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Geology of the Northern Part of the Ortiz Mountains, Santa Fe County, New Mexico

Otis M. McRae

THE ORTIZ MOUNTAINS

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GEOLOGY OF THE NORTHERN PART OF THE ORTIZ MOUNTAINS SANTA FE COUNTY NEW MEXICO

By

Otis M. McRae

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

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1958

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

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April 11, 1958
DATE

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View looking southwest at the Ortiz Mountains from the Dolores Ranch road.

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ABSTRACT

The northern part of the Ortiz Mountains of north-central New Mexico consists of a tilted fault block of Cretaceous Mancos shale and Mesaverde formation intruded by latite-andesite porphyry sills and laccoliths and a nepheline-bearing augite monzonite stock. Igneous activity started with the development of a volcanic vent in what is now the central part of the mountains. Volcanic debris from the vent was removed from the area by erosion and provided sedimentary material for the late Eocene Espinaso volcanics of the adjoining areas. Intrusion of the latite-andesite porphyry sills and laccoliths followed extrusive igneous activity, as demonstrated by the fact that porphyritic rocks intrude the Espinaso volcanics in the adjacent areas. Igneous activity was concluded by the intrusion of the nepheline-bearing augite monzonite which cuts across the earlier rocks. Normal faulting along the eastern border of the adjoining Rio Grande depression uplifted the area in late Pliocene or early Pleistocene time.

Classification of rock types was based on petrographic analyses of 35 thin-sections supported by a feldspar staining technique utilized to provide a reliable estimate of the orthoclase content in the rocks.

The vent rock grades upward from a quartz-bearing latite porphyry to a brecciated trachyte, which contains numerous xenolithic inclusions of the country rock.

The latite-andesite porphyry generally contains andesine and hornblende phenocrysts in a salt-and-pepper-like microcrystalline groundmass. The groundmass consists predominantly of orthoclase with subordinate plagioclase and quartz. This rock constitutes the smaller mountains and caps cuestas along the western and northern part of the mapped area.

The stock makes up the higher and more rugged peaks of the Ortiz Mountains. These rocks are fine- to medium-grained and consist essentially of equal amounts of andesine and orthoclase with augite, the principal mafic mineral, occurring in subordinate amounts. Nepheline is present in amounts of less than 10%.

INTRODUCTION

Geography

The Ortiz Mountains are located in Santa Fe County in north-central New Mexico, approximately 32 miles northeast of Albuquerque and 30 miles southwest of Santa Fe. The center of the mountains is approximately at longitude $106^{o}10'$ W. and latitude $35^{o}20'$ N. (figure 1).

They may be reached by traveling north from Albuquerque for 31 miles on U. S. Highway 85 or south from Santa Fe on U. S. Highway 85 for 32 miles to the junction of State Highway 22, thence south for 11 miles to State Highway 10 which, from this point southward, parallels the west edge of the Ortiz Mountains for four miles. Northeast from this junction State Highway 10 extends across the northwestern part of the area mapped to the town of Madrid five miles away (figure 1). Access to the eastern part of the area is gained by traveling south from Cerrillos on the Dolores Ranch road for seven miles (figure 2).

The mapped area is in T. 13 N., R. 7-8 E. (New Mexico Principal Meridian), approximately in the center of the old Mexican mine grant called the Ortiz Mine Grant. This grant was originally awarded to Jose Francisco Ortiz and Ignacio Carro on December 19, 1833 by the First Alcalde of Santa Fe under the Mining Laws of Mexico. It has an area of 69,458.33 acres or approximately 100 square miles (figure 2).

The Ortiz [illegible]

north-central New Mexico, [illegible]

of Albuquerque [illegible]

center of [illegible]

106°10' W. [illegible]

They may be reached [illegible]

for 22 miles [illegible]

U. S. Highway [illegible]

May 22, [illegible]

from this point [illegible]

Ortiz Mountains [illegible]

State Highway 10 extends [illegible]

area mapped [illegible]

access to the western part [illegible]

ing south from Cerrillos on the [illegible]

miles (Figure 7).

The mapped area [illegible]

principal [illegible]

Mexico [illegible] miles [illegible]

was originally [illegible]

Cerrillos [illegible]

under the [illegible]

of [illegible]

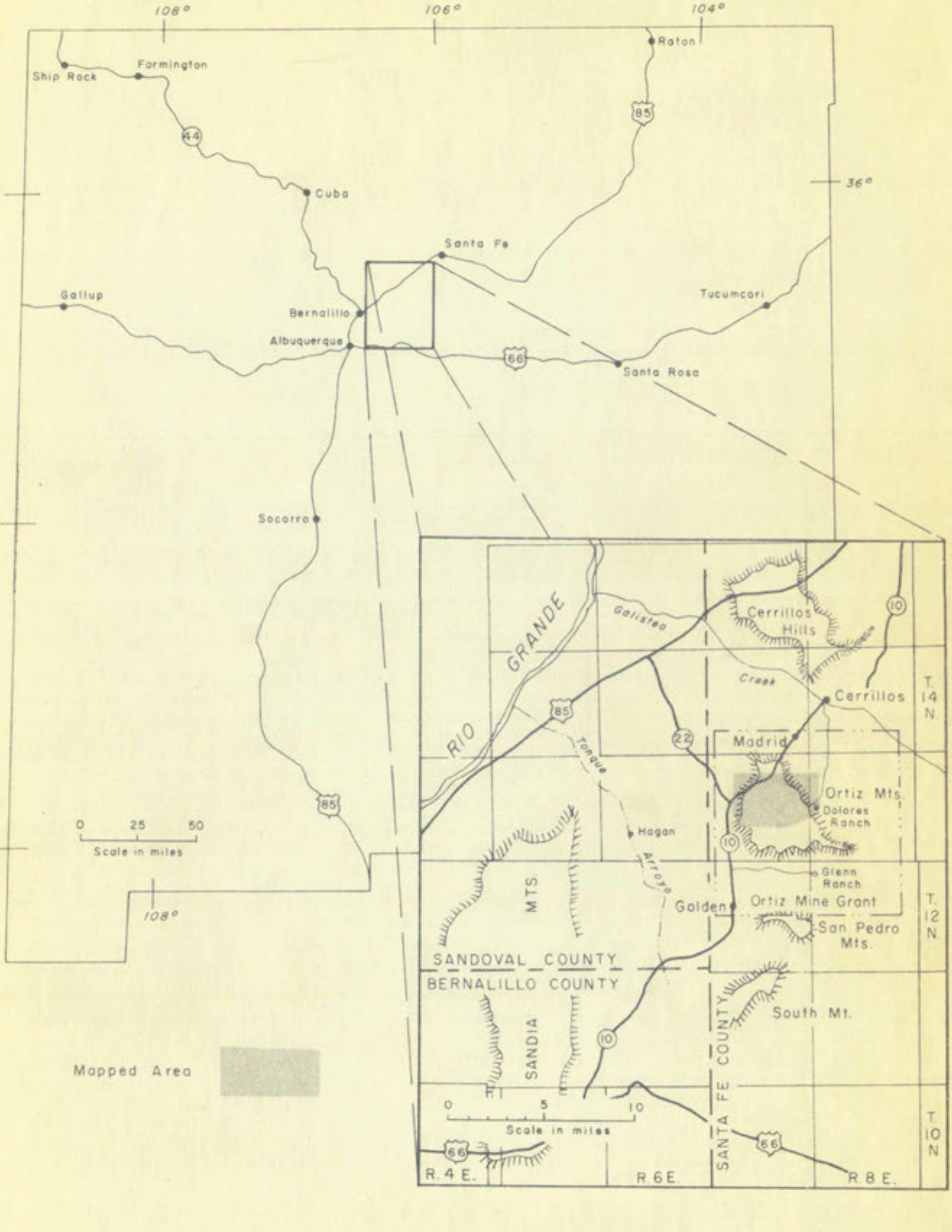

Figure 2. Index map.

In the northern part of the Ortiz Mountains maximum relief is approximately 2,700 feet. The highest peak in the area, Placer Mountain, rises to an elevation of 8,928 feet (Plate I-A). The base of the main part of the mountains roughly follows the 6,700 foot contour line. The Ortiz Mountains as a whole are roughly circular, centering on Placer Mountain.

The southern part of the mapped area is characterized by the rugged, irregular topography typical of a dissected igneous intrusive core. The northern part of the area mapped consists of numerous cuestas resulting from the intrusion of many resistant sills into relatively nonresistant late Cretaceous shales and sandstones that are now dipping gently to the east. Approximately 75% of the area is covered by soil and float, gravel deposits and talus.

Climate and Vegetation

Based on data recorded at nearby Santa Fe before 1931, maximum and minimum recorded temperatures for the area were 97°F and -13°F, respectively. Average precipitation was 14.27 inches of rain and 31.6 inches of snow. The heaviest rains fall from local thunder showers between April and October, and maximum snowfall occurs from December to March (Griswold, 1948). As a result of their relatively high elevation the mountains receive considerably more precipitation than the surrounding lowlands. Thus, <u>Pinus ponderosa</u>, In the northern part of the [illegible] the maximum relief is approximately 700 feet, [illegible] in the area, [illegible], rises to an elevation of [illegible] feet (Plate 1-A). The trend of the main part of the mountains roughly follows the [illegible]. The [illegible] and [illegible] on [illegible].

The southern part of the [illegible] area is characterized by the rugged, irregular topography [illegible] igneous intrusive rocks. The northern part of the area consists of numerous [illegible] many rounded hills [illegible] relatively [illegible] Cretaceous shales and sandstones that [illegible] to the east. Approximately [illegible] of the area is [illegible] soil and "float," gravel deposits and talus.

Climate and Vegetation

Based on data from [illegible], the maximum and minimum recorded temperatures for the area were 97°F and -13°F, respectively. Average precipitation is 14.27 inches of rain and 51.8 inches of snow. [illegible] rains fall [illegible] October, and [illegible] (Criswell, 1948). [illegible] elevation [illegible] than the surrounding lowlands. The flora [illegible]

<u>Quercus</u> <u>undulata</u> and various shrubs of the oak and holly families are found on the slopes of the higher peaks. <u>Yucca</u> and cacti, such as <u>Opuntia</u> and <u>Cereus</u> are found both at elevated places and on the lowlands, while pinon, juniper and sage brush are for the most part confined to the lower elevations (Ogilvie, 1905).

In the mapped area there are no permanent streams; ranch and stock water is obtained from a few shallow wells.

Purpose, Scope and Method

The purpose of this thesis was twofold: first, to conduct a petrographic study of the igneous rocks that crop out in the area, and second, to provide a geologic map of the northern part of the Ortiz Mountains.

The area studied includes approximately 13.5 square miles. Field investigations were conducted intermittently from June, 1957 through February, 1958. A total of about 50 days were spent in the field. All geologic contacts, with the exception of a few isolated and discontinuous outcrops of contacts, were inferred on the basis of float, soil, and topographic expression. These inferred contacts were plotted on stereoscopically studied contact prints of aerial photographs in the fields. In the laboratory, using a vertical sketch-master, the inferred contacts were transferred to a planimetric drainage base map (scale 2 inches to the mile) compiled from the same aerial photographs by

the Soil Conservation Service. This map was then enlarged to the scale of four inches to the mile.

The igneous rock masses were thoroughly and regularly sampled as mapping progressed. These samples were studied and classified megascopically in the laboratory. Standard thin-sections were made of 35 of these samples, and they were studied and classified in detail with the petrographic microscope. Rock slices were etched with hydrofluoric acid and stained with sodium cobaltinitrite to determine the potash feldspar content.

No attempt was made to study or evaluate the ore deposits found in the area, and all data concerned with this aspect of the study, as well as the general history of the area, were derived from the literature.

Acknowledgements

The writer expresses appreciation to Dr. J. Paul Fitzsimmons, of the Geology Department, University of New Mexico, for suggesting the problem and for criticism, helpful suggestions and particularly for his patient guidance in the field and in the laboratory. Thanks are also due Drs. Abraham Rosenzweig and W. E. Elston for their critical reading. To Mr. G. R. Griswold thanks are expressed, not only for permitting access to the Ortiz Mine Grant, but also for making the geologic and engineering files of the Grant available.

the Soil Conservation Service. [illegible] were enlarged to the scale of four inches a mile.

The igneous rock masses were [illegible] sampled at varying intervals. [illegible] specimens were studied and classified megascopically in the field. [illegible] thin-sections were made of [illegible] samples, and they were studied and classified in detail with a petrographic microscope. Rock slices were [illegible] and stained with [illegible] to [illegible] potash feldspar content.

No attempt was made to study or evaluate [illegible] found in the area, [illegible] aspect of the study, no work on the general geology of the area, were [illegible] from the literature.

Acknowledgments

The writer expresses [illegible] to Dr. [illegible] Kelley, of the Geology Department, University of New Mexico, for suggesting the problem and [illegible] helpful suggestions and [illegible] in the field and in the laboratory. Thanks are also due Drs. [illegible] and [illegible] for critically [illegible] reading [illegible] only for [illegible] for making [illegible] available.

To J. W. Peterson, who mapped the southern part of the Ortiz Mountains, special thanks are due for sharing the field expenses and especially for the enlightening, though sometimes heated, conversations about the problems, both in the field and in the laboratory.

The writer is also indebted to the New Mexico Geological Society for financial aid in procuring thin-sections.

History of Exploration and Mining

Until 1828 no gold had been discovered in what is now the United States except for an insignificant deposit that was found in North Carolina in 1801. In 1828 a Mexican sheepherder, following his flock into the mountains seven miles south of the town of Cerrillos, discovered placer gold in the gravel deposits on the east side of the mountains that were later named the Ortiz Mountains (Prince, 1883). These gravel deposits, at the mouth of Cunningham Gulch, are known as the Old Placers and have been worked intermittently with good results since their discovery, particularly from 1832 to 1835, during which period they reportedly produced from $30,000 to $80,000 in gold annually. Total production is not known, but it is probably near $2,000,000 (Lindgren, 1910).

At first these gravels were worked by the most crude methods. Melt water from the winter snows was retained in various ways and a small amount of gravel was placed in a wooden bowl called a "batea" which was immersed in the water

and agitated in the same manner as a gold pan. In this way the heavier sands and gold were separated from the lighter gravels (Harrington, 1939).

It is reliably reported from several sources that during the period from 1897 to 1900 Thomas A. Edison, the famous inventor, erected a mill just east of the Dolores Ranch. This mill was unique in that it was supposed to extract gold from the Old Placers gravel deposit by electrical methods, but the operation was unsuccessful (Jones, 1904 and 1935; Lindgren, 1910; Arnold, 1933; Harrington, 1939).

In more recent years these same gravels were worked by means of "dry washers." In such a device a blast of air from a hand driven blower is directed through screened cleats or "riffles" which are given a jerking motion by a cam-mechanism operated by a crank. The heavier fractions of the gravels remain in back of the "riffles" and are washed with water to separate the tiny flakes of gold (Harrington, 1939).

In 1833 Don Cano, who came to Mexico from Spain in the early part of the 19th century, discovered a gold-bearing quartz vein on the Jose Francisco Ortiz property in Cunningham Gulch. The owner of the property took into partnership a man named Lopez, a skilled miner for his day, and under his direction and management the mining operation was successful. Wishing to reap all the profit for himself Ortiz soon got rid of Lopez by having him deported. Under the new and inexperienced management, however, the mining

operation was entirely unsuccessful (Jones, 1904).

This mine later became known as the Ortiz Mine and apparently is the second lode mine discovered in the United States; the first being the celebrated "Mina del Tierra" located in the Cerrillos District about ten miles to the north. The discovery of this mine precedes that of the Ortiz mine by at least 100 years (Jones, 1904).

The Ortiz Mine is half a mile southwest of the Dolores Ranch at an elevation of about 7,600 feet. From this mine the largest shoot was reportedly mined out between 1854 and 1864 from a maximum depth of 150 feet. In 1864 the property was acquired by the New Mexico Mining Company which sank the mine shaft to the 200 foot level. From 1895 to 1900 the mine was leased to the Ortiz Mining and Milling Company which sank the shaft to the 400 foot level (Lindgren, 1910).

