0.62837 0.0001	-0.14041 0.2888	-0.24958 0.0566	-0.17644 0.1813	1.00000 0.0000	-0.13696 0.3009	-0.56857 0.0001	-0.13248 0.3172	0.74745 0.0001	-0.41265 0.0012	-0.33232 0.0101
RB	-0.07303 0.5825	0.23558 0.0725	-0.01289 0.9228	-0.05706 0.6677	0.12385 0.3500	0.19693 0.1349	-0.13696 0.3009	1.00000 0.0000	-0.03648 0.7838	0.15214 0.2500	-0.19639 0.1360	0.16402 0.2145	0.13886 0.2942
V	0.39570 0.0019	0.54910 0.0001	0.87858 0.0001	-0.14806 0.2631	0.39301 0.0021	-0.06294 0.6358	-0.56857 0.0001	-0.03648 0.7838	1.00000 0.0000	-0.18744 0.1551	-0.60057 0.0001	0.47762 0.0001	0.43621 0.0006
SIO2	-0.09821 0.4593	-0.25687 0.0495	-0.35738 0.0055	0.00026 0.9984	-0.64385 0.0001	0.20363 0.1230	-0.13248 0.3172	0.15214 0.2500	-0.18744 0.1551	1.00000 0.0000	0.16314 0.2170	-0.57423 0.0001	-0.55591 0.0001
AL2O3	-0.20438 0.1205	-0.67861 0.0001	-0.77665 0.0001	-0.17756 0.1785	-0.61781 0.0001	-0.21839 0.0966	0.74745 0.0001	-0.19639 0.1360	-0.60057 0.0001	0.16314 0.2170	1.00000 0.0000	-0.81161 0.0001	-0.70155 0.0001
FE2O3	0.12735 0.3365	0.66199 0.0001	0.72899 0.0001	0.03998 0.7637	0.83107 0.0001	0.05040 0.7046	-0.41265 0.0012	-0.16402 0.2145	0.47762 0.0001	-0.57423 0.0001	-0.81161 0.0001	1.00000 0.0000	0.91366 0.0001
FEO	0.09175 0.4895	0.58076 0.0001	0.66394 0.0001	-0.05234 0.6938	0.76609 0.0001	0.02285 0.8636	-0.33232 0.0101	0.13886 0.2942	0.43621 0.0006	-0.55591 0.0001	-0.70155 0.0001	0.91366 0.0001	1.00000 0.0000
MGO	0.16049 0.2246	0.65720 0.0001	0.74485 0.0001	0.22570 0.0856	0.65816 0.0001	0.18809 0.1537	-0.74176 0.0001	0.15751 0.2335	0.55090 0.0001	-0.23622 0.0717	-0.96182 0.0001	0.79723 0.0001	0.69108 0.0001
CAO	-0.22370 0.0885	-0.22597 0.0853	-0.49825 0.0001	0.28429 0.0291	-0.61182 0.0001	0.04321 0.7452	-0.02598 0.8451	0.00158 0.9905	-0.38670 0.0025	0.35114 0.0022	0.21304 0.1039	-0.50954 0.0001	-0.47531 0.0001
NA2O	0.06782 0.6098	-0.48077 0.0001	-0.30055 0.0207	-0.34340 0.0078	-0.36725 0.0042	-0.12124 0.3604	0.46553 0.0002	-0.12143 0.3596	-0.11120 0.4015	0.16183 0.2207	0.00151 0.9901	-0.56705 0.0001	-0.46109 0.0002
K2O	0.04532 0.7332	-0.01964 0.8826	0.00067 0.9960	-0.01315 0.9213	-0.04975 0.7092	0.07690 0.5627	0.26552 0.0421	0.04223 0.7508	0.00625 0.9625	0.04746 0.7211	0.03420 0.7970	-0.03784 0.7760	-0.03876 0.7707

	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	0.16049	-0.22370	0.06782	0.04532	0.44199	0.21946	0.30752
	0.2246	0.0885	0.6098	0.7332	0.0005	0.0949	0.0178
CR	0.65720	-0.22597	-0.48077	-0.01964	0.36650	0.25646	0.40822
	0.0001	0.0853	0.0001	0.8826	0.0043	0.0499	0.0013
ZN	0.74485	-0.49825	-0.30055	0.00067	0.88995	0.23607	0.47630
	0.0001	0.0001	0.0207	0.9960	0.0001	0.0719	0.0001
PB	0.22570	0.28429	-0.34340	-0.01315	-0.17203	0.21454	0.02924
	0.0856	0.0291	0.0078	0.9213	0.1926	0.1027	0.8260
NI	0.65816	-0.61182	-0.36725	-0.04975	0.32517	0.20464	0.53945
	0.0001	0.0001	0.0042	0.7082	0.0120	0.1200	0.0001
BA	0.18809	0.04321	-0.12124	0.07690	-0.07704	0.30899	0.14749
	0.1537	0.7452	0.3604	0.5627	0.5619	0.0173	0.2650
SR	-0.74176	-0.02598	0.46553	0.26552	-0.63715	-0.21844	-0.20853
	0.0001	0.8451	0.0002	0.0421	0.0001	0.0965	0.1130
RB	0.15751	0.00158	-0.12143	0.04223	-0.05987	0.08149	-0.05016
	0.2335	0.9905	0.3596	0.7508	0.6524	0.5395	0.7060
V	0.55090	-0.38670	-0.11126	0.00625	0.94212	0.05403	0.31816
	0.0001	0.0025	0.4015	0.9625	0.0001	0.6844	0.0141
SIO2	-0.23622	0.39114	0.16183	0.04746	-0.05588	-0.15888	-0.39048
	0.0717	0.0022	0.2207	0.7211	0.6742	0.2294	0.0022
AL2O3	-0.96182	0.21384	0.60151	0.03420	-0.62133	-0.34665	-0.41104
	0.0001	0.1039	0.0001	0.7970	0.0001	0.0072	0.0012
FE2O3	0.79723	-0.50954	-0.56705	-0.03784	0.40891	0.35818	0.56698
	0.0001	0.0001	0.0001	0.7760	0.0013	0.0053	0.0001
FEO	0.69108	-0.47531	-0.46109	-0.03876	0.36766	0.32785	0.53691
	0.0001	0.0001	0.0002	0.7707	0.0042	0.0112	0.0001
MGO	1.00000	-0.23307	-0.66270	-0.08595	0.57288	0.26818	0.34248
	0.0000	0.0756	0.0001	0.5175	0.0001	0.0400	0.0079
CAO	-0.23307	1.00000	-0.10132	-0.11052	-0.34486	-0.02772	-0.43310
	0.0756	0.0000	0.4451	0.4047	0.0075	0.8349	0.0006
NA2O	-0.66270	-0.10132	1.00000	0.13650	-0.08920	-0.30177	-0.18628
	0.0001	0.4451	0.0000	0.3026	0.5017	0.0202	0.1578
K2O	-0.08595	-0.11052	0.13650	1.00000	0.00764	0.11991	0.15391
	0.5175	0.4047	0.3026	0.0000	0.9542	0.3657	0.2445
TIO2	0.57288	-0.34486	-0.08920	0.00764	1.00000	0.08832	0.30835
	0.0001	0.0075	0.5017	0.9542	0.0000	0.5059	0.0175
P2O5	0.26818	-0.02772	-0.30177	0.11991	0.08832	1.00000	0.74295
	0.0400	0.8349	0.0202	0.3657	0.5059	0.0000	0.0001
MNO	0.34248	-0.43310	-0.18628	0.15391	0.30835	0.74295	1.00000
	0.0079	0.0006	0.1578	0.2445	0.0175	0.0001	0.0000