The first mill built to handle ore from the Ortiz Mine contained 15 stamps and was erected at the Dolores townsite in 1854. This mill was replaced by one of 20 stamps in 1869, and in 1895 a plant of 10 stamps, two Huntington mills, and three vanners was built at the mine site (Lindgren, 1910). No production data on the mine are available.

Some years later an unknown company erected a large amalgamating and concentrating plant at the mine, but it was never operated successfully (Griswold, 1948).

Late in the 1800's the Galisteo Company of New York took possession of the Ortiz Mine Grant from the New Mexico

Mining Company, but apparently they did not conduct a mining program (Griswold, 1948).

Charles McKinnis, an engineer-promoter, leased the mineral rights of the Grant from the Galisteo Company from 1934 to 1939. He did considerable sampling of several deposits and sank a 300 foot shaft on the Candelaria vein in the southwestern part of the mountains. No ore was shipped or milled (Griswold, 1948).

A dry process for extracting gold from the Old Placers was attempted by the Universal Placer Mining Company during 1939 and 1940. This process recovered only 14 cents per cubic yard of material and did not prove successful (Griswold, 1948).

In 1943 the Galisteo Company sold the Grant to the Ortiz Cooperative Livestock Association. In 1946 it was sold to Mr. and Mrs. George W. Potter of Joplin, Missouri. The following year the Silas Mason Company of New York held an option on the mineral rights and did considerable placer sampling and prospecting (Griswold, 1948).

From 1946 to the present Potter and Sims of Joplin, Missouri have conducted an extensive exploration program on parts of the Grant, particularly on the Cunningham Gulch area and "Lime area" in the southwestern part of the mountains. This program has consisted of geologic and topographic mapping, geophysical studies including magnetometer, radiometric and ultra-violet light surveys, detailed trench

and pit sampling and prospect drilling. The results of this program are well documented in many and voluminous reports and correspondences by Griswold, Stewart, and Wilson prepared both for Mr. Potter and for Potter and Sims.

During the most recent exploration period scheelite was found in the gold pannings and was also observed as minute disseminations with gold and pyrite in igneous rocks.

The great number of shallow prospect pits, trenches, and adits that mark the landscape attest to the thoroughness with which this area has been explored for gold.

Review of Previous Work

Prior to 1869 only brief mention was made of the Ortiz Mountains by a few military and civilian United States Government representatives who visited the area. In 1869 and 1870 Rossiter W. Raymond, United States Commissioner of Mining Statistics, submitted to the United States House of Representatives two reports that summarized his investigations of the gold placer and lode deposits on the Ortiz Mine Grant. Also, in 1869 F. V. Hayden's Third Annual Report of his "survey of the Territories" was published. Included in this report was a brief discussion of the lode deposits of the Ortiz Mine Grant by Persifor Frazer, Jr.

In 1897 a mining engineer from New York City, S. G. Burns, submitted a report to Thomas Edison on the mineral potential of the Ortiz Mine Grant. The report summarized and pit sampling [illegible] . [illegible] this program [illegible] reports and correspondence [illegible] prepared both for Mr. [illegible]

During the [illegible] period [illegible] was found in the gold panel [illegible] minute disseminations [illegible]

The great number of shallow [illegible] pits [illegible] and other [illegible] ness with which this area has been [illegible].

[illegible]

Prior to 1900 [illegible] Mountains by a few [illegible] Government representatives who visited the area. [illegible] and 1870 [illegible] of Mining Statistics, [illegible] of Representatives two reports [illegible] gations of the gold placers and lode deposits on the [illegible] Mine area. Also, in [illegible] port of his "Survey of the [illegible] cluded in this report [illegible] deposits of the [illegible]

In 1897 a [illegible] Burns, [illegible] potential of the [illegible] the results of rather detailed sampling of the gravel and lode deposits, as well as a description of various mines in the area.

M. B. Yung and R. S. McCaffery in 1903 published a geologic report on the San Pedro Mining District, which includes the Ortiz Mountains. The report attempted to describe not only the ore deposits of both the San Pedro and Ortiz Mountains but also the regional geology.

In 1904 F. A. Jones described the mining history and attempted to classify the types of ore deposits of what he called "The New Placer District," which embraces the area between the Ortiz Mountains and South Mountain.

During the winter of 1904-05 the area was visited by I. H. Ogilvie. Part of the result of her investigation was reported in 1905 and may be partly summarized in Miss Ogilvie's own words as follows:

> "Its (Ortiz intrusive) cover has been largely removed by erosion, and the tops of the central and highest mountains consist of (an) igneous core. Across the edges of the surrounding strata a plain has been partly built and partly cut, this plain sloping away from the laccolith on all sides. Because of its outward slope in all directions this form is here named a conoplain, and its slope is partly cut and partly built."

During her investigation Miss Ogilvie also collected several samples of the igneous rocks of the area. These samples were chemically analysed and classified according to the C. I. P. W. normative system. The results of these analyses and classifications were reported in 1908.

the results of future chemical sampling on the [illegible] lode deposits; as well as [illegible] work in [illegible] the area.

[illegible] and [illegible] geologic sketch of the [illegible] area [illegible] includes the [illegible] mountains. [illegible] not only the ore deposits [illegible] and [illegible] Mountain but also the [illegible].

In 1904 [illegible] attempted to explain the [illegible] called "The [illegible] Placer" [illegible] the area between the [illegible] mountains and [illegible].

During the winter of [illegible] I. E. Ogilvie. [illegible] reported in 1905 and may be [illegible] own words as follows:

> "[illegible] has been [illegible] by [illegible] and [illegible] forms the [illegible] has been partly [illegible] sloping away from [illegible] cades of the [illegible] lode in [illegible] partly [illegible]."

[illegible] investigation [illegible] several samples of the [illegible] samples were [illegible] analyzed [illegible] to the U. S. G. S. [illegible] analyzed and [illegible] were reported in [illegible].

Lindgren and Graton (1906) briefly discussed the ore deposits of the Ortiz and San Pedro Mountains.

Charles R. Keyes (1909) cited the garnetiferous copper deposits of the Ortiz and Tuerto (San Pedro) laccoliths and the contact-deposits of copper at Jimenez, Mexico as examples of garnetization at shallow depths and low pressures.

Lindgren, Graton and Gordon (1910) provided a generalized description of both the sedimentary and igneous rocks, as well as a description of the placer, quartz-vein, and contact-metamorphic deposits of the district.

Two papers published by Willis T. Lee (1912, 1913) describe in detail the stratigraphy of the coal-bearing strata in the vicinity of Madrid, immediately north of the area covered by the present report.

A very brief description of the area and its ore deposits was published by R. W. Ellis (1929).

In 1933 Ralph Arnold visited the Ortiz Mine Grant and wrote an engineering report (unpublished) that summarized his impressions of both the placer and lode deposits found on the grant. His report included a recommendation for a preliminary geologic survey of the entire Grant and a detailed sampling of both the placer and vein deposits.

A consulting mining engineer, F. A. Jones, in a report written in 1935, described the geology and economics of the placer, vein, and contact-metamorphic deposits of the Ortiz Mine Grant and recommended an expenditure of two million

Lindgren and Graton (1906) briefly discussed [illegible] the deposition of [illegible] and [illegible].

Charles [illegible] gave [illegible] deposits of [illegible] and [illegible] the contact-deposits [illegible] of [illegible] and [illegible].

Lindgren, [illegible] and [illegible] (1910) gave [illegible] ized description of [illegible] as well as a description of the [illegible] contact-metamorphic deposits of [illegible].

Two papers published by [illegible] (1919, 1920) describe in detail the [illegible] on the [illegible] strata in the vicinity of [illegible] area covered by the present report.

A very brief [illegible] was published by [illegible].

In 1950 [illegible] wrote an [illegible] his impressions of [illegible] on the [illegible] preliminary [illegible] tailed sampling [illegible].

A [illegible] written in 1953, [illegible] placer, mining, and [illegible] mine [illegible].

dollars on the development of the "Lime Bed" deposits and the Cunningham lode.

An historical sketch of the gold discoveries and early mining methods used in the area was published by Harrington (1939).

The most significant contribution to the geologic literature dealing with the Ortiz Mountains area is a series of reports written by C. E. Stearns in 1943 and 1953. In his earliest paper he describes the Galisteo formation and points out that east of the mountains igneous rocks of the Ortiz intrusives occur within the Galisteo formation which contains fossils of Duchesnean age. The Duchesnean, according to Wood and others (1941) is uppermost Eocene, but it has also been referred to as "lowermost Oligocene" by Wilmarth (1938). In either event the Ortiz intrusives are, therefore, no older than early Oligocene or late Eocene.

In 1953 Stearns published three more reports on the geology of this part of north-central New Mexico. In April (Stearns, 1953a) he provided a geologic map and an excellent treatise on the Tertiary geology of the areas surrounding the Ortiz Mountains. In May (Stearns, 1953b) he published a report on the stratigraphy of the Upper Cretaceous rocks of the surrounding area. His most recent work on the subject, published in June (Stearns, 1953c), included both field and petrographic descriptions of the Tertiary igneous rocks, particularly the extrusives, of the area adjacent to dollars on [illegible] [illegible] [illegible] [illegible] in the Cunningham Lode.

An [illegible] [illegible] of the gold [illegible] and early mining methods used in the [illegible] [illegible] [illegible] (1954).

The most significant contributions to the [illegible] literature dealing with the [illegible] [illegible] [illegible] reports written by [illegible] [illegible] [illegible] 1903 and 1906. In the earliest paper he describes [illegible] [illegible] [illegible] out that [illegible] [illegible] [illegible] intrusives [illegible] [illegible] the [illegible] which [illegible] [illegible] [illegible] [illegible]. The [illegible] [illegible] to [illegible] and [illegible] (1941) [illegible] [illegible] [illegible] also [illegible] [illegible] [illegible] [illegible] (1950). [illegible] [illegible] [illegible] [illegible] fore, no older than [illegible] [illegible] [illegible].

In 1953 [illegible] [illegible] [illegible] [illegible] [illegible] geology of [illegible] [illegible] [illegible] [illegible] (Stearns, 1953), [illegible] [illegible] [illegible] [illegible] and [illegible] treatise on the [illegible] geology of [illegible] [illegible] the [illegible] Mountains. [illegible] [illegible] [illegible] a report on the [illegible] [illegible] [illegible] of the surrounding [illegible]. [illegible] [illegible] [illegible] ject, [illegible] [illegible] [illegible] [illegible] field and [illegible] [illegible] [illegible] rocks, [illegible] [illegible] [illegible] the Ortiz Mountains.

The stratigraphy and geologic history sections of the current report draw heavily from Stearns' work.

During the period 1948 to the present many private reports on the area were prepared for the property owners by G. R. Griswold (1948), C. T. Griswold (1950), D. R. Stewart (1948, 1949, 1953) and E. D. Wilson (1953).

REGIONAL GEOLOGIC SETTING

Within the area mapped the sedimentary rocks include the Upper Cretaceous Dakota (?) formation, Mancos shale, and Mesaverde formation. These rocks are intruded and metamorphosed by early Tertiary latite-andesite sills and laccoliths and an augite monzonite stock.

North-central New Mexico occupies a unique place in the physiography of North America for it is here that four great physiographic provinces merge: the Great Plains, the Southern Rocky Mountains, the Colorado Plateau and the Basin and Range Provinces. The Ortiz Mountains are within this area of mergence.

The Nacimiento uplift whose western edge marks the easternmost extent of the Colorado Plateau and the Jemez uplift of the Southern Rocky Mountains Province are located west and northwest of the Ortiz Mountains 44 miles and 28 miles respectively (figure 3). The Sangre de Cristo anticlinal uplift, also of the Southern Rocky Mountain Province, the [illegible] Mountains.

The [illegible] and [illegible], [illegible] the current report are [illegible].

During the period [illegible] the present [illegible] re- ports on the area were prepared for the [illegible] by G. H. [illegible] ([illegible]), [illegible] (1948, 1949, 1950) and [illegible] ([illegible]).

[illegible]

[illegible] the [illegible] at the [illegible], [illegible] form [illegible]. These rocks are [illegible] and [illegible]- phosed by [illegible] and an [illegible].

North-central [illegible] physiography [illegible] physiographic [illegible] Southern [illegible] and Range [illegible] area of [illegible].

The [illegible] [illegible] and the [illegible] [illegible] west and [illegible] [illegible] [illegible].

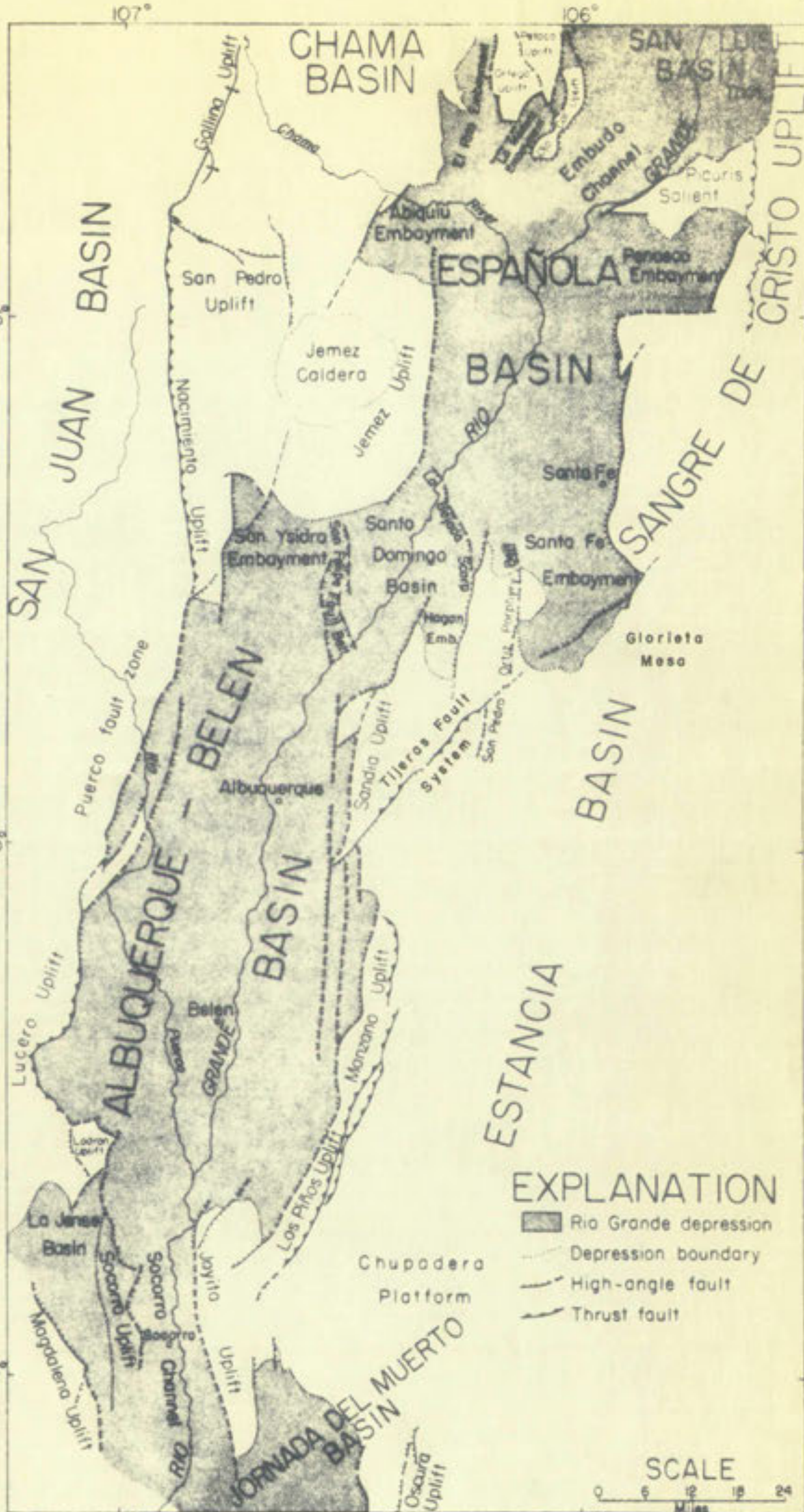

Figure 3. Tectonic Map of the Middle Rio Grande Depression (modified after V. C. Kelley, 1954)

is approximately 25 miles to the northeast. Some 27 miles to the east is Glorieta Mesa whose eastern escarpment marks the western edge of the Great Plains. The northern end of Estancia Valley, a Basin and Range type bolson, is about five miles to the southeast. The Sandia Mountains, fault-block Basin and Range type mountains, are about 16 miles to the southwest (Fenneman, 1931).