RAGGEDY MOUNTAIN

GABBRO GROUP

	CU	CR	ZN	PB	NI	SB	MO	SN	V	SIO2	AL2O3
CU	1.00000 0.0000	0.43756 0.0001	0.48867 0.0001	-0.09622 0.3151	0.52360 0.0001	0.13259 0.1941	0.16581 0.0820	-0.43304 0.0001	0.16850 0.0771	0.43478 0.0001	-0.14543 0.1278
CR	0.43756 0.0001	1.00000 0.0000	0.49948 0.0001	-0.05357 0.5766	0.77119 0.0001	0.04922 0.6300	0.06093 0.5252	-0.52652 0.0001	0.04660 0.6272	0.45316 0.0001	-0.36034 0.0001
ZN	0.48867 0.0001	0.49948 0.0001	1.00000 0.0000	-0.07998 0.4040	0.53545 0.0001	0.27338 0.0037	0.52733 0.0001	-0.74241 0.0001	0.49770 0.0001	0.81289 0.0001	-0.96276 0.3775
PB	-0.09622 0.3151	-0.05357 0.5766	-0.07998 0.4040	1.00000 0.0000	-0.11622 0.2245	0.07528 0.4323	0.05399 0.5735	-0.65577 0.5010	0.01018 0.9155	-0.05330 0.3361	0.00681 0.5206
NI	0.52360 0.0001	0.77119 0.0001	0.53545 0.0001	-0.11622 0.2245	1.00000 0.0000	0.16356 0.0003	0.00704 0.9416	-0.43282 0.0001	-0.02012 0.8346	0.29288 0.0018	-0.54154 0.0001
SB	0.16581 0.0820	0.06093 0.5252	0.52733 0.0001	0.05349 0.5735	0.00704 0.9416	0.24917 0.0089	1.00000 0.0000	-0.44614 0.0001	0.04798 0.0001	0.36242 0.0001	0.59046 0.0001
SP	-0.43304 0.0001	-0.52652 0.0001	-0.74241 0.0001	-0.05577 0.5610	-0.43282 0.0001	-0.22504 0.0156	-0.44614 0.0001	1.00000 0.0000	-0.42506 0.0001	-0.00330 0.0001	-0.11597 0.2255
RB	0.16850 0.0771	0.04660 0.6272	0.49770 0.0001	0.01018 0.9155	-0.02012 0.8340	0.30836 0.0012	0.04798 0.0001	-0.42506 0.0001	1.00000 0.0000	0.33715 0.0003	0.00508 0.9660
V	0.43478 0.0001	0.45316 0.0001	0.81289 0.0001	-0.05330 0.3361	0.29288 0.0018	0.18761 0.0486	0.36242 0.0001	-0.00330 0.0001	0.33715 0.0003	1.00000 0.0000	0.07865 0.4612
SIO2	-0.14543 0.1278	-0.36034 0.0001	-0.96276 0.3775	0.05041 0.5260	-0.54154 0.0001	0.24054 0.0110	0.59046 0.0001	-0.11597 0.2255	0.00508 0.9660	0.07865 0.4612	1.00000 0.0000
AL2O3	-0.48631 0.0001	-0.67321 0.0001	-0.85290 0.0001	-0.01856 0.8407	-0.64312 0.0001	-0.20089 0.0345	-0.52140 0.0001	0.00972 0.0001	-0.47134 0.0001	-0.04169 0.0001	0.00653 0.9956
FE2O3	0.43630 0.0001	0.70998 0.0001	0.80173 0.0001	-0.00413 0.9637	0.79225 0.0001	0.22543 0.0174	0.35772 0.0001	-0.62618 0.0001	0.33818 0.0003	0.53761 0.0001	-0.28405 0.0025
FEO	0.41004 0.0001	0.66679 0.0001	0.76598 0.0001	-0.11328 0.2345	0.76069 0.0001	0.18364 0.0537	0.34097 0.0003	-0.57814 0.0001	0.32272 0.0006	0.51307 0.0001	-0.30257 0.0012
MGO	0.44673 0.0001	0.74107 0.0001	0.73413 0.0001	0.02013 0.8339	0.77551 0.0001	0.17133 0.0722	0.21397 0.0241	-0.74104 0.0001	0.15072 0.1605	0.56094 0.0001	-0.29883 0.0014
CAO	-0.38055 0.0001	-0.34062 0.0003	-0.87599 0.0001	0.21326 0.0246	-0.51998 0.0001	-0.22566 0.0172	-0.54339 0.0001	0.38658 0.0001	-0.52953 0.0001	-0.48032 0.0001	-0.04695 0.6243
NA2O	-0.15095 0.0999	-0.52664 0.0001	-0.28452 0.0025	-0.00851 0.4750	-0.49883 0.0001	0.04477 0.6408	0.06180 0.5193	0.38880 0.0001	0.13108 0.1683	-0.11384 0.2342	0.33500 0.0003
K2O	0.45572 0.0008	0.09687 0.3118	0.55275 0.0001	-0.02287 0.8116	0.69632 0.3458	0.30999 0.0009	0.89174 0.0001	-0.44293 0.0001	0.87357 0.0001	0.36034 0.0001	0.52596 0.0001
TIO2	0.51859 0.0001	0.36575 0.0001	0.84867 0.0001	-0.16708 0.2633	0.31551 0.0007	0.23937 0.0114	0.54630 0.0001	-0.72139 0.0001	0.51105 0.0001	0.92283 0.0001	0.20772 0.0287
P2O5	0.39321 0.0001	0.24458 0.0097	0.62656 0.0001	0.06281 0.5125	0.23397 0.0135	0.27952 0.0030	0.74240 0.0001	-0.54139 0.0001	0.68361 0.0001	0.46863 0.0001	0.31566 0.0007
PNO	0.25044 0.0066	0.32380 0.0005	0.42583 0.0001	-0.00596 0.9505	0.33543 0.0003	0.00476 0.9665	0.26342 0.0052	-0.24656 0.0091	0.16292 0.0875	0.37038 0.0001	-0.07041 0.4254

	FEO	MGO	CAO	NA2O	K2O	TIO2	P2O5	MNO
CU	0.41004 0.0001	0.44673 0.0001	-0.38055 0.0001	-0.15695 0.0999	0.25572 0.0068	0.51859 0.0001	0.39321 0.0001	0.25644 0.0066
CR	0.66679 0.0001	0.74107 0.0001	-0.34062 0.0003	-0.52664 0.0001	0.09687 0.3118	0.36575 0.0001	0.24458 0.0097	0.32380 0.0005
ZN	0.76598 0.0001	0.73413 0.0001	-0.67599 0.0001	-0.28452 0.0025	0.55275 0.0001	0.88607 0.0001	0.62656 0.0001	0.42583 0.0001
PB	-0.11328 0.2365	0.02013 0.8339	0.21326 0.0246	-0.06851 0.4750	-0.02287 0.8116	-0.10708 0.2633	0.06281 0.5125	-0.00596 0.9505
NI	0.76069 0.0001	0.77551 0.0001	-0.51998 0.0001	-0.48883 0.0001	0.09032 0.3458	0.31551 0.0007	0.23397 0.0135	0.33343 0.0003
ZONE	0.18364 0.0537	0.17133 0.0722	-0.22566 0.0172	0.04477 0.6408	0.30999 0.0009	0.23937 0.0114	0.27952 0.0030	0.00476 0.9605
BA	0.34097 0.0003	0.21397 0.0241	-0.54339 0.0001	0.06180 0.5193	0.89174 0.0001	0.54636 0.0001	0.74240 0.0001	0.26342 0.0052
SR	-0.57814 0.0001	-0.74104 0.0001	0.38658 0.0001	0.38880 0.0001	-0.44293 0.0001	-0.72139 0.0001	-0.54139 0.0001	-0.24656 0.0091
RB	0.32272 0.0006	0.15672 0.1005	-0.52953 0.0001	0.13168 0.1683	0.87357 0.0001	0.51105 0.0001	0.69361 0.0001	0.16292 0.0875
V	0.51307 0.0001	0.50694 0.0001	-0.48032 0.0001	-0.11384 0.2342	0.36634 0.0001	0.92283 0.0001	0.40863 0.0001	0.37038 0.0001
SIO2	-0.30257 0.0012	-0.29893 0.0014	-0.04699 0.6243	0.33500 0.0003	0.52596 0.0001	0.20772 0.0287	0.31566 0.0007	-0.07640 0.4254
AL2O3	-0.83149 0.0001	-0.90821 0.0001	0.56998 0.0001	0.49551 0.0001	-0.52429 0.0001	-0.74871 0.0001	-0.63421 0.0001	-0.39128 0.0001
FE2O3	0.95393 0.0001	0.85800 0.0001	-0.65649 0.0001	-0.53013 0.0001	0.39875 0.0001	0.58470 0.0001	0.54589 0.0001	0.48413 0.0001
FEO	1.00000 0.0000	0.80171 0.0001	-0.63342 0.0001	-0.47968 0.0001	0.38372 0.0001	0.55809 0.0001	0.52521 0.0001	0.47031 0.0001
MGO	0.80171 0.0001	1.00000 0.0000	-0.45085 0.0001	-0.64889 0.0001	0.22512 0.0175	0.57097 0.0001	0.38012 0.0001	0.29243 0.0018
CAO	-0.63342 0.0001	-0.45085 0.0001	1.00000 0.0000	0.00519 0.9569	-0.60639 0.0001	-0.56899 0.0001	-0.50732 0.0001	-0.41146 0.0001
NA2O	-0.47968 0.0001	-0.64889 0.0001	0.00519 0.9569	1.00000 0.0000	0.07116 0.4580	-0.12685 0.1846	-0.10724 0.2626	-0.14582 0.1267
K2O	0.38372 0.0001	0.22512 0.0175	-0.60639 0.0001	0.07116 0.4580	1.00000 0.0000	0.56514 0.0001	0.76048 0.0001	0.24213 0.0105
TIO2	0.55809 0.0001	0.57097 0.0001	-0.56899 0.0001	-0.12685 0.1846	0.56514 0.0001	1.00000 0.0000	0.59475 0.0001	0.36309 0.0001
P2O5	0.52521 0.0001	0.38012 0.0001	-0.50732 0.0001	-0.10724 0.2626	0.76048 0.0001	0.59475 0.0001	1.00000 0.0000	0.41058 0.0001
MNO	0.47031 0.0001	0.29243 0.0018	-0.41146 0.0001	-0.14582 0.1267	0.24213 0.0105	0.36309 0.0001	0.41058 0.0001	1.00000 0.0000