The Ortiz Mountains are the largest of four mountain groups extending along a north-south line that parallels the Sandia Mountains to the west. The northernmost are the Cerrillos Hills, the Ortiz are next, and the Tuerto or San Pedro Mountains and South Mountain constitute the southernmost members of the group (figure 2). Many workers consider the four to have similar origin, igneous petrology, and form, and to constitute a single comagmatic region (Ogilvie, 1908; Lindgren, 1910; Stearns, 1953c).

Although this group of mountains is within the boundaries of the Mexican Highlands Section of the Basin and Range Province the rocks have been referred to by various writers as intrusive sheets, stocks, and laccoliths, a type more characteristic of the Southern Rocky Mountain and Colorado Plateau Provinces.

is approximately 200 miles [illegible]. [illegible] of which

to the east is [illegible]

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Estancia Valley, a basin and range type [illegible]

five miles to the [illegible]

block basin and range type mountains, [illegible]

the southeast (Thompson, 1966).

The Ortiz Mountains [illegible]

groups extending [illegible]

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Colorado Plateau province.

STRATIGRAPHY

The stratigraphy of the region has been thoroughly described by Stearns, Johnson, Harrison, and Lee. It will be considered in this paper no further than is necessary for a general understanding of the lithology, age, and structural relations of Cretaceous and younger formations relative to the early Tertiary intrusives. Descriptions and measured sections of the sedimentary rocks are provided by all of these authors. Measurement of thicknesses of the various Upper Cretaceous formations in the area mapped are precluded by the absence of continuous exposures across the strike and by the presence of numerous igneous sheets of varying thickness irregularly intruded throughout the section.

Cretaceous System

The sedimentary rocks exposed in the area are all of Upper Cretaceous age and consist of three easily recognizable units. The upper unit, Mesaverde formation, consists of thick-bedded sandstones and shales with interbedded coal. The middle unit, Mancos shale, is predominantly gray and black shale with subordinate sandstone and a thin bed of limestone near its base. The basal unit, Dakota (?) sandstone, consists of discontinuous sandstone with interbedded shale.

An isopleth map prepared by Stearns (1953b) shows the Upper Cretaceous rocks in the vicinity of the Ortiz Mountains originally to have ranged in thickness from about 2,500 feet to 3,100 feet.

Dakota (?) Sandstone

Beds mapped as Dakota (?) sandstone are confined to the extreme southwestern part of the area. A complete section is not exposed.

In the Hagan Coal basin, a few miles to the west, the Dakota (?) sandstone, according to Harrison (1949), consists of 265 feet of gray-buff to orange, greenish buff and gray sandstone composed predominantly of subangular to subrounded, medium- to coarse-grained quartz fragments with a siliceous cement and a sugary texture. In some places it is shaly and friable and in other places conglomeratic.

In the Galisteo-Tonque area, which borders the Ortiz Mountains on the west, north, and east, Stearns (1953b) reported that the Dakota (?) sandstone ranged in thickness from 0-40 feet and consisted of well-bedded to interbedded, brown to gray-white, siliceous sandstone. In this area Stearns did not map the Dakota (?) sandstone as a separate unit because it is highly discontinuous (figure 4).

Disbrow (1953) showed the Dakota (?) sandstone to be 50-100 feet thick in the Cerrillos Hills area.

Era	Sys.	Formation	Thick.	Lith.	Description
QUATERNARY	PLEISTOCENE TO RECENT	Tuerto Gravels	5 to 150 ft		Coarse gravels
		unconf.			
TERTIARY	MIOCENE & PLIOCENE	Santa Fe formation	0 to 2000 ft.	Not Present In Area Mapped	Loose to moderately cemented, poorly sorted silt, sand, and gravel (fan deposits); clean, well-rounded gravel (river deposits); andesite and basalt flows.
		Abiquiu (?) formation	0 to 1500 ft.	tuff	Clay, silt, sand, and fine gravel, locally a wedge of water-laid tuff.
		unconf.			
	MIDDLE (?) TO LATE EOCENE	Espinaso volcanics	0 to 1500 ft.		Water-laid volcanic debris, subordinate massive flows and pyroclastic breccias.
		Galisteo formation	0 to 4500 ft.		Variegated beds of clay, shale, sand, sandstone, and conglomerate; minor amounts of limestone and water-laid tuffs.
		unconf.			
MESOZOIC	UPPER CRETACEOUS	Mesaverde formation	0 to 1000 ft.		Sandstone, shale, and coal.
		Mancos shale	800 to 1000 ft.		Sandy shale, abundant limestone concretions. Thin lenses of sandstone. Cano member of Mesaverde formation. Sandy shale, abundant limestone concretions. Thin lenses of sandstone near top.
			500 ft.		Dark shale.
			500 to 800 ft.		Juana Lopez member: Dark thin-bedded limestone. Carlile shale: Dark shale, locally sandstone beds. Greenhorn limestone: Platy dark limestone. Graneros shale: Dark shale, locally sandstone beds. Dakota (?) formation: Discontinuous sandstone and shale.

Figure 4. Generalized stratigraphic column of Ortiz Mountains and surrounding areas. (modified after Stearns, 1953a)

Mancos shale

The Mancos shale in the Ortiz Mountains is similar to that of surrounding areas. It is generally exposed in stream valleys or as nonresistant scarp-slopes of eastward dipping cuestas capped by intrusive sheets across the western half of the area mapped. It conformably overlies the Dakota (?) sandstone in the surrounding area. According to Stearns (1953b) it can be differentiated into the Graneros shale, Greenhorn limestone, Carlile shale and Niobrara shale. In the Ortiz Mountains the various members of the Mancos shale are only locally recognizable and hence cannot be mapped as separate units.

In the Galisteo-Tonque area the Graneros shale is represented by 200-250 feet of gray, fossiliferous shale and interbedded sandstone. A brown, thin-bedded, siliceous sandstone 5-30 feet thick occurs locally in the middle of the section and is called the Tres Hermanos (Stearns, 1953b).

The Greenhorn limestone consists of 30-40 feet of light gray interbedded limestone and nodular calcareous shale (Stearns, 1953b).

The Carlile-Niobrara shales in the Galisteo-Tonque area range in thickness from about 1,000 to 1,300 feet and are represented by dark blue-gray, brown or black shales with a few intercalated beds of sandy shale and thin-bedded sandstone. The Juana Lopez member occurs from 300 to 500 feet above the Greenhorn limestone and consists of about

6 feet of interbedded arenaceous shale and very thin-bedded, arenaceous fetid limestone (Stearns, 1953b). This in turn is overlain by 1,300 to 1,500 feet of shale, sandy shale and thin-bedded sandstone. The Mancos shale, therefore, apparently ranges in thickness from 1,830 to 2,265 feet (figure 4).

Harrison (1949) reported that the Mancos shale in the Hagan Coal Basin is represented by 1,304 feet of gray to dark gray, buff to gray-buff shale with sandy and calcareous zones.

At the Rogers Mine, two miles southwest of Cerrillos, Lee (1917) measured 2,352 feet of Mancos shale.

Mesaverde formation

The lithology of the Mesaverde formation is also similar to that of surrounding areas. It is confined to the western half of the area and is usually exposed in stream valleys or as nonresistant scarp-slopes of eastward dipping cuestas.

The Mesaverde formation in the Hagan Coal Basin, as described by Harrison (1949), is composed of sandstones and coal-bearing shales conformably overlying the Mancos shale. The sandstones are olive-drab, tan, buff, yellow-buff, gray and gray white, thin- to thick-bedded and are composed predominantly of fine- to coarse-grained, subangular to subrounded quartz fragments. They contain some feldspar grains and are locally argillaceous and friable, with either

a siliceous or ferruginous cement. The thick-bedded sandstones are particularly common in the lower half of the formation. The shales are gray, buff to brown, locally arenaceous and contain thin calcareous concretionary beds and lenses.

In the Tonque Valley about six miles to the west of the Ortiz Mountains the Mesaverde formation contains about 1,500 feet of buff-white to brown sandstone and brown or black carbonaceous shale and coal. A 100 to 250 foot thick massive sandstone commonly occurs at the base of the formation (figure 4). In the Arroyo Pinovetito, six miles north of Hagan, the Mesaverde formation is only 535 feet thick (Stearns, 1953b).

At the Rogers coal mine, two miles southwest of Cerrillos, the Mesaverde formation consists of 758 feet of light gray, massive sandstones and interbedded coal-bearing, in part carbonaceous, shale. A diamond drill hole at Madrid penetrated 852 feet of gray sandstone and coal-bearing shale of the Mesaverde formation (Lee, 1917).

Tertiary Sedimentary Rocks of Adjacent Areas

About six miles to the west in the Hagan Coal Basin and only about two miles to the east of the area mapped for this thesis, the Upper Cretaceous beds are unconformably overlain by the Galisteo formation. Vertebrate fossils collected from the Galisteo formation have been assigned to

the Duchesnean time which dates the formation as late Eocene or early Oligocene (Stearns, 1943). In the Hagan Coal Basin and three miles east of Cerrillos the Galisteo formation is overlain without stratigraphic interruption by the Espinaso volcanics which consist predominantly of water-laid volcanic debris (Stearns, 1943). Unconformably overlying the Espinaso volcanics are clay, silt, sand, and fine gravels of the Abiquiu (?) formation (Stearns, 1953a). This can be seen on figure 4.

These beds are unconformably overlain by fan deposits, river deposits, travertine, water-laid pumice and lava flows of the late Miocene or early Pliocene Santa Fe formation. Late Tertiary and Quaternary gravels of the so-called "Ortiz pediment" veneer the beveled underlying sedimentary rocks (Stearns, 1943).

Galisteo formation

The Galisteo formation is composed of sandstone, sand, conglomerate, clay, limestone, and fluviatile tuff. The unit consists predominantly of gray-white, buff, yellow, brown and pink, medium- to coarse-grained, cross-bedded sandstones and sands consisting of quartz, feldspar, and chert and igneous rock fragments. These sandstones and sands are locally conglomeratic and are intercalated with variegated, unindurated sandy clay. Locally, 2- to 3-foot beds of light tan to light gray, nodular, fresh-water limestone are present and thin beds of water-laid tuff or the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] early [illegible] [illegible] [illegible] [illegible] [illegible] the [illegible] Coal [illegible] and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] formation is [illegible] [illegible] [illegible] [illegible] [illegible] by the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] water-laid [illegible] [illegible] [illegible] [illegible] [illegible] overlying the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] fine gravels of the [illegible] [illegible] formation ([illegible], [illegible]). This can be [illegible] [illegible] [illegible].

These beds are [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] river deposits, [illegible], [illegible] [illegible] [illegible] and lava flows of the [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible] [illegible]. [illegible] [illegible] and [illegible] [illegible] [illegible] [illegible] called "[illegible] [illegible]" [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] ([illegible], [illegible]).

Hillsboro Formation (1)

The Hillsboro Formation [illegible] [illegible] [illegible] [illegible] [illegible], conglomerate, [illegible], [illegible], [illegible] [illegible] [illegible] unit [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible], brown [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] sandstones [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] chert and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] sands are locally [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] limestones are [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] tuffaceous sandstones have also been observed (figure 4). The area of Galisteo deposition is bordered on the southwest by the Sandia Mountains, on the northwest by the Jemez Mountains and on the northeast by the Sangre de Cristo Mountains. Across this area the thickness of the Galisteo formation varies from 900 feet to at least 4,300 feet, increasing in thickness from the northwest part of the depositional basin to the southeast (Stearns, 1943).

An isopleth map prepared by Stearns (1943) shows the original thickness of the Galisteo formation in the vicinity of the Ortiz Mountains to have been 3,000-4,000 feet.

Espinaso volcanics

Two miles north of Hagan on Espinaso Ridge (type locality) the Espinaso volcanics attain a maximum thickness of at least 1,400 feet and consist of coarse fragments of poorly sorted volcanic debris (figure 4). That the material was deposited by streams is suggested by rude stratification and sorting, mixing of pebble types, and general subangularity of pebbles and boulders. A few beds of volcanic ash have been observed, but lava flows and beds of pumice, scoria, and other products of volcanic explosion are rare. Rock fragments and pebbles have been identified as latite and quartz latite porphyry. The dominant color is blue-gray, but brownish, purplish, and reddish grays are also common (Stearns, 1953c).

Abiquiu (?) formation

The Abiquiu (?) formation is assigned to the early Miocene and consists of 1,400 feet of loosely consolidated gray-white, tan, pink, and orange-buff, medium- to coarse-grained sand and subordinate sandy silt that unconformably overlie the Espinaso volcanics on Espinaso Ridge (figure 4) (Stearns, 1953a).

The Espinaso volcanics, Galisteo formation, and Cretaceous and Jurassic sedimentary rocks are believed by Baldwin (1956) to be the source beds of the Abiquiu (?) formation.

Santa Fe formation

The Santa Fe formation consists of a maximum of 2,000 feet of late Miocene and early Pliocene fan deposits of loosely cemented, poorly sorted silt, sand, and gravel; river deposits of clean well-rounded gravels with interbedded quartz latite andesite; and andesite-basalt flows (figure 4) (Stearns, 1953a).

These deposits were derived from Precambrian and Pennsylvanian rocks of the Sangre de Cristo Mountains (Stearns, 1953a; Baldwin, 1956).

Late Tertiary and Quaternary Alluvium and Gravels

More than seventy-five per cent of the area is covered by a thick mantle of late Tertiary and Quaternary alluvium and gravel. Geologic contacts of older rocks were inferred

and projected beneath this cover. Since this thesis deals only with bedrock geology these deposits were not mapped, but they consist of unconsolidated aggregates of pebbles, cobbles, and blocks of igneous rocks and metamorphosed sedimentary rocks in a sand matrix that unconformably overlies the upturned and beveled edges of older rock units. These are the deposits that make up the "high altitude conoplain" described by Ogilvie (1905). They are referred to by Stearns (1953a) as the Quaternary Tuerto gravels (figure 4).

Recently Baldwin (1956) suggested that the term "Santa Fe" be raised to group status and for it to include the Miocene Abiquiu (?) formation of Stearns (1953a) as the basal unit of the Santa Fe group. To what was previously referred to as the "Santa Fe formation" Baldwin applied the name Tesuque formation and called it the middle unit of the Santa Fe Group. The Upper unit is Stearns' (1953a) Tuerto gravel of late Pliocene or early Pleistocene age.

The angular unconformity between the Santa Fe formation (Tesuque formation) and the Tuerto Gravels is referred to by Baldwin (1956) as the "lower Ortiz surface" of late Pliocene time. Along the Rio Grande, north of the area mapped, accumulation of these gravels was interrupted by a period of erosion which formed the "upper Ortiz surface" upon which were deposited basalt flows of Pleistocene time (Baldwin, 1956). Deposition of alluvium and gravels of the same type, also derived from the Ortiz Mountains, has continued to the present. For and projected beneath that cover [illegible] of the [illegible] beds [illegible] only with bedrock geology, [illegible] but they consist of [illegible] and [illegible] cobbles, and blocks of [illegible] rocks [illegible] mentary rocks [illegible] the upturned and truncated edges of [illegible]. These are the deposits [illegible] described by [illegible] (1958a) as the [illegible].

Recently [illegible] (19[illegible]) [illegible] he raised [illegible] Alcoche [illegible] (re-[illegible] of [illegible]) as the basal unit of the Santa Fe group. [illegible] to as the "Santa Fe [illegible]" [illegible] Tesuque formation and [illegible] of the Santa Fe group. The upper unit [illegible] of late Pliocene or early [illegible].