APPENDIX C

CORRELATION MATRIX FOR MODAL-CHEMICAL AND MODAL ANALYSIS

	PLAG	OLIVINE	CLINO_PY	ORTHO_PY	OPAQUE	BIOTITE
CU	-0.69136	0.46056	0.46986	-0.30258	0.50329	0.53791
	0.0001	0.0205	0.0178	0.1415	0.0103	0.0056
CR	-0.60353	0.63916	0.18594	-0.18091	0.46097	0.53997
	0.0014	0.0006	0.3735	0.3868	0.0204	0.0053
ZN	-0.84296	0.75826	0.38010	-0.23201	0.70572	0.49763
	0.0001	0.0001	0.0609	0.2644	0.0001	0.0114
PB	-0.09518	0.05948	0.14660	-0.03668	-0.05951	-0.15583
	0.6509	0.7776	0.4844	0.8618	0.7775	0.4570
NI	-0.68343	0.90922	0.15196	0.00253	0.24946	0.59052
	0.0002	0.0001	0.4684	0.9904	0.2291	0.0019
BA	0.04410	0.21106	-0.23535	0.05185	-0.14729	0.39872
	0.8342	0.3112	0.2574	0.8056	0.4823	0.0483
SR	0.72994	-0.50443	-0.53182	0.33945	-0.45124	-0.48102
	0.0001	0.0101	0.0062	0.0969	0.0236	0.0149
RB	-0.27145	0.42218	0.06283	-0.18117	-0.06590	0.44977
	0.1893	0.0355	0.7654	0.3861	0.7543	0.0241
V	-0.49951	0.21429	0.26789	-0.23296	0.89852	0.04670
	0.0110	0.3037	0.1954	0.2624	0.0001	0.8246
SIO2	0.25763	-0.57708	0.14869	-0.12956	-0.06262	-0.32574
	0.2137	0.0025	0.4781	0.5371	0.7662	0.1121
AL2O3	0.92529	-0.78503	-0.56722	0.17912	-0.47602	-0.59944
	0.0001	0.0001	0.0031	0.3916	0.0162	0.0016
FE2O3	-0.69451	0.76809	0.28449	-0.04164	0.29483	0.53479
	0.0001	0.0001	0.1681	0.8433	0.1525	0.0059
MGO	-0.88251	0.81509	0.50412	-0.12272	0.40714	0.54486
	0.0001	0.0001	0.0102	0.5590	0.0434	0.0049
CAO	0.63338	-0.81940	-0.10170	-0.01407	-0.38900	-0.50966
	0.0007	0.0001	0.6286	0.9468	0.0546	0.0093
NA2O	0.53246	-0.56185	-0.29294	0.22667	-0.10197	-0.48912
	0.0062	0.0035	0.1553	0.2759	0.6277	0.0131
K2O	-0.53699	0.58608	0.27406	-0.19883	-0.00289	0.85905
	0.0057	0.0021	0.1849	0.3407	0.9891	0.0001
TIO2	-0.66018	0.33431	0.42686	-0.25309	0.84234	0.22686
	0.0003	0.1024	0.0333	0.2222	0.0001	0.2755
P2O5	-0.50629	0.49864	0.29633	-0.20789	0.02935	0.79909
	0.0098	0.0112	0.1503	0.3187	0.8893	0.0001
MNO	-0.32051	0.40995	-0.01258	-0.02411	0.38291	0.22615
	0.1183	0.0418	0.9524	0.9089	0.0589	0.2770