The angular unconformity [illegible] the Santa Fe [illegible] (Tesuque formation) and the [illegible] Baldwin (1956) [illegible] time. [illegible] the Rio Grande [illegible] lation of these [illegible] which formed the [illegible] ed conditions [illegible] tion of alluvium [illegible] from the [illegible].

a detailed resume of the description and areal distribution of the late Tertiary and Quaternary deposits the reader is referred to Bryan (1938), Bryan and McCann (1936, 1937, and 1938), Stearns (1953a) and Baldwin (1956).

GEOLOGIC STRUCTURE

Regional Tectonic Setting

The Ortiz Mountains are situated along the eastern arm of the New Mexico Rockies tectonic province which is bordered on the east by the Great Plains and on the west by the Rio Grande depression or basin. The area is included in the San Pedro-Ortiz porphyry belt which is bordered on the west by the Hagan embayment of the Santo Domingo basin and on the north and east by the Santa Fe embayment of the Espanola basin (figure 3) (Kelley, 1954).

Kelley (1955) has subdivided the Colorado Plateau into five distinct northwest-trending tectonic segments separated by tectonic lineaments which he defined as "either a general alignment of structural features or a boundary between contrasting structural features." He further demonstrated that all of the laccolithic intrusions of the Colorado Plateau occur within the so-called San Juan segment which is bordered by the Uncompahgre and Zuni lineaments. Within this segment all the laccolithic centers fall on one of three parallel lines that also trend northwest. These lines are referred to as "porphyry lines," and he notes that the

La Sal porphyry line, which connects the Park City, La Sal, La Plata, and Bland intrusive centers, if extended southeastward, would also include the Cerrillos centers, which presumably includes the Ortiz Mountains, in the adjoining Southern Rockies tectonic province. He concluded that perhaps the position of these intrusions is controlled by the intersection of the northerly and northeasterly tectonic trends of the Southern Rockies Province and the northwesterly trends of the Colorado Plateau.

The Tijeras fault system extends northeastward across the southern part of the Ortiz Mountains and roughly parallels Cunningham Gulch. This fault system is of regional extent and is continuous from the west base of the Manzano Mountains southeast of Albuquerque for over 25 miles to the southern end of the Sangre de Cristo Mountains (figures 3 and 5). The fault system consists essentially of a pair of parallel faults through much of its length and outlines a linear slice that is in part, a graben, and in part, a horst. Individual faults of the system are principally high angle normal faults, but high angle reverse faults have also been observed. This fault system in regarded as pre-Abiquiu (?) in age (Stearns, 1953a).

Local Structure

The most pronounced structural feature of the northern part of the Ortiz Mountains is the persistent eastward dip of the sedimentary rocks and the igneous sheets that intrude

them. This is an expression of a southward extension of the Galisteo monocline as mapped by Stearns (1953a). This structure consists of eastward dipping sedimentary formations on the upthrown side of the post-Santa Fe Rosario or La Bajada and Barro faults, two of the numerous normal faults that mark the eastern edge of the Rio Grande depression. The Rosario fault borders the Ortiz Mountains on the west and extends northward for 15 miles (figure 5). At its point of maximum throw, midway along its strike, the Triassic Dockum group is upthrown against the late Tertiary Santa Fe formation (Stearns, 1953a).

One minor normal fault of little displacement was mapped in the extreme northwest part of the area (figure 1). It seems likely that faults exist in other parts of the mapped area, but fault breccia, displaced beds and other criteria suggesting faults, if present, are thoroughly obscured by alluvium and gravel.

Two small folds were mapped in the west central part of the area. They are local structures and resulted from the buckling of sedimentary beds between two laccolithic intrusive centers (figure 1).

Structure of Igneous Intrusive Bodies

The Ortiz Mountains have been referred to by some authors as a simple laccolith and by others as a laccolith with associated intrusive sheets. However, in the northern

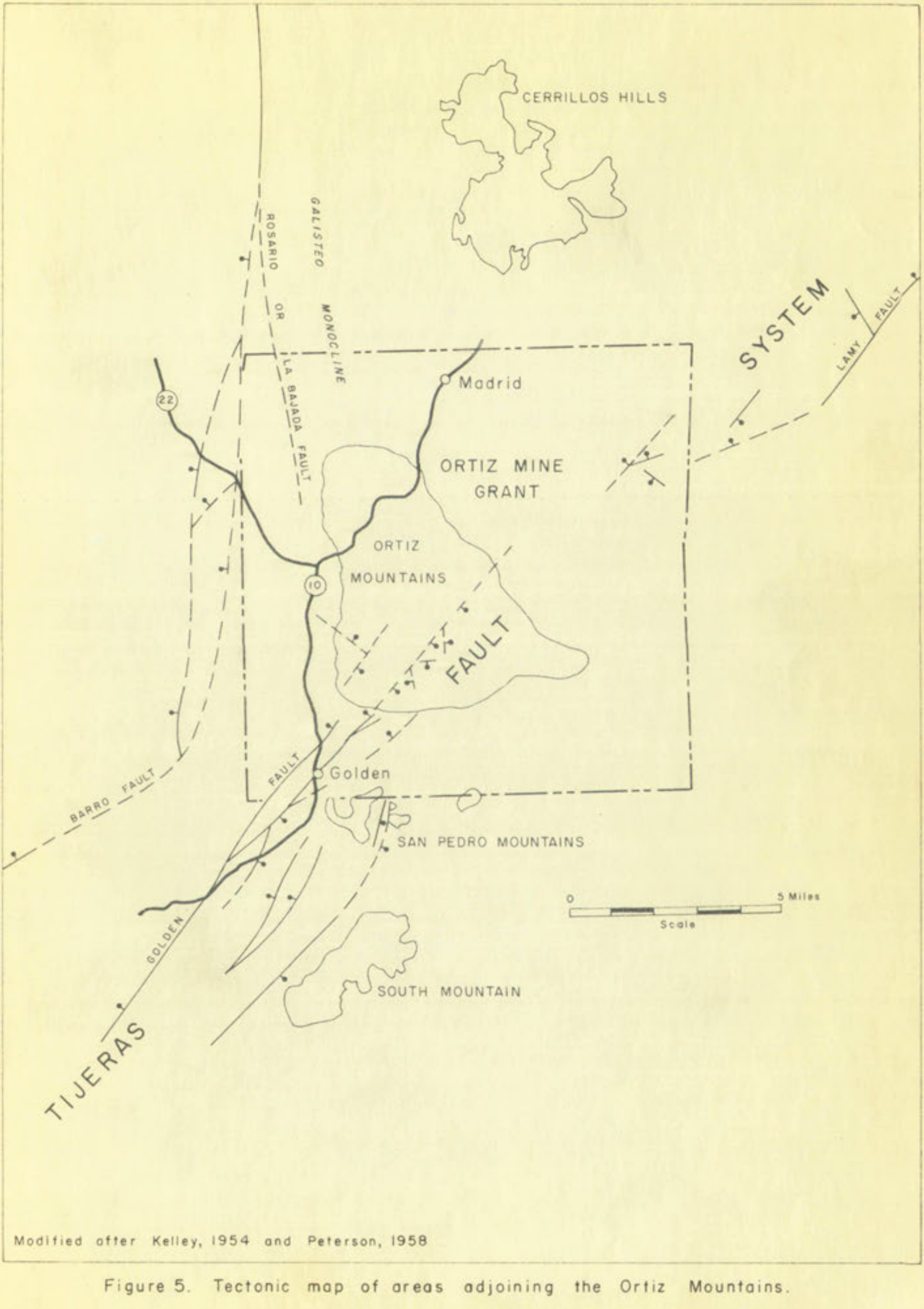

Figure 5. Tectonic map of areas adjoining the Ortiz Mountains.

part of the mountains it can be demonstrated that the igneous instrusive rocks actually occur as many extensive porphyry sills and several small porphyry laccoliths, and as a large non-porphyritic stock. A volcanic vent and a few dike- or plug-like feeders connecting sills may also be observed.

At least a dozen individual sills were mapped. They range in thickness from less than 50 feet to over 400 feet. They are generally continuous and throughout most of their extent follow the bedding of the sedimentary rocks that they intrude, but locally they cut across the bedding at a very low angle. This fact was first noted by Lee (1913). A few may be traced northward from the area mapped for a distance of over four miles. The sills are relatively resistant to erosion and consequently they form the cap and dip slope of cuestas. They occur from along the top of the Dakota (?) formation through the Mesaverde formation, but are most abundant in the Mancos shale (figure 1).

Six small laccoliths were observed, and they are all confined to the western side of the area. Their tops have been eroded; they presently range in thickness from about 600 feet to over 900 feet and are roughly circular, with diameters that range from 1,800 feet to over half a mile (figure 1). They have intruded the Mancos shale exclusively, and the apparent centers of five of them form a lineament that trends N. 20°W. and roughly parallels the Rosario

part of the mountain [illegible] porphyry [illegible]
dacis [illegible] porphyry [illegible]
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or La Bajada fault, which is approximately one mile to the west. Of these five, the northern three appear to have been intruded at the same stratigraphic level as indicated on figure 1. The fourth one is stratigraphically higher than the first three. The sixth, located immediately east of the first three, is approximately at the same stratigraphic level as the fifth (figure 1). These laccoliths appear to thin rapidly away from their intrusive centers to a point beyond which a persistent thickness is maintained, forming fringing sills.

The most prominent intrusive body in the area is a large elliptical stock that has cut across the sedimentary beds and the sills that intrude them. It is approximately two and a half miles long and one and a half miles wide with the long dimension trending east-north-east. This igneous body has been called a laccolith, but the present author thinks it is a stock because it was nowhere observed to lie on older rocks, and because it cuts across the rocks that surround it (figure 1).

PETROGRAPHY

The igneous rocks of the Ortiz Mountains area are almost all of intermediate composition and can be subdivided into two broad categories -- porphyritic and non-porphyritic. They have been called syenite porphyry (Yung and McCaffery, 1903), diorite approaching monzonite (Lindgren, 1910), or La Bajada Hills, [illegible] in the west. Of these five, [illegible] part is [illegible] intruded at the [illegible] point as [illegible] in figure 1. The [illegible] the first [illegible] the first three, [illegible] level as the [illegible]. [illegible] this [illegible] away from [illegible] beyond which [illegible] fringing plain.

The most prominent [illegible] body in the [illegible] large elliptical [illegible] beds and the [illegible] two and a half miles long and [illegible] the long diameter [illegible] body has been called a [illegible], but the present writer thinks it is a stock because [illegible] on older rocks, [illegible] surround it (figure 1).

[illegible]

The igneous rocks of the [illegible] area are almost all of intermediate [illegible] into two broad categories -- [illegible] and non-[illegible]. They have [illegible] (Stearns and [illegible], 19[illegible]), [illegible] trachyandesite (Johnson, 1903), and dacite, diorite, essexite, and andesite (Ogilvie, 1908).

Table I is a tabulation of three chemical and normative analyses of rock samples collected by Ogilvie (1908). In her original paper she provided eleven analyses of rocks from the Ortiz Mountains, but apparently only these three samples were collected within the area of the current study.

In the initial phases of the petrographic study of the porphyries, potash feldspars were not optically ascertainable. However, a glance at the chemical analyses by Ogilvie disclosed that approximately 2-4% of these rocks is potash. It was, therefore, assumed that the potash feldspar is present as minute grains in the microcrystalline groundmass. This assumption was confirmed by application of a feldspar staining technique modified somewhat from the method originally developed by Gabriel and Cox (1929). The technique consisted of suspending a sawed surface of a rock one-quarter inch above a surface of fuming hydrofluoric acid, the temperature of which was maintained at approximately 150°F. After fuming for approximately four minutes the sample was submerged in a container of water for a few seconds to remove the excess acid. Next, the sample was immersed in a concentrated sodium cobaltinitrite solution for three minutes. It was then allowed to dry at room temperature for a period of no less than ten to twelve hours. Afterward, it was again rinsed in flowing water to remove

trachyandesite (Johnson, [illegible]), [illegible] te-
sexite, and andesite ([illegible]).

Table [illegible] is a tabulation of [illegible] chemical and [illegible]-
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of a feldspar-staining technique modified somewhat from the
method originally developed by [illegible] and [illegible] ([illegible]). The
technique consisted of suspending a sawed surface [illegible]
one-quarter inch above a surface of fuming hydrofluoric
acid, the temperature of which was maintained at approx-
imately 100°F. After fuming for approximately [illegible] minutes
the sample was immersed in a container of water for [illegible]
seconds to remove the excess acid. Then, the sample was
immersed in a [illegible] solution of sodium cobaltinitrite
for three minutes. It was then [illegible] at room
temperature [illegible]
Afterwards, it was again [illegible]

TABLE I. Chemical and normative analysis of three igneous rocks from the northern part of the Ortiz Mountains (after Ogilvie, 1908).

Chemical Analysis				Normative Analysis			
	I	3	9		I	3	9
SiO_2	63.11	62.48	51.42	Qu	12.72	15.06	—
Al_2O_3	16.75	18.07	19.40	Or	20.57	12.79	23.91
Fe_2O_3	2.68	2.61	3.72	Ab	39.82	39.82	22.01
FeO	1.39	1.97	3.33	An	14.18	21.68	17.24
MgO	1.22	1.34	2.56	Ne	—	—	14.48
CaO	3.88	4.67	7.80	Diop	4.32	0.22	12.21
Na_2O	4.76	4.69	5.28	Hyp	2.00	4.12	—
K_2O	3.48	2.16	3.96	Ol	—	—	0.90
H_2O+	1.09	0.52	0.49	Mag	2.32	3.71	5.34
H_2O-	0.32	0.12	0.04	Hem	1.12	—	—
TiO_2	0.80	0.60	1.39	Ilm	1.52	1.22	2.74
P_2O_5	0.25	0.28	0.53	Ap	0.34	0.67	1.34
S	0.03	0.03	0.03				
MnO	0.11	0.17	0.23				
BaO	0.16	0.09	0.21				
Total	100.03	99.79	100.39				

I. Dacite (Laurvikose-Lassenose) - intrusive sheet on the west side of the mountains.

3. Dacite (Yellowstonose) - intrusive sheet on the northeast side of the mountains.

9. Essexite (Essexose) - from the top of the highest mountain (Placer Mountain?).

the solution that did not react with, but superficially coated feldspars and other minerals. As pointed out by the originators of the technique the hydrofluoric acid converts the surface of the minerals to a gel-like substance. Upon immersion in the staining solution the gel produced by the potash feldspar reacts with the sodium cobaltinitrite to form a precipitate of bright yellow potassium cobaltinitrite, thereby selectively coloring the potash feldspar and permitting its content to be estimated with a fair degree of accuracy.

Petrographic investigation of the non-porphyritic rocks disclosed that the plagioclase feldspar is andesine, whose optical properties are not greatly different from those of orthoclase. Consequently, it was also necessary to subject the non-porphyritic rocks to stain tests in order to provide a reliable estimate of the potash feldspar content. These tests and microscopic investigations showed that plagioclase and potash feldspar occur in essentially equal proportions in these rocks.

Trachyte-latite Vent Rock

The Cunningham Gulch area is occupied by an elongate mass of partly brecciated intrusive rock (figure 1). Griswold (1948) called it a "brecciated monzonite stock." Stearns (1953c) concluded that the mass represented a "vent

the solution that [illegible]
coated feldspar and other minerals [illegible]
the original form of the [illegible]
verts the surface of the [illegible]
Upon immersion in the [illegible]
the potash feldspar readily [illegible]
to form a [illegible]
trite, thereby selectively [illegible]
permitting its content to be determined with a [illegible]
accuracy.

Petrographic investigation of the non-porous [illegible]
disclosed that the plagioclase [illegible]
optical properties [illegible]
oligoclase. Consequently, [illegible]
the non-porous [illegible]
vide a [illegible]
These tests [illegible]
calcite and potash feldspar [illegible]
portions [illegible]

[illegible]

The [illegible]
mass of [illegible]
volc [illegible]
[illegible]

breccia." He postulated that the vent in early Tertiary time had extruded volcanic material that was later removed by erosion and deposited in the surrounding areas as the Espinaso volcanics.

All but the extreme southwestern part of this mass appears hydrothermally altered to such a degree that the constituent grains for the most part are not apparent. It has a dirty gray, chalky appearance and is thoroughly stained with limonite. The rock is reportedly gold- and scheelite-bearing. In the northeastern half of the Cunningham Gulch area it contains numerous xenoliths of hornfels, quartzite, porphyry, and other rocks that are foreign to the general area. These xenoliths, which range from less than an inch to several feet in diameter, are themselves thoroughly altered and commonly silicified (plate I-B).

The southwestern part of the mass is essentially unaltered and can best be described as a light- to medium-gray porphyry with very small, dark green mafic minerals and large sized feldspar phenocrysts in an aphanitic groundmass. On a hill just south of the Ortiz Mine a dike-like mass of rock 40 feet long and about 10 feet wide, consisting essentially of equal amounts of quartz and feldspar, was observed to cut across this rock.

Along its northwestern border the mass is apparently truncated and included by the augite monzonite stock (plate II-A). Along its northeastern border it appears to intrude breccia. The possibility [illegible] time had [illegible] by erosion and [illegible] deposited [illegible].

All but [illegible] appears hydrothermally altered [illegible] [illegible] is a dirty grey [illegible] with limonite. The rock is apparently [illegible] bearing. [illegible] the northwestern part of the [illegible] area it contains numerous [illegible] quartzite, porphyry, and other rocks that are foreign to the general area. These xenoliths, which range from less than an inch to several feet in diameter, are commonly [illegible] altered and commonly [illegible] (fig. II-[illegible]).

The southwestern part of the [illegible] is hydrothermally altered and [illegible] grey porphyry with very small [illegible] and large [illegible] mass. [illegible] mass of [illegible] essentially [illegible] was observed [illegible].

Along the northwestern [illegible] is [illegible] fractured and [illegible] (plate II-4). Along the [illegible] sandstone and shale of the Mesaverde formation. Along its southern border, which for the most part is outside the area mapped, it is cut by a fault of the Tijeras fault system. Along the fault it is thoroughly brecciated.

The regional dip across the entire mapped area is approximately 15° to 20° to the east, consequently, the extreme southwestern part of this mass of igneous rock is now approximately 1,500 feet higher relatively than it was prior to the faulting that resulted in this regional dip. In this part of the mass it is relatively unaltered and contains distinct feldspar phenocrysts up to one inch in length.

Time did not permit a detailed investigation of thin-sections of these rocks, but a cursory examination was made of five thin-sections prepared from samples taken from various parts of the igneous mass.

Those taken from the northeastern or structurally higher part of the mass disclosed that it consists of fine-grained, angular fragments of trachytic-textured rock consisting of feldspar microlites, angular fragments of fine-grained, cryptocrystalline to glassy material and anhedral, perhaps brecciated, crystals of orthoclase and plagioclase. These are contained in a micro- to cryptocrystalline groundmass the texture of which is in part trachytic and in part resembles the salt-and-pepper-like texture of the latite-andesite porphyries. No mafic minerals are present and apparently they have been completely destroyed by hydrothermal sandstone and shale of the [illegible] Formation. [illegible] the southern border, [illegible] of the [illegible] within the area mapped, it [illegible] along the [illegible]. Along the fault [illegible] a [illegible].

The regional [illegible] approximately [illegible] 20° in the [illegible], and the extreme southeastern part [illegible] approximately 1,500 feet [illegible] than it was prior to the faulting that resulted in this [illegible]. In this part of the area it is relatively [illegible] and contains distinct feldspar phenocrysts [illegible].

Time did not permit a detailed investigation of thin-sections of these rocks, but a [illegible] of five thin-sections prepared from samples [illegible] various parts of the igneous mass.

Those taken from the northwest or [illegible] part of the mass disclosed that it consists of fine-grained, angular fragments of [illegible] consisting of feldspar microlites, [illegible] of fine-grained, cryptocrystalline [illegible] material and [illegible], perhaps [illegible]. These are contained in a [illegible] mass the texture of which [illegible] resembles the [illegible] andesite porphyries. [illegible] apparently they have been completely [illegible] activity and weathering, thereby accounting for the intense limonite staining.

These samples are suggestive of a lithic tuff and this part of the mass probably represents volcanic material that congealed within the upper part of the vent.

A stain test disclosed that potash feldspar is the dominant feldspar, and that plagioclase occurs in only subordinate amounts. The rock appears to be a trachyte.

The term trachyte is used here as defined by Williams et al. (1954) to describe a rock containing less than 10% quartz or 10% feldspathoid plus olivine in which orthoclase constitutes more than two-thirds of the total feldspar.

Thin-sections of samples from the southwestern or relatively deeper part of the mass are distinctly porphyritic with phenocrysts of poikilitic orthoclase and plagioclase. These minerals are imbedded in a microcrystalline groundmass. Quartz was positively identified and occurs in amounts of slightly less than 10%. Fragmentation, characteristic of the upper part of the mass, is not evident in the deeper part.

Several samples of this rock type were subjected to a feldspar stain test, and it was discovered that those samples taken from the upper part of the vent consist predominantly of orthoclase with only minor amounts of plagioclase. Those samples taken from the lower part of the vent consist of essentially equal amounts of orthoclase and plagioclase.

activity and weathering, however, accounting for the abundant limonite staining.

These samples are [illegible] and this part of the mass probably [illegible] congealed within this upper part of the mass.

A stain test disclosed that potash feldspar is the dominant feldspar, and that [illegible] occurs in only subordinate amounts. The rock appears to be a granite.

The term [illegible] was used by [illegible] et al. (1955) to describe a rock [illegible] quartz or [illegible] in which [illegible] constituents were [illegible].

This section of samples from the [illegible] relatively deeper part of the mass are [illegible] with phenocrysts of [illegible] and [illegible]. These minerals are enclosed in a [illegible] groundmass. Quartz was readily identified and occurs in amounts of slightly less than 10%, [illegible] characteristic of the [illegible] in the mass, [illegible] the deeper part.

Several samples of [illegible] were also [illegible] feldspar [illegible] taken from the upper part [illegible] of orthoclase with a [illegible] amount of plagioclase. The samples taken from the lower part of the mass consist of essentially equal amounts of orthoclase and plagioclase.

Thus, the igneous mass as a unit varies in composition and texture from a quartz-bearing latite porphyry where it is structurally lower to a brecciated trachyte where it is structurally higher, that is from southwest to northeast. A detailed study of this rock mass was not made and the explanation for its variation in composition is by no means clear. However, as previously noted the upper or northeastern part of this igneous mass has been intensely altered by hydrothermal solutions. These solutions may have been rich in potassium which would replace the sodium in the plagioclase feldspar converting it to a potash feldspar, thereby accounting for the trachyte composition of this part of the rock mass.

Since this igneous mass appears to represent a volcanic conduit and because it grades vertically upward from a quartz-bearing latite porphyry to a trachyte vent breccia it is collectively referred to, and mapped as, intrusive trachyte-latite vent rock.

Latite-andesite Porphyry

These porphyry rocks occur as extensive sills and small laccoliths and, generally speaking, are saturated with respect to silica. That is to say, they usually contain less than 10% quartz. For the most part potash feldspar constitutes more than one-tenth but less than one-third of these rocks. The remaining feldspar is andesine. These rocks generally consist of plagioclase and hornblende phenocrysts

in a microcrystalline groundmass that under the petrographic microscope has a distinct salt-and-pepper-like appearance not unlike the fine aggregate mosaic structure commonly displayed by chalcedony (plate II-B and plate III-A). Such aphanophyric rocks that are intermediate in composition between trachyte and andesite have been referred to by some workers as trachyte-andesite (Johannsen, 1937) or trachyandesite (Williams, et al., 1954).

Williams, et al. (1954) apply the term trachyandesite to all andesites with more than ten per cent modal or normative potash feldspar. They point out, however, that many trachyandesites are recognizable only be means of chemical analyses because the potash is often contained in micro- and crypto-felsitic interstitial material. Andesine or oligoclase is the dominant plagioclase. Diopsidic augite is the usual pyroxene and most specimens contain phenocrysts of olivine, hornblende, or biotite. An examination of the petrographic analyses of the rocks in the appendix of this report demonstrates that such a definition well suits the prophyry rocks that occur in the northern part of the Ortiz Mountains and the author is not opposed to applying the term trachyandesite porphyry to these rocks.

However, Johannsen (1937) points out that the terms trachyandesite and trachyte-andesite have been applied by various workers to describe not just rocks that are intermediate in composition between trachyte and andesite, but

in a microscope [illegible] [illegible] [illegible] [illegible] the [illegible]
microscope and a [illegible] [illegible] [illegible] [illegible]
not unlike the [illegible] [illegible] [illegible] [illegible] [illegible] dis-
played by chalcedony [illegible] [illegible] [illegible] [illegible]
aphanophyric rocks [illegible] [illegible] [illegible] [illegible] be-
tween trachyte and [illegible] [illegible] [illegible] [illegible] [illegible]
workers as trachyte-related [illegible] [illegible] [illegible] or [illegible]
andesite (Williams, et al., 1954).

Wilkinson, et al. (1954) [illegible] [illegible] [illegible] [illegible]
to all andesites [illegible] [illegible] [illegible] [illegible] [illegible] norma-
tive potash feldspar. [illegible] [illegible] [illegible], however, this easy
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
analyses because the potash is often concealed in micro-
and crypto-felsitic interstitial material [illegible] [illegible]
oligoclase in the [illegible] [illegible]. [illegible] [illegible]
in the usual [illegible] and [illegible] [illegible] [illegible] [illegible]
of olivine, [illegible] or [illegible]. An [illegible] of the
petrographic analyses of [illegible] [illegible] [illegible] [illegible]
[illegible] demonstrates that [illegible] [illegible] [illegible] [illegible]
porphyry rocks [illegible] occur in the [illegible] part of the [illegible]
Mountains [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] petrography [illegible] [illegible] rocks.

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible]-andesite [illegible] [illegible] [illegible]
various workers [illegible] [illegible] [illegible] [illegible] the [illegible] inter-
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

rocks that have a specific texture and mafic and feldspathoid composition. Such confusion, he concludes, calls for the abandonment of both terms.

Many petrographers agree that an aphanitic rock with less than 10% quartz or less than 10% olivine and feldspathoids with equal amounts of orthoclase and plagioclase should be called latite. They likewise seem to agree that an aphanitic rock with less than 10% quartz or less than 10% olivine and felspathoids, less than 10% potash feldspar and with plagioclase dominant over the mafic minerals should be called andesite. Since, for the most part, the porphyritic rocks of the northern part of the Ortiz Mountains are intermediate in composition between latite and andesite they are referred to, and mapped as, latite-andesite porphyry.

Nineteen samples of this rock type and three phanerocrystalline equivalents of it were examined under the petrographic microscope. In these samples the groundmass constitutes 18-50% of the rock but it is usually about 36%. The constituents of this material range in size from about .01 mm to .05 mm in diameter, and it is postulated on the basis of stain tests that they are principally orthoclase with some plagioclase and subordinate quartz.

The principal phenocrysts are subhedral to euhedral andesine. Subhedral to euhedral hornblende phenocrysts are invariably the principal mafic mineral, although anhedral to subhedral augite phenocrysts were also observed. Quartz

rarely occurs as phenocrysts, but it is commonly found in minor amounts as anhedral grains not much larger than the groundmass constituents. Magnetite is common and is present in amounts up to 5% of the rock. Biotite is rare. Accessory minerals sphene, apatite, zircon, and allanite (?) are often present in trace amounts. Sphene or apatite, from the evidence of a few slides, locally constitutes 2-3% of the rock. Ilmenite is locally present in place of magnetite, but only in trace amounts. Epidote is common and usually occurs as a replacement of plagioclase or mafic phenocrysts. Carbonate, presumably calcite, is a common and sometimes abundant constituent. It occurs both interstitially and as a product of alteration of mafic minerals. It appears to be most common in those rocks that form the western side of mountains. Based on stratigraphic inferences this is the general area where the Greenhorn limestone might be expected, and thus a genetic relationship is suggested between the occurrence of considerable carbonate in the igneous rocks and the presence of a limestone in that part of the section intruded by the igneous rocks. In the same area hornblende xenoliths, usually about four inches long and three inches wide, are commonly found in the latite-andesite porphyry.

Keyes (1909) pointed out that the Greenhorn limestone in the southwestern part of the Ortiz Mountains is locally garnetiferous and contains replacement ore bodies. Within the mapped area along the western side of the mountains the

rarely occurs as phenocrysts, but is a common [illegible] [illegible] and this at abnormal [illegible] with length [illegible] groundmass constituent. [illegible] in amounts up to [illegible] [illegible] [illegible]. Acces-
sory minerals [illegible] [illegible] [illegible] and [illegible] [illegible]
often present in [illegible] [illegible] [illegible], [illegible] [illegible]
evidence of a [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
rocks. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
but only in [illegible] amounts. [illegible] [illegible] [illegible] [illegible]
occurs as a [illegible] [illegible] [illegible] [illegible] [illegible]
Carbonate, [illegible] [illegible] [illegible] [illegible] [illegible]
abundant [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] and as
a product of [illegible] of [illegible] [illegible] [illegible] [illegible]
be most common [illegible] [illegible] near the [illegible] [illegible]
mountains. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in the
general area where [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
and thus a genetic relationship is suggested by [illegible]
occurrence of considerable [illegible] in the [illegible] [illegible]
and the presence of [illegible] [illegible] in each [illegible] [illegible] [illegible]
intruded by the [illegible] [illegible]. [illegible] [illegible] [illegible] [illegible]
[illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
wide, are [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
in the southeastern part of [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Greenhorn limestone was not found and it may be that the limestone reacted with the intruding magma, thus accounting for the subsilicious character of the rock and the presence of hornblende xenoliths.

The most common porphyry rock is quartz-bearing hornblende latite-andesite porphyry. Locally the quantity of quartz exceeds 10% and the name rhyodacite porphyry was applied (plate III-B). This is demonstrated by sample numbers OM-105 and OM-115. In sample number OM-79 no potash feldspar was detected and the name andesite was given. The sample, however, had been thoroughly hydrothermally altered, and it is presumed that whatever potash feldspar must have been present had been kaolinized or destroyed in some other way, perhaps by being altered to cryptocrystalline quartz. The porphyritic texture and over-all appearance of this rock type throughout the area mapped is for the most part remarkably uniform; locally, however, the rock is phanerocrystalline. These occurrences are restricted to "feeders" and areas that appear to be adjacent to sill or laccolith intrusive centers. Such rocks have been referred to as syenodiorite, the phanerocrystalline equivalent of latite-andesite porphyry.

These phanerocrystalline rocks are locally porphyritic with anhedral orthoclase and plagioclase phenocrysts that are poikilitic, commonly with inclusions of all other varieties of minerals found in the slide, demonstrating that the

phenocrysts were the last crystals to form. This is illustrated by sample number OM-250 which was cut from a plug- or dike-like feeder between two sills. It is proposed that the final magma entrapped in this feeder was permitted to cool slowly because of the heat liberated by the adjacent cooling sills. By reducing the rate of cooling the last material to consolidate crystallized as large poikilitic crystals. This same material under more rapid cooling conditions would crystallize as microcrystalline groundmass typical of the sill rocks.

Some of these rocks may conceivably be related to a separate intrusive phase, but on the basis of field relations and similar mineral composition, they are here considered to be related to the latite-andesite porphyry intrusives. They are believed to be in no way related to the intrusion of the main non-porphyry stock for the simple reason that the syenodiorites all contain quartz, whereas all samples taken from the stock contain nepheline. The principal compositional difference between the syenodiorites and the latite-andesite porphyries is that in the former augite is a common mafic mineral, whereas in the latter hornblende is the dominant mafic mineral. The syenodiorites are represented by sample numbers OM-18, OM-98, and OM-250.

The latite-andesite porphyries are particularly susceptible to oxidation and are invariably iron-stained on weathered surfaces.

phenocrysts were the [illegible] as found. [illegible] illus-
trated by sample number [illegible], which are [illegible]
or dike-like feeder between the [illegible] [illegible] that
the first magma emplaced in this [illegible] was able to
cool slowly because [illegible] [illegible] the [illegible]
cooling fluids by reducing the rate of cooling [illegible]
material to consolidate progressively [illegible] a large [illegible]
or itself. This same material which [illegible] cooling con-
ditions would crystallize as a [illegible] [illegible] porphyry
typical of the sill rocks.