	PLAG	OLIVINE	CLINO_PY	ORTHO_PY	OPAQUE
PLAG	1.00000	-0.69595	-0.74361	0.21283	-0.52837
	0.0000	0.0001	0.0001	0.3071	0.0066
OLIVINE	-0.69595	1.00000	0.09459	-0.25060	0.27073
	0.0001	0.0000	0.6529	0.2270	0.1906
CLINO_PY	-0.74361	0.09459	1.00000	-0.06768	0.21942
	0.0001	0.6529	0.0000	0.7479	0.2920
ORTHO_PY	0.21283	-0.25060	-0.06768	1.00000	-0.23084
	0.3071	0.2270	0.7479	0.0000	0.2669
OPAQUE	-0.52837	0.27073	0.21942	-0.23084	1.00000
	0.0066	0.1906	0.2920	0.2669	0.0000
BIOTITE	-0.60216	0.62540	0.29681	-0.17485	0.07845
	0.0015	0.0008	0.1496	0.4032	0.7094

APPENDIX D

MODAL ANALYSES OF SELECTED SAMPLES FROM RMGG

TABLE XVIII

MODAL ANALYSES OF SELECTED SAMPLES FROM RMGG

ZONE	K		L		
Sample No.	WG-45	WG-40	WG-39	WG-69	WG-77
Plagioclase	97%	97%	92%	95%	98%
Olivine	tr	1%	tr	tr	tr
Clinopyroxene	1%	tr	5%	4%	1%
Orthopyroxene	tr	1%	tr	tr	tr
Opaque[1]	2%	1%	2%	1%	1%
Others[2]	tr	tr	1%	tr	tr

[1]Opaque is included magnetite, Ilmenite, and Hematite.

[2]Alteration products of Plagioclase or mafic minerals.

TABLE XVIII (Continued)

ZONE	L	M		
Sample No.	WG-36	WG-59	WG-62	WG-35
Plagioclase	45%	70%	65%	97%
Olivine	28%	22%	tr	tr
Clinopyroxene	10%	5%	25%	1%
Orthopyroxene	tr	tr	tr	tr
Opaque[1]	15%	3%	10%	1%
Biotite	2%	--	--	--
Others[2]	tr	tr	tr	tr

TABLE XVIII (Continued)

ZONE	M		
Sample No.	WG-60	WG-83	WG-38
Plagioclase	93%	53%	99%
Olivine	tr	tr	5%
Clinopyroxene	5%	45%	tr
Orthopyroxene	tr	tr	tr
Opaque[1]	2%	2%	5%
Others[2]	tr	tr	tr

TABLE XVIII (Continued)

ZONE	G			
Sample No.	WG-57	WG-56	WG-64	WG-65
Plagioclase	74%	67%	50%	45%
Olivine	10%	25%	2%	15%
Clinopyroxene	1%	1%	28%	25%
Orthopyroxene	tr	tr	tr	tr
Opaque[1]	15%	7%	20%	15%
Others[2]	tr	tr	tr	tr

TABLE XVIII (Continued)

ZONE	COOPERTON AREA				
Sample No.	WC-11	WC-12	WC-13	WC-14	WC-15
Plagioclase	53%	40%	40%	40%	45%
Olivine	20%	28%	25%	30%	27%
Clinopyroxene	15%	24%	27%	22%	20%
Orthopyroxene	tr	tr	tr	3%	tr
Opaque[1]	7%	5%	3%	3%	5%
Biotite	5%	2%	5%	2%	3%
Others[2]	tr	tr	tr	tr	tr

TABLE XVIII (Continued)

ZONE	COOPERTON AREA			ROOSVET GABBRO
Sample No.	WC-16	WC-53	WQ-5	WR-87
Plagioclase	45%	70%	96%	60%
Olivine	20%	25%	1%	tr
Clinopyroxene	27%	3%	3%	39%
Orthopyroxene	tr	tr	tr	tr
Opaque[1]	5%	2%	1%	1%
Biotite	3%	tr	--	tr
Others[2]	tr	tr	tr	tr

VITA[2]

Samad Alipouraghtapeh

Candidate for the Degree of

Master of Science

Thesis: GEOCHEMISTRY OF MAJOR AND TRACE ELEMENTS OF THE "RAGGEDY MOUNTAIN GABBRO GROUP," WICHITA MOUNTAINS, SOUTHWESTERN OKLAHOMA

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Professional Experience: High school teacher at Ministry of Education, Iran, May, 1973-June, 1975; Geologist, Iranian National Copper Industries Company, June, 1975-June, 1976; Research Assistant, Oklahoma State University, Stillwater, Oklahoma, October, 1979-December, 1979.

R16W R15W

T4N T3N

EXPLANATION

SEDIMENTARY ROCKS

PLEISTOCENE

Qt — TERRACE DEPOSITS
(Unconsolidated rounded boulders of granite, green quartzite, petrified wood, and clay.)

PERMIAN

lP — PERMIAN AND RECENT (Undifferentiated "Red Beds" and alluvium deposits.)

lPt — TEPEE CREEK
(Fine-grained purplish-red to brick-red "calcarous zeolite opal rock.")

IGNEOUS ROCKS

PRE-CAMBRIAN

pЄc — CALCITE VEINS
(In composite dikes.)

pЄq — QUARTZ VEINS
(In composite dikes and alaskite pegmatites.)

pЄap — APLITE AND PEGMATITE DIKES

pЄgr — UNDIFFERENTIATED GRANITE (pЄgr)

pЄg / pЄdgr — MIXED GABBRO AND GRANITE (pЄg) MIXED MICRODIORITE AND GRANITE (pЄdgr)
(As intrusion breccia and hybrid rocks.)

pЄd — MICRODIORITE DIKES AND SILLS (pЄd)

pЄt / pЄmg — MICROGABBRO (pЄmg) TROCTOLITE (pЄt)
(Contains massive magnetite as irregular bodies and dikes.)

pЄdg / pЄa — DIALLAGE GABBRO (pЄdg) ANORTHOSITE (pЄa)

QUARRY

VERTICAL SHAFT

INCLINED SHAFT

BOUNDRY WILDLIFE REFUGE – U.S.

RAILROAD

183 — U.S. HIGHWAY

54 — STATE HIGHWAY

COUNTY ROAD

TRAILS

SCALE
0 1/4 1/2 1 Mile
1:12,000

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Oklahoma State University

PLATE 1

GEOLOGIC MAP OF IGNEOUS ROCKS,

COOPERTON AREA, WICHITA MOUNTAINS, OKLAHOMA

(modified after G.Chase,1950)

R18W R17W

T5N
T4N

35 36 31 32 33 34

WR 88
WR 87
WR 86
WR 89
WG 81

R18W R17W

2 1 6 ROOSEVELT 5

Otter Creek

† ROOSEVELT CEMETERY

WR 85

11 12 7 8

WR 91
WR 92
WR 93
WR 94

pЄdgr
pЄg

US 183

14 13 18 17

pЄa

WR 95
WR 96
WR 97

ROUND MOUNTAIN

pЄdgr

IP

pCa
pЄap
pЄa
23 24 19 20
IPt
pЄdgr
pЄd

COLD SPRINGS

26 25 30 29

TOM STEED RESERVOIR

pЄa

R18W R17W

EXPLANATION

SEDIMENTARY ROCKS

PLEISTOCENE

Qt
TERRACE DEPOSITS
(Unconsolidated rounded boulders of granite, green quartzite, petrified wood, and clay.)

PERMIAN

IP
PERMIAN AND RECENT (Undifferentiated "Red Beds" and alluvium deposits.)

IPt
TEPEE CREEK
(Fine-grained purplish-red to brick-red "calcarous zeolite opal rock.")

IGNEOUS ROCKS

PRE-CAMBRIAN

pЄc
CALCITE VEINS
(In composite dikes.)

pЄq
QUARTZ VEINS
(In composite dikes and alaskite pegmatites.)

pЄap
APLITE AND PEGMATITE DIKES

pЄgr
UNDIFFERENTIATED GRANITE (pЄgr)

pЄg | pЄdgr
MIXED GABBRO AND GRANITE (pЄg)
MIXED MICRODIORITE AND GRANITE (pЄdgr)
(As intrusion breccia and hybrid rocks.)

pЄd
MICRODIORITE DIKES AND SILLS (pЄd)

pЄt | pЄmg
MICROGABBRO (pЄmg)
TROCTOLITE (pЄt)
(Contains massive magnetite as irregular bodies and dikes.)

pЄdg | pЄa
DIALLAGE GABBRO (pЄdg)
ANORTHOSITE (pЄa)