Some of these bodies [illegible] may be related to a
separate intrusive phase, but the similar textures, [illegible]
tions and similar altered [illegible], they are con-
sidered to be part of [illegible] [illegible] [illegible]
themselves. They are [illegible] [illegible] [illegible] by the
intrusion of [illegible] [illegible] [illegible] the [illegible]
reason that the [illegible] phenocrysts [illegible] with [illegible],
all samples [illegible] [illegible] [illegible] [illegible]
principal [illegible] [illegible] [illegible] [illegible]
and the [illegible] [illegible] [illegible] in the [illegible]
augite in a [illegible] [illegible], [illegible] in the [illegible]
groundmass [illegible] [illegible] [illegible]. The [illegible]
are represented by [illegible] [illegible] [illegible] and [illegible].

The [illegible] [illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible]
[illegible] surface.

Nepheline-bearing Augite Monzonite

The non-porphyritic rocks of the northern part of the Ortiz Mountains occur as a large crosscutting stock that forms the higher peaks in the central part of the mountains. These rocks are exposed through a vertical range of 1,600 feet. They are undersaturated with respect to silica. That is to say, they not only contain no quartz but have up to 10% nepheline. Plagioclase and orthoclase occur in essentially equal proportions, although orthoclase invariably is slightly subordinate to plagioclase, which is exclusively andesine. The principal mafic mineral is augite, although minor amounts of an unidentified pyroxene were observed in most slides. Hornblende was noted, but usually occurs as uralitic rims around augite crystals (plate IV-A). These rocks are phanerocrystalline, but it is not possible megascopically to identify the feldspar crystals as either plagioclase or orthoclase. The grain size is generally less than one millimeter and the rocks are, therefore, referred to as microphaneritic.

Petrographers agree that phanerocrystalline rocks with essentially equal amounts of orthoclase and plagioclase should be called monzonites. In this monzonite, augite is the principal mafic mineral and nepheline is always present: therefore, the rock is referred to as nepheline-bearing augite monzonite.

Nepheline-bearing [illegible]

The non-[illegible] [illegible] of the Ortiz Mountains [illegible] that forms the [illegible] of the [illegible]. These rocks are exposed through a [illegible] feet. They are [illegible] [illegible]. [illegible] is to say, [illegible] and 10% nepheline. [illegible] substantially equal proportions [illegible] slightly subordinate [illegible] andesine. The [illegible], although much occurs [illegible] observed in most slides. [illegible] (figure [illegible]). Some rocks are phanerocrystalline, but it is [illegible] as either plagioclase or [illegible]. The grain size [illegible] than the [illegible], however, referred to as [illegible].

[illegible] agree that [illegible] essentially equal amounts of [illegible] should be called [illegible] the [illegible] therefore, the rocks are referred to as nepheline-bearing [illegible].

Thirteen samples of this rock type were examined under the petrographic microscope. In these samples plagioclase constitutes from 28% to 40% of the rock, but is usually 34%. Orthoclase constitutes from 24% to 38% but is usually 30% of the rock. The amount of augite ranges from 12% to 20%; nepheline ranges up to 10%. Biotite is common, and in a few slides ranges from 7% to 9%. Magnetite ranges up to 7%. Accessory minerals include apatite, zircon, and sphene. The amount of sphene in these rocks is unusually high for an accessory mineral. It ranges up to 4%. No olivine was observed.

The texture of these rocks varies from allotriomorphic to hypidiomorphic, seriate to granular. Locally a poikilitic fabric is exhibited, owing to the growth of orthoclase or nepheline around numerous small grains of the other constituents (plate IV-B).

Samples OM-257, OM-265, and OM-271 possess a texture characterized by a sub-parallel arrangement of subhedral to euhedral, tabular plagioclase crystals (plate V-A). This preferred orientation of plagioclase is regarded as a linear flow structure parallel to the direction of flow of the magma in its late stages of consolidation.

Mineral grains in the monzonite range from less than 1 mm to 3.50 mm. The color varies from light gray through bluish gray to black.

Unlike the porphyritic rocks, minerals in the nepheline-bearing augite monzonite are essentially unaltered. Feldspars

Thirteen samples of [illegible] were [illegible] the petrographic [illegible] [illegible] constitutes from [illegible] [illegible] orthoclase [illegible] [illegible] of the rock. The amount of augite [illegible] nepheline ranges [illegible] [illegible] silica ranges from [illegible] [illegible] Accessory minerals [illegible] [illegible] amount of sphene [illegible] accessory minerals. [illegible] served.

The texture of [illegible] to hypidiomorphic, [illegible] fabric is exhibited, [illegible] nepheline [illegible] ents (plates [illegible]).

Samples [illegible] characterized [illegible] to subhedral, [illegible] preferred orientation [illegible] flow structure [illegible] in [illegible] [illegible].

Mineral grains [illegible] 1 mm to 3.00 mm. [illegible] bluish gray to black.

Unlike the [illegible] bearing [illegible] are fresh instead of saussuritized, sericitized, and kaolinized. Augite, though uralitized, is not altered to chlorite, actinolite, epidote or the clay-like material as are the mafic minerals in the porphyries. However, this rock demonstrates a very peculiar weathering phenomenon. Large weathered blocks and boulders that occur in the gravels along stream beds radially away from the stock are distinctly spotted (plate V-B). These spots are dark bluish gray and range in size from half an inch to one inch in diameter and are not basic segregates. The intervals between the spots consist of whitish, chalky-appearing weathered feldspar (plagioclase?). A slice of spotted rock was subjected to the stain test and a thin-section was prepared from some of these spots. This investigation disclosed that they represent roughly spherical, finer grained segregations in which unaltered orthoclase and nepheline are particularly abundant.

Locally the nepheline-bearing augite monzonite contains basic segregations that generally are three to four inches in diameter (plate V-C). They consist of aggregates of medium-grained, oriented or parallel prismatic to feather-like anhedral crystals of augite and subordinate fine-grained feldspars (plate VI-A). They are particularly rich in the accessory minerals apatite and sphene. Sample number OM-124 is an example.

The augite monzonite stock is believed to have attained its present position by a combination of magmatic stoping

are fresh [illegible] ([illegible]) [illegible]-
ized. Augite, though [illegible], is [illegible]
orthoclase, [illegible]
[illegible]
stained a very [illegible]
ered blocks and [illegible]
stream [illegible]
(Plate V-[illegible]). [illegible]
size from [illegible]
basic segregation. [illegible]
of [illegible]
A slice of [illegible]
a thin-section [illegible]
investigation [illegible]
finer grained [illegible]
magnetite are [illegible] abundant.

Locally [illegible]
basic segregations [illegible]
in diorite (Plate [illegible]). [illegible]
[illegible]
like [illegible]
feldspars [illegible]
accessory [illegible]
in an [illegible].

The augite [illegible]
its [illegible]

and subordinate arching of the overlying beds. Along the north side of the stock the alternating sills and sedimentary beds have not been structurally deformed at the stock contact, which suggests that the magma punctured and assimilated these rocks. The process of stoping is further demonstrated by sample number OM-272, which was cut from an irregular contact of typical nepheline-bearing augite monzonite and a large granoblastic and porphyroblastic hornfels xenolith. This xenolith is several yards long and several feet thick and is completely engulfed by the monzonite deep in the central part of the stock. Although obscure, the attitude of the bedding in this xenolith appears to be horizontal. If this hornfels represented an unaltered remnant of a process of granitization one would expect the attitude of the xenolith to be the same as the regional dip. Since it is not, this hornfels mass is regarded as a stoped mass.

Arching of the overlying beds is demonstrated along the northeast part of the stock where the Mesaverde beds are arched over the stock (figure 1).

The problem of the origin of alkaline rocks has been discussed by numerous authors. Daly (1914) proposed that alkaline rocks in general represent differentiates from subalkaline magmas that have absorbed limestone. The presence of such feldpathoids as nepheline is regarded as a result of desilication of the magma by the limestone and the removal of lime silicates by a process of differentiation. The and substances brought [illegible] north side of the [illegible] beds [illegible] which suggests [illegible] zones. The [illegible] sample number [illegible] of typical normal [illegible] graphic [illegible] monolith is [illegible] completely [illegible] part of the [illegible] ding in this [illegible] normals [illegible] granitization [illegible] to be [illegible] normals [illegible].

Grading of the [illegible] northwest part of the [illegible] arched over the [illegible] (Figure [illegible]).

The [illegible] of the origin of [illegible] discussed by numerous [illegible] alkaline rocks [illegible] alkaline magmas [illegible]. [illegible] of such [illegible] or [illegible] al [illegible].

presence of limestones in the stratigraphic section intruded by alkaline rocks is regarded by some workers as strongly suggestive that such rocks may have originated in that manner. The magma from which the nepheline-bearing augite monzonite of the Ortiz Mountains was derived was required to pass through a thick series of Paleozoic limestones in rising toward the surface. These limestones may have been a contributing factor in the formation of this rock type. However, numerous areas have been cited as examples where alkaline rocks are found but where limestones are absent. In addition, Bowen (1915) cited the Halibuton-Bancroft area of Ontario as an example of an area where an alkaline rock, in this case nepheline syenite, has intruded limestone with no apparent absorption of the limestone by the magma. Evidence of desilication is also lacking because huge volumes of the magma in the same area has crystallized as granite.

As an alternate hypothesis regarding the origin of alkaline rocks, he concludes that most, if not all, intermediate and sialic rocks have probably been derived from basaltic magma by some process of differentiation. He proposed (1928) that at a certain point in the granite stage of a differentiating magma in the presence of water (volatiles) there is a tendency for the feldspars to break down into micas, accompanied by the release of silica. If these micas and quartz sink out of the magma the amount of $NaAlSiO_4$ will eventually reach such a concentration that

presence of large opening [illegible] [illegible] [illegible] [illegible]
by alkaline rocks [illegible] [illegible] [illegible] [illegible] suggest [illegible] [illegible]
suggestive that such [illegible] [illegible] [illegible] [illegible] in a [illegible] man-
ner. The major movement of the [illegible] region
monzonite of the [illegible] structure [illegible] [illegible] [illegible] [illegible]
to pass through a [illegible] [illegible] of [illegible] [illegible]
rising toward the surface. [illegible] [illegible] [illegible] [illegible]
a contributing factor in the [illegible] [illegible] [illegible] [illegible].
However, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
alkaline rocks are found [illegible] [illegible] [illegible] [illegible]
In addition, [illegible] (1915) [illegible] [illegible] [illegible] area
of Ontario as an example of [illegible] [illegible] [illegible] [illegible].
In this case [illegible] [illegible] [illegible] [illegible] [illegible]
no apparent [illegible] of [illegible] [illegible] [illegible]. [illegible]
cance of [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
of the magma in the same area [illegible] [illegible] [illegible].

An alternate hypothesis [illegible] [illegible] [illegible] of
alkaline rocks [illegible] [illegible] [illegible], if [illegible] [illegible]
mediate and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]
basaltic magma by [illegible] [illegible] [illegible] differentiation. [illegible]
posal (1928) that [illegible] [illegible] [illegible] [illegible] as a [illegible]
of a differentiation [illegible] [illegible] the presence of [illegible] [illegible]
tions, [illegible] in a tendency [illegible] the [illegible] [illegible] [illegible]
into micas, [illegible] [illegible] [illegible] [illegible]. [illegible]
micas and quartz [illegible] [illegible] [illegible] [illegible]
[illegible], [illegible] [illegible] [illegible] [illegible] [illegible]

nepheline will begin to crystallize.

The investigation of the alkaline rocks of the Ortiz Mountains provided no new evidence that might aid in the solution of this interesting problem. However, the author believes that the presence of limestones in the section is not sufficient by itself to explain the alkaline character of the rocks. If it were, one would expect the porphyry rocks of the area which were also required to pass through the same limestone to be alkaline too and such is obviously not the case. However, the alkaline rocks were the last to be intruded, and they may, therefore, have had sufficient time to differentiate in the magma chamber before they were intruded.

The rarity of alkaline rocks in general suggests that a combination of contributing factors is required to explain their origin. Two such factors may well be those proposed by Daly and Bowen.

METAMORPHISM

Intrusion of the igneous rocks into the sedimentary rocks was accompanied by widespread metamorphism. Sandstones have been changed to dense, hard, erosion-resistant quartzites; shales have been altered to hornfels, and the Greenhorn limestone was observed in the extreme northwest part of the area to be recrystallized and to contain abundant epidote. Incrustations of epidote on bedding planes and

fracture surfaces are common throughout the entire area.

Within an ill-defined aureole around the non-porphyry stock the latite-andesite porphyries are hydrothermally altered. Plagioclase and the groundmass material are deeply kaolinized. Plagioclase is saussuritized and sericitized. Iron appears to have been abstracted from the mafic minerals and redeposited along fractures as hematite and limonite. Mafic minerals are commonly altered to chlorite, epidote, tremolite, and a dirty clay-like material.

TERTIARY HISTORY

In order to understand the late geologic history of the northern part of the Ortiz Mountains it is necessary to have some idea of the sequence of events that took place in the north-central New Mexico region as a whole. These events as reported here are largely a condensation or summary of the interpretations of Stearns (1943, 1953) enlarged upon by the results of the current study.

The final withdrawal of the transgressive-regressive seas in which the Upper Cretaceous Mancos shales and Mesaverde formation were deposited was followed by regional deformation and a period of erosion that continued until late Eocene time. That this early Tertiary erosion was intense is verified by the fact that in the Galisteo Basin, that area north of the Cerrillos Hills between Glorieta Mesa and the Jemez Mountains, the Mesaverde formation was fracture surfaces, with [illegible], and [illegible].

Within an [illegible] zone the [illegible] stock the [illegible] [illegible] [illegible] [illegible]tered. [illegible] kaolinized. Plagioclase is [illegible] and [illegible]. Iron appears to have been [illegible] from the [illegible] and redeposited along fractures as [illegible] and limonite. The mafic minerals are [illegible] tremolite, and a [illegible] clay-like material.

[illegible]

In order to understand the [illegible] of the northern part of the Cella [illegible] it is necessary to have some idea of the sequence of events that took place in the north-central [illegible]. [illegible] reported here are largely [illegible] interpretations of [illegible] results of [illegible].

The [illegible] area in which the [illegible] Formation were deposited and followed by [illegible] and a period of [illegible] late [illegible] time. [illegible] entirely removed by erosion and subsequent beds were deposited directly on the Mancos shale. It is postulated that at least 2,000 feet of Upper Cretaceous rocks were removed by erosion in this area. Upon this erosion surface the Galisteo formation was deposited in late Eocene time. North of Hagan and Madrid and about five miles east of the area mapped the Galisteo formation rests directly on the Mesaverde coal beds and at Hagan and Madrid it is separated from the coal beds by a few hundred feet of Mesaverde shales (Stearns, 1943).

The detrital quartz in the Galisteo formation was primarily derived from the underlying Mesaverde formation. However, Stearns (1943) points out that the occurrence of chert pebbles and fragments of Precambrian crystalline rocks, coupled with a marked thinning of the Galisteo formation towards the northwest, suggests that the Paleozoic and Precambrian rocks of the Nacimiento Mountains that were uplifted in Eocene (Wasatch) time, contributed sediments to the Galisteo depositional basin. In the area east of Cerrillos large pebbles of limestone, granite, gneiss and schist are common in the upper part of the Galisteo formation. The only possible source of such sediments was the early Paleozoic and Precambrian rocks of the southern part of the Sangre de Cristo Mountains, and Stearns (1943) suggests, therefore, that they were highlands in late Galisteo time.

entirely removed [illegible] rests [illegible]-
ed directly on [illegible] at
least 2,000 feet of [illegible] overlying [illegible]
erosion in this [illegible] and the [illegible]
formation was deposited [illegible]
and Madrid [illegible] east of [illegible] the upper [illegible]
Galisteo formation [illegible]
and at Hagan and [illegible]
by a few hundred feet of [illegible] (1950).
The boulders [illegible] were pre-
sumably derived from the [illegible]
However, Stearns (1943) [illegible] the abundance of
chert pebbles and fragments of [illegible]
coupled with a marked [illegible]
towards the northeast, suggests that [illegible] and Pre-
cambrian rocks [illegible] were up-
lifted in [illegible]
the Galisteo [illegible]
rillas Large boulders of [illegible]
schist are common in the upper part of the Galisteo forma-
tion. This only [illegible]
early [illegible] of the [illegible]
of the Sangre de Cristo Mountains, [illegible]
gests, therefore, that [illegible]
time.