QUARRY
VERTICAL SHAFT
INCLINED SHAFT
BOUNDRY WILDLIFE REFUGE - U.S.
RAILROAD
183 U.S. HIGHWAY
54 STATE HIGHWAY
COUNTY ROAD
TRAILS

PLATE 2
GEOLOGIC MAP OF IGNEOUS ROCKS,
ROOSEVELT AREA, WICHITA MOUNTAINS, OKLAHOMA
(modified after G.Chase,1950)

N

SCALE
0 1/4 1/2 1 Mile
RF 1:12,000

Cartography Service, Department of Geography
Oklahoma State University

R17W R16W

T5N
T4N

WG90 WG82 WG84 WG83 WG80 WG60 WG62 WG61 WG65 WG64 WG57 WG58 WG56 WG66 WG63 WG98 WG99 WG100 WG101 WG102 WG77 WG76 WG75 WG74 WG73 WG72 WG71 WG69 WG68 WG70 WG67 WG55 WG40 WG54 WG39 WG36 WG38 WG37 WG35 WG34 WG43 WG42 WG45 WG44 WG41 WG47 WG46 WG48 WG49 WG79 WG78 WG103 WG107 WG105 WG106

Glenn Creek

IRON MOUNTAIN

US 183

TOM STEED RESERVIOR

CLDT

omg bomg md bomd

R17W R16W

T4N

EXPLANATION

SURFICAL DEPOSITS

S — S zone: Scree and soil cover (Not differentiated from Quaternary on eastern half of map).

PERMIAN AND QUATERNARY

MIXED ROCK

INTRUSIVE GROUP SEDIMENTS

gr/mr/md zone: Andesite or microdiorite intruded by granite forming intrusion breccia and assimilation products. Includes granite (gr) and microdiorite (md) intrusives. Genetic relation to layered group unknown.

omg, bmog: Olivine microgabbro (omg) and basaltic olivine microgabbro (bmog).

PRE-CAMBRIAN AND/OR CAMBRIAN

GLEN MOUNTAIN LAYERED COMPLEX*

ZONE "M" (OLIVINE GRABBRO ZONE)

M — M zone: (~60m)* Largely anorthosite with local concentrations of pyroxene and/or olivine geodiucing lenses and layers of anorthositic-gabbro and -troctolite. "Fine ophitic" augite oikocrysts with randomly oriented plagioclase chadacrysts of smaller size than laminated external plagioclase. Plagioclase, olivine and augite are cumulus. (See text.) Rythmic layering and lamination modest.

ZONE 'L' (ANORTHOSTIC GABBRO ZONE)

L — L zone: (40m) Largely anorthosite with irregular masses of pyroxene gabbro and rare troctolite. "Coarse ophitic" augite oikocrysts with plagioclase chadacrysts of size and preferred orientation comparable to external plagioclase. Plagioclase and olivine are cumulus, augite intercumulus. (See text.) Rythmic layering poorly developed or lacking. Igneous lamination pronounced.

L--a zone: (5m) Narrow zone of gabbroic anorthosite 20m above the base of the L zone and characterized by "fine ophitic" texture similar to that of the M zone, with addition of olivine oikocrysts. Plagioclase, augite and olivine are cumulus.

ZONE 'K' (TROCTOLITE ZONE)

K — K zone: (~40m)* Alternating anorthosite and troctolite with notable rythmic layering. Olivine in small individual grains and as larger poikilitic grains analogous to "fine ophitic" augite. Orthopyroxene--magnetite symplectic coronas around olivine common. Plagioclase and olivine cumulus. Augite intercumulus. Igneous lamination notable.

ZONE ' G'

G — G zone: Anorthositic--gabbro and --troctolite with abundant magnetite (5--15%) and an absence of igneous lamination and or ophitic textures.

Iron Mountain Gabbro member of Raggedy Mountain Gabbro Group

* Minimum thicknesses as upper (M) or lower (K) boundaries not observed.

* Description by Powell N. Benjamin, Joseph F. Fischer, 1976.

CONTACTS

Defined

Approximate

FAULTS

Defined

Probable

N

SCALE

0 1/4 1/2 1 Mile

1:12,000

PLATE 3

GEOLOGIC MAP OF GLEN MOUNTAINS LAYERED COMPLEX, WICHITA MOUNTAIN, OKLAHOMA

(modified after C.Gilbert,1960 and,A.Spencer,1961)

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