A period of late Eocene volcanism is recorded by the fact that conformably overlying the Galisteo formation are the water-deposited Espinaso volcanics. Locally, the upper part of the Galisteo formation contains small, rounded and rotten pebbles of porphyry and grades transitionally into a fine-grained, water-laid tuff, which is considered the base of the Espinaso volcanics. The distinct contrast in lithology between the Galisteo formation and the Espinaso volcanics is indicative that the extrusive centers were located within the boundaries of the Galisteo basin of deposition (Stearns, 1953c).

Stearns (1943, 1953a, 1953c) proposed that the Espinaso volcanics were "deposited by mud flows and streams radiating from centers of contemporaneous eruption in the Ortiz Mountains and Cerrillos Hill." The large intrusive mass of volcanic breccia in Cunningham Gulch is considered to be such a center.

Stearns (1953c) demonstrated that peripheral laccoliths, sills and dikes of "hornblende quartz latite porphyry," which is petrographically similar to the quartz-bearing hornblende latite-andesite porphyry of this report, are "identical to extrusive rocks of the Espinaso volcanics," but the intrusives are "younger than (the) adjacent (Espinaso) volcanic rocks." He had earlier reported that "dikes and sills of rock types similar to the (Ortiz) intrusives occur in the Galisteo formation and Espinaso volcanics through

the area mapped (Galisteo-Tonque area)" (Stearns, 1943). He further concluded, with reference to the intrusive rocks, that "continuity with late Espinaso vents in space and in time may be inferred" (Stearns, 1953c). Therefore, one would conclude that deposition of the late Eocene Galisteo formation was terminated by deposition of water-laid volcanics derived from vents whose initial extrusive phases were followed by intrusions of porphyry laccoliths and sills in the Ortiz Mountains, as well as in the Cerrillos Hills.

It has been demonstrated by Disbrow (1953) and Stearns (1953c) that intrusion of the laccoliths, stocks, sills, and dikes in the Cerrillos Hills was followed by the intrusion of crosscutting monzonite and syenodiorite stocks. A similar development took place in the Ortiz Mountains. The intrusion of the nepheline-bearing augite monzonite stock is here regarded as the final stage of the igneous activity in the northern part of the Ortiz Mountains for the following reasons:

1. the sill rocks are quartz-bearing and the stock rocks are nepheline-bearing; therefore, they are not likely to have been derived from the same immediate magma;
2. the geologic map (figure 1) demonstrates that the stock cut across the sedimentary rocks and sills that surround it and, therefore, succeeded them;

the same support (Bailey [illegible]) [illegible]
He further concluded, with reference to the [illegible],
that "recrystallization [illegible]
time may be inferred (Grubenmann [illegible]) [illegible]
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tion was [illegible]
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only [illegible], as [illegible] the [illegible].

It has been [illegible] by [illegible]
(1936) that [illegible]
dikes in the [illegible]
of [illegible]
development [illegible]
of the [illegible]
garded as the [illegible] of the [illegible]
northern part of [illegible]
zone.

1. [illegible]
There are [illegible]
not likely to [illegible]
earlier [illegible]
2. The [illegible]
[illegible]
[illegible]

3. that the sill rocks are hydrothermally altered within an aureole surrounding the stock further shows that the sills preceded the stock;
4. the nepheline-bearing augite monzonite is chilled along its contact with the vent rock, and the monzonite contains xenoliths of the vent rock, therefore, the vent rock must have preceded the monzonite (plate I-B).

With the advent of igneous activity, the Ortiz Mountains became a highland area and has remained one ever since. No Oligocene sediments are found anywhere in this region and it is concluded, therefore, that the area as a whole was uplifted and subjected to erosion during this period. The region was also subjected to faulting and folding for the Tijeras fault system, the Sandia Mountains, and several minor folds in the Hagan area were established (Stearns, 1953a).

In Miocene time the area between Madrid and Santa Fe, as well as the Hagan area, was depressed and received sediments derived from erosion of the Galisteo and Espinaso formations from adjoining highlands, one of which was the Ortiz Mountains area. The sediments, the Abiquiu (?) formation, are of fine-grained detritus, implying that the source areas had low relief (Stearns, 1953a). In late Miocene time the Rio Grande depression began to form and into this basin

3. [illegible]

4. The Oligocene-Miocene(?) [illegible] along [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible]

With the [illegible] being [illegible] to Oligocene sediments [illegible] It is concluded, [illegible] -tilted and subjected [illegible] region was also subjected to faulting and [illegible] Tijeras fault [illegible] Mountain [illegible] minor folds in the [illegible] (1956a).

In Eocene time the [illegible] as well as the [illegible] ments derived from [illegible] formations from adjoining [illegible] Ortiz Mountains area. [illegible] tion, [illegible] areas had [illegible] the Santa Fe (Tesuque) formation was deposited. These sediments were derived almost entirely from Precambrian and Pennsylvanian rocks of the Sangre de Cristo Mountains (Baldwin, 1956).

In late Pliocene or early Pleistocene time the Ortiz Mountains were elevated and, having been stripped of the overlying Galisteo and Espinaso formations, began contributing coarse sediments, the Tuerto Gravels, derived from the metamorphosed Mesozoic sedimentary rocks and the early Tertiary intrusive rocks (Stearns, 1953a; Baldwin, 1956). The uplifting of the mountains was accomplished by normal faulting along the western border of the mountains, the Rosario or La Bajada and Barro faults (Stearns, 1953a).

This faulting accompanied slight regional deformation and the Tuerto Gravels rest unconformably on the underlying Santa Fe (Tesuque) formation. This unconformable surface is the "lower Ortiz surface." Deposition of the Tuerto Gravels through early Pleistocene time was temporarily interrupted at least once by a slight period of erosion during which time basalt flows along the Rio Grande north of the Ortiz Mountains were extruded. This unconformity has been called the "upper Ortiz surface" (Baldwin, 1956).

The Tertiary geologic history is summarized in Table II, modified after Stearns (1953a) and Baldwin (1956).

In conclusion, field evidence demonstrates that the porphyry sills and laccoliths resulted from forcible intrusion

the sands to (Thurmond, [illegible] Mississippian). These sedi-
ments were derived [illegible] the [illegible] the
Pennsylvanian rocks of the [illegible] (Bal-
win, 1956).

In late Paleozoic or early [illegible] the [illegible]
Mountains were elevated and [illegible]
overlying [illegible] coarse
coarse sediments, [illegible] meta-
morphosed [illegible] early [illegible]
intrusive rocks [illegible] 1956; [illegible]
lifting of the [illegible] and [illegible] fault-
ing along the western [illegible] of the [illegible] the [illegible]
or [illegible] (Baltz, 1965).

[illegible]
and the [illegible] the [illegible]
sands in [illegible]
in the "[illegible]" [illegible]
gravels through early [illegible]
rupted at [illegible] period of [illegible]
which time [illegible] the [illegible]
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called the [illegible]

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TABLE II. Summary of Tertiary history of the Ortiz Mountains and surrounding areas (modified after Stearns, 1953a).

TIME	SEDIMENTATION	DEFORMATION OR IGNEOUS ACTIVITY
Early Pleistocene	Tuerto Gravels erosion--	Basalt flows (upper Ortiz surface)
	erosion--	Rosario or La Bajada and Barro faults (lower Ortiz surface)
Pliocene	Santa Fe (Tesuque) formation	Subsidence of Rio Grande depression
Miocene	Abiquiu (?) formation	Subsidence of Abiquiu basin of deposition
Oligocene	Erosion	Tijeras fault system
Eocene	Espinaso volcanics	Intrusion of augite monzonite in Ortiz Mountains Intrusion of latite-andesite porphyry in Ortiz Mountains Intrusive trachyte-latite vent rock in Ortiz Mountains
	Galisteo formation	Subsidence of intermontane Galisteo sedimentary basin
	Erosion over Ortiz Mountains and adjacent areas	Regional uplift
Paleocene		
Cretaceous	Mesaverde formation	

of the magmas between the sedimentary layers. The non-porphyry stock, on the other hand, attained its position by a combination of forcible intrusion and stoping of the country rock. For this reason and because the intrusions are known to have taken place at shallow depth and are associated with volcanism, the author dismisses granitization as a possible process of formation of the stock rocks.

As previously noted the igneous rocks of South Mountain, San Pedro Mountains, the Ortiz Mountains, and the Cerrillos Hills are similar in form and composition; and are of the same age (Ogilvie, 1908; Lindgren et al., 1910; and Stearns, 1953c). Kelley's (1955) suggestion that the occurrence of these intrusives is controlled by the intersection of northwesterly Colorado Plateau tectonic trends and the northward trending tectonics of the Rockies province is supported by the similarity in composition and texture of these rocks and those of the La Plata Mountains of the Colorado Plateau. Eckel (1949) has shown that the La Plata Mountains consist of late Cretaceous or Tertiary porphyry laccoliths, sills, and dikes and younger non-porphyry stocks that intrude Paleozoic and Mesozoic sedimentary rocks. The porphyry rocks are intermediate between diorite porphyry and monzonite porphyry and consist of plagioclase, usually labradorite, and dark green to black hornblende phenocrysts in a dense groundmass. Orthoclase is largely confined to the groundmass which is a granular mixture of orthoclase,

of the rocks between the [illegible]
porphyry [illegible]
by a [illegible]
country rock. [illegible]
are known to have [illegible]
ciated with [illegible]
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tain, [illegible]
Cerrillos Hills [illegible]
are of the same [illegible]
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occurrence of [illegible]
ation of [illegible]
and the [illegible]
is supported by the similarity in [illegible]
of these rocks [illegible]
Colorado Plateau. [illegible]
mountain [illegible]
laccoliths, [illegible]
Thus [illegible]
porphyry rocks [illegible]
moderate [illegible]
laccoliths, [illegible]
in a [illegible]
the [illegible]

quartz and accessory minerals. The similarity between these porphyries and those of the Ortiz Mountains is striking.

The non-porphyry stock rocks of the La Plata Mountains are also younger than the porphyries and are monzonite, syenite, and diorite.

However, Kelley (1955) has also shown that pebbles of rock types similar to those found in the La Plata Mountains have been found in beds of Montanan age in the San Juan Basin. Therefore, the La Plata intrusives may be at least as old as the late Cretaceous. It has been demonstrated that the Ortiz Mountains intrusives are no older than late Eocene. Thus, the regional tectonic controls were not only in effect in mid-Laramide time when the La Plata Mountains were formed, but remained effective until late Laramide time when the Ortiz and adjacent intrusions took place.

The Rio Grande depression contains numerous and extensive basalt flows of late Tertiary and Quaternary age. One might speculate that the magmas from which the intermediate-type rocks of the Ortiz Mountains and adjoining areas were derived represented an early magmatic differentiate of a basaltic magma that later gave rise to these flows.

quartz and accessory minerals. [illegible]

porphyries and [illegible]

The [illegible]-porphyry [illegible]

are also younger than [illegible]

syenite, and [illegible].

However, [illegible]

rock types similar to those found in [illegible]

have been found [illegible]

Basin. Therefore, [illegible]

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Eocene. [illegible]

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sive [illegible]

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basaltic [illegible]

APPENDIX

The following pages contain petrographic analyses of 35 igneous rocks from the northern part of the Ortiz Mountains. The locations from which the samples were taken are plotted on the accompanying geologic map (figure 1). The first 22 samples were taken from sills, laccoliths and feeders that were collectively mapped as latite-andesite porphyry. The next 13 samples were taken from the non-porphyry stock. As previously noted estimates of potash feldspar were based on stain tests. Where optically ascertainable the potash feldspar was exclusively orthoclase; therefore, all potash feldspar detected by staining was assumed also to be orthoclase. Determination of the type of plagioclase was based on the Michel-Levy method of maximum extinction angle of albite twins as described by Rogers and Kerr (1942).

Examination of a stained surface of porphyritic rock under a binocular microscope disclosed that the staining of the groundmass was not uniform. Although the surface was generally yellow it was observed to be pitted or "pock-marked" with extremely fine, white unstained areas. These were assumed to be microscopic grains of plagioclase and/or quartz.

In these analyses (tr) is meant to imply that the mineral occurs in amounts of less than 1%. In referring to grain size the following scale is used:

Small - - - - less than 1 mm

Medium - - - - 1 mm to 5 mm

Large - - - - over 5 mm

Following the petrographic analyses are photographs of the area and photomicrographs of the principal rock types.

Petrographic Analyses

Sample No. OM-18

Rock name: quartz-bearing augite syenodiorite

Mode of occurrence: laccolith (?)

Microscopic description: hypidiomorphic-granular, grains range in size from .05 x .35 mm to 1.6 x 1.7 mm.

Minerals	Per Cent
Plagioclase (Ab_{72})	47
Orthoclase	27
Augite	15
Magnetite	5
Quartz	4
Sphene	1
Apatite	tr
Zircon	tr
Biotite	tr

Remarks: Feldspars are partly kaolinized and sericitized. Some plagioclase crystals are zoned and many are twinned according to the albite law. Augite is slightly uralitized. Orthoclase is poikilitic with inclusions of plagioclase, augite, magnetite, biotite, sphene and quartz. Orthoclase was thus the last mineral to crystallize. Megascopically, the rock is microphaneritic, fine-grained, very light gray and locally porphyritic.

Sample No. OM-20

Rock name: quartz-bearing augite andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with predominantly euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .10 x .10 mm to 1.30 x 2.30 mm. Groundmass constituents about .01 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{62})	40
Augite	20
Quartz	1
Apatite	tr
Ilmenite	tr
Microcrystalline groundmass	38

Remarks: Plagioclase is partly kaolinized and sericitized. A few plagioclase phenocrysts are zoned and many are twinned according to the albite law. Augite is deeply altered to a dirty clay-like material, carbonate, actinolite and chlorite. Ilmenite displays alteration rims of leucoxene. Two stain tests gave negative results for orthoclase in the microcrystalline material. Megascopically, the rock is aphanophyric, very light-gray but commonly weathers reddish orange due to efflorescence of hematite and/or limonite on the weathered surface.

Sample No. OM-21

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with subhedral to euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .10 x .20 mm to 1.50 x 3.25 mm. Groundmass constituents approximately .01 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{62})	55
Hornblende	22
Quartz	2
Carbonate	2
Apatite	tr
Microcrystalline groundmass	18

Remarks: Plagioclase is partly sericitized, kaolinized and saussuritized. Groundmass is partly kaolinized. A few plagioclase phenocrysts are zoned and many are twinned according to the albite and carlsbad laws. Some hornblende crystals are twinned and many are resorbed and are altered to chlorite. A stain test suggests that perhaps as much as 60-70% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with small, greenish black hornblende phenocrysts and small white, purplish white feldspar phenocrysts set in a light blue-gray groundmass.

Sample No. OM-22

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with some euhedral, but mostly subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .55 x 1.60 to 1.75 x 2.25 mm. Groundmass constituents .01 x .01 mm to .02 x .02 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{57})	42
Hornblende	20
Epidote	4
Magnetite	2
Quartz	1
Actinolite	tr
Allanite (?)	tr
Apatite	tr
Microcrystalline groundmass	30

Remarks: Plagioclase phenocrysts are partly sericitized and kaolinized. A few plagioclase phenocrysts are zoned and many are twinned according to both the carlsbad and albite laws. Groundmass slightly kaolinized; hornblende crystals partly resorbed and altered to chlorite and epidote. A stain test suggests that perhaps as much as 60-70% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with medium, white feldspar phenocrysts and small, greenish black hornblende phenocrysts set in a light bluish gray groundmass.

Sample No. [illegible]

Rock name: [illegible] porphyry

Mode of occurrence: sill

Microscopic description: [illegible], but mostly subhedral plagioclase [illegible] like micrographic intergrowths. [illegible] size from .[illegible] to [illegible] mm. [illegible] stituents .[illegible] to .[illegible] mm [illegible].

Minerals	Percent
Plagioclase (An[illegible])	[illegible]
Hornblende	[illegible]
Apatite	[illegible]
Magnetite	[illegible]
Quartz	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Micrographic intergrowths	[illegible]

Remarks: Plagioclase phenocrysts are partly replaced [illegible] and zoisite. [illegible] and [illegible] crystals [illegible] partly replaced [illegible] 70% of the [illegible] rock is [illegible] crysts and [illegible] set in a [illegible].

Sample No. OM-26

Rock name: quartz-bearing latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .08 x .36 mm to .42 x .72 mm. Groundmass constituents are approximately .01 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{51})	34
Chlorite (var. penninite)	18
Carbonate	10
Quartz	4
Magnetite	3
Hematite	tr
Ilmenite	tr
Apatite	tr
Epidote	tr
Allanite (?)	tr
Microcrystalline groundmass	29

Remarks: Plagioclase phenocrysts are partly sericitized and slightly kaolinized. The groundmass is slightly kaolinized. Some plagioclase phenocrysts are zoned and many are twinned according to the carlsbad and albite laws. Chlorite is altered from original hornblende. Ilmenite displays alteration rims of leucoxene. A stain test suggests that 50-60% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with white to pinkish white, small feldspar phenocrysts and dark green small mafic phenocrysts in a blue-gray aphanitic groundmass.

Sample No. OM-27

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with some euhedral, but mostly subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .80 x .82 mm to 1.50 x 2.25 mm. Groundmass constituents are approximately .02 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{51})	43
Hornblende	22
Carbonate	2
Epidote	1
Ilmenite	1
Hematite	tr
Quartz	tr
Apatite	tr
Microcrystalline groundmass	30

Remarks: Plagioclase phenocrysts are partly saussuritized, sericitized, and kaolinized. Some plagioclase phenocrysts are zoned and many are twinned according to the albite law. Some hornblende crystals are partly resorbed and considerably altered to chlorite: some are being replaced by epidote. Ilmenite displays alteration rims of leucoxene. A stain test suggests that 40-50% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with white and pinkish white, small feldspar phenocrysts and greenish black hornblende phenocrysts in a bluish gray aphanitic groundmass.

Sample No. OM-79

Rock name: andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with subhedral phenocrysts in a salt-and-pepper-like microcrystalling groundmass. Phenocrysts range in size from .30 x .48 mm to .45 x 1.25 mm. Groundmass constituents are about .01 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{67})	39
Augite	20
Tremolite	tr
Apatite	tr
Leucoxene	tr
Microcrystalline groundmass	40

Remarks: Plagioclase phenocrysts are deeply kaolinized and sericitized. Groundmass is partly kaolinized. Augite is largely resorbed and thoroughly altered to a dirty clay-like material. A stain test suggests that 10-20% of the groundmass is orthoclase. Megascopically, the rock is aphanitic. It is grayish white and apparently is thoroughly hydrothermally altered.

Sample No. OM-98

Rock name: quartz-bearing augite syenodiorite

Mode of occurrence: laccolith (?)

Microscopic description: allotriomorphic-granular. Grains range in size from .02 x .07 mm to 1.00 x 2.00 mm.

Minerals	Per Cent
Plagioclase (Ab_{68})	43
Orthoclase	27
Augite	18
Magnetite	5
Quartz	3
Sphene	3
Biotite	tr
Actinolite	tr
Hematite	tr
Apatite	tr

Remarks: Feldspars are partly kaolinized and sericitized. All plagioclase crystals are zoned and many are twinned according to both the carlsbad and albite laws. Some augite crystals are partly resorbed, some are twinned and many are partly altered to chlorite. Megascopically, the rock is fine-grained and medium gray.

Sample No. CN-20

Rock name: quartz-bearing augite diorite

Mode of occurrence: Intrusion

Microscopic description: Hypidiomorphic-granular, grains range in size from [illegible] mm to [illegible] mm.

Minerals	Per cent
Plagioclase (An[illegible])	[illegible]
Orthoclase	[illegible]
Augite	[illegible]
Magnetite	[illegible]
Quartz	[illegible]
Sphene	[illegible]
Biotite	[illegible]
Actinolite	[illegible]
Zeolite	[illegible]
Apatite	[illegible]

Remarks: [illegible] All plagioclase crystals are zoned; many are [illegible] according to [illegible] [illegible] [illegible]. The augite crystals are [illegible] and many are partly altered to [illegible]. The rock is [illegible]-grained and [illegible].

Sample No. OM-91

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with some euhedral, but mostly subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .80 x .80 mm to .60 x 2.30 mm. Groundmass constituents are about .01 x .03 mm.

Minerals	Per Cent
Plagioclase (Ab_{61})	34
Hornblende	16
Carbonate	3
Magnetite	1
Hematite	tr
Quartz	tr
Epidote	tr
Microcrystalline groundmass	45

Remarks: Plagioclase phenocrysts are deeply kaolinized and saussuritized. Some are completely kaolinized and saussuritized. Groundmass is partly kaolinized. Hornblende crystals are partly resorbed and some are quite thoroughly altered to chlorite, epidote, and a dirty clay-like substance. Carbonate is twinned and is poikilitic with inclusions of euhedral quartz. Some plagioclase is zoned and twinned according to both the carlsbad and albite laws. A stain test suggests that 50-60% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with white and pinkish white, small feldspar phenocrysts and greenish black, small phenocrysts of hornblende in a bluish gray aphanitic groundmass.

Sample No. OM-105

Rock name: hornblende rhyodacite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .21 x .54 mm to 1.50 x 4.00 mm. Groundmass constituents are about .01 mm in diameter (plate III-B).

Minerals	Per Cent
Plagioclase (Ab_{72})	40
Quartz	17
Hornblende	8
Apatite	1
Ilmenite	tr
Hematite	tr
Pyrite	tr
Allanite (?)	tr
Zircon	tr
Epidote	tr
Microcrystalline groundmass	32

Remarks: Plagioclase phenocrysts are very slightly kaolinized and sericitized. Groundmass is partly kaolinized. Hornblende is partly resorbed and altered to a dirty clay-like material. Some hornblende crystals are partly altered to chlorite (plate III-B). Ilmenite displays alteration rims of leucoxene. A stain test suggests that perhaps as much as 60-70% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with grayish white feldspar phenocrysts in a light bluish gray aphanitic groundmass. It weathers reddish brown, owing to efflorescence of hematite and/or limonite on the weathered surface.

Sample No. OM-106

Rock name: quartz-bearing latite-andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with subhedral to euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .25 x .35 mm to 2.50 x 3.50 mm. Groundmass constituents are about .04 x .05 mm.

Minerals	Per Cent
Plagioclase (Ab_{72})	50
Actinolite	6
Quartz	3
Hornblende	2
Biotite	2
Apatite	1
Magnetite	1
Hematite	tr
Sphene	tr
Epidote	tr
Microcrystalline groundmass	33

Remarks: Plagioclase phenocrysts are partly kaolinized, sericitized and saussuritized. Groundmass is slightly kaolinized. Biotite and hornblende are partly resorbed. Some hornblende is partly altered to tremolite. A stain test suggests that only 30-40% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with grayish white medium feldspar phenocrysts in a bluish gray aphanitic groundmass.

Sample No. OM-107

Rock name: quartz-bearing latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with anhedral to euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .25 x .60 mm to 2.00 x 3.50 mm. Groundmass constituents are about .04 mm in diameter (plate II-B).

Minerals	Per Cent
Plagioclase (Ab_{72})	44
Hornblende	6
Quartz	4
Magnetite	tr
Hematite	tr
Apatite	tr
Pyrite	tr
Biotite	tr
Microcrystalline groundmass	45

Remarks: Plagioclase phenocrysts and groundmass are partly kaolinized. Two plagioclase phenocrysts display cross-like intergrowth (plate II-B). The rest are twinned according to the carlsbad and albite twin laws. Hornblende phenocrysts are almost completely altered to chlorite and a dirty clay-like substance, but the amphibole cross-sections are preserved. A stain test suggests that at least 40-50% of the groundmass is orthoclase. Megascopically, the rock is aphanitic. It is chalky white and weathered surfaces are reddish brown owing to an efflorescence of hematite and/or limonite on the weathered surface.

Sample No. OM-109

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with anhedral to subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .09 x .90 mm to 1.75 x 2.50 mm. Groundmass constituents are about .02 mm. in diameter.

Minerals	Per Cent
Plagioclase (Ab_{57})	40
Hornblende	23
Quartz	tr
Tremolite	tr
Ilmenite	tr
Hematite	tr
Microcrystalline groundmass	35

Remarks: Plagioclase phenocrysts are partly kaolinized and sericitized. Groundmass is partly kaolinized. Some hornblende crystals are partly resorbed and some are partly altered to chlorite and a dirty clay-like material. Ilmenite displays alteration rims of leucoxene. A stain test suggests that perhaps as much as 50-60% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with small to medium pinkish white feldspar phenocrysts and small greenish black hornblende crystals in a bluish gray aphanitic groundmass.

Sample No. OM-113

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with subhedral to euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .40 x .60 mm to 1.60 x 2.25 mm. Groundmass constituents are about .04 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{59})	32
Hornblende	16
Epidote	6
Quartz	5
Actinolite	3
Sphene	2
Apatite	tr
Magnetite	tr
Zircon	tr
Microcrystalline groundmass	34

Remarks: Plagioclase phenocrysts are kaolinized, sericitized and saussuritized. In a few plagioclase phenocrysts the cores of zoned crystals are almost completely saussuritized and the outer zones are essentially unaltered. Groundmass is kaolinized. Some plagioclase phenocrysts are zoned and many are twinned according to the albite law. A few hornblende crystals are slightly resorbed, a few are twinned, and some are altered to epidote and actinolite. A stain test suggests that perhaps as much as 30-40% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with small, whitish pink feldspar phenocrysts and

greenish black, small needle-like hornblende crystals in a medium gray aphanitic groundmass.

Sample No. OM-115

Rock name: hornblende rhyodacite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with anhedral to subhedral phenocrysts in a salt-and-pepper-like groundmass. Phenocrysts range in size from .30 x .70 mm to .55 x 4.95 mm. Groundmass constituents are about .01 x .02 mm.

Minerals	Per Cent
Plagioclase (Ab_{57})	48
Hornblende	12
Quartz	12
Actinolite	6
Biotite	tr
Epidote	tr
Magnetite	tr
Hematite	tr
Sphene	tr
Zircon	tr
Microcrystalline groundmass	20

Remarks: Plagioclase phenocrysts are deeply kaolinized, saussuritized and sericitized. The groundmass is deeply kaolinized. The thin-section is thoroughly stained with limonite. Epidote has almost completely replaced some plagioclase crystals. A few plagioclase crystals are zoned and some are twinned according to both the carlsbad and albite laws. A few hornblende crystals are slightly resorbed; some have altered to actinolite. A stain test suggests that as much as 60-70% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with whitish pink, small feldspar phenocrysts and small to medium hornblende crystals in a brownish gray aphanitic groundmass. Outcrops are yellowish brown as a result of thorough limonite staining.

A stain test suggests that perhaps as much as 65-75% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric and consists essentially of pinkish white small feldspar phenocrysts and greenish black, small hornblende crystals in a subordinate aphanitic brownish gray groundmass.

Sample No. [illegible]-115

A [illegible] [illegible] [illegible] [illegible] [illegible]
the groundmass [illegible] [illegible] [illegible] [illegible]
is [illegible] [illegible] [illegible] [illegible] [illegible]
small [illegible] [illegible] [illegible] [illegible] [illegible]
blocky crystals [illegible] [illegible] [illegible] [illegible]
groundmass.

Sample No. OM-120

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .72 to .96 mm to 4.75 x 5.50 mm. Groundmass constituents are about .02 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{63})	28
Hornblende	21
Carbonate	7
Epidote	6
Quartz	3
Hematite	1
Apatite	tr
Leucoxene	tr
Pyrite	tr
Microcrystalline groundmass	33

Remarks: Plagioclase phenocrysts are kaolinized and saussuritized. Parts of some plagioclase crystals are completely replaced by epidote. A few plagioclase phenocrysts are zoned and many are twinned according to the albite law. Hornblende crystals are partly resorbed; several are twinned; and some are altered to chlorite and epidote. Carbonate is interstitial. A stain test suggests that only about 30-40% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with pinkish white, small to medium feldspar phenocrysts and greenish black hornblende crystals in a blue-gray aphanitic groundmass.

Sample No. OM-121

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with anhedral to subhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .13 x .60 mm to 2.25 x 5.00 mm. Groundmass constituents are about .03 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{70})	40
Hornblende	10
Epidote	5
Actinolite	3
Magnetite	2
Apatite	1
Quartz	tr
Microcrystalline groundmass	38

Remarks: Plagioclase phenocrysts are partly sericitized and kaolinized. The groundmass is partly kaolinized. Some plagioclase is twinned according to both the carlsbad and albite laws. Some hornblende crystals are partly resorbed, many are completely altered to actinolite and some are completely altered to chlorite. A stain test suggests that 30-40% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with medium orangish white feldspar phenocrysts in a bluish gray aphanitic groundmass. Weathered surfaces are reddish orange as a result of an efflorescence of hematite and/or limonite which has been abstracted from the mafic minerals in the rock.

Sample No. OM-141

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: laccolith

Microscopic description: porphyritic with anhedral to euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .42 x .48 mm to 2.75 x 3.25 mm. Groundmass constituents are about .02 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{68})	35
Hornblende	9
Augite	5
Actinolite	5
Biotite	4
Carbonate	3
Magnetite	2
Quartz	tr
Apatite	tr
Sphene	tr
Hematite	tr
Microcrystalline groundmass	36

Remarks: Plagioclase is partly kaolinized, sericitized and saussuritized. Some plagioclase crystals are zoned and most are twinned according to the albite law. Hornblende crystals are partly resorbed, rimmed by carbonate, and some are partly altered to chlorite and actinolite. A stain test suggests that only 30-40% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with pinkish white, small to medium feldspar phenocrysts and black medium hornblende phenocrysts in a light gray aphanitic groundmass.

Sample No. OM-144

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with anhedral to euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .37 x .78 mm to 2.00 x 3.00 mm. Groundmass constituents are about .02 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{61})	43
Hornblende	12
Actinolite	4
Epidote	4
Carbonate	3
Quartz	2
Magnetite	1
Microcrystalline groundmass	30

Remarks: Plagioclase phenocrysts are only very slightly kaolinized and sericitized. A few are zoned and most are twinned according to the albite law. All the hornblende crystals are partly resorbed and many are partly altered to epidote. A stain test suggests that only 25-35% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with medium white feldspar phenocrysts and greenish black, small to medium hornblende crystals in a bluish gray aphanitic groundmass.

Sample No. OM-147

Rock name: quartz-bearing hornblende latite-andesite porphyry

Mode of occurrence: sill

Microscopic description: porphyritic with anhedral to euhedral phenocrysts in a salt-and-pepper-like microcrystalline groundmass. Phenocrysts range in size from .36 x .49 mm to 1.85 x 2.60 mm. Groundmass constituents are about .02 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{63})	35
Hornblende	12
Sphene	1
Magnetite	1
Quartz	tr
Tremolite	tr
Microcrystalline groundmass	50

Remarks: Plagioclase phenocrysts are partly saussuritized, sericitized, and kaolinized. Groundmass is deeply kaolinized. Most plagioclase phenocrysts are twinned according to the albite law. Hornblende crystals are partly resorbed and some are twinned. A stain test suggests that 40-50% of the groundmass is orthoclase. Megascopically, the rock is aphanophyric with medium white feldspar phenocrysts and black, small to medium hornblende crystals in a bluish gray aphanitic groundmass.

Sample No. OM-250

Rock name: quartz-bearing syenodiorite porphyry

Mode of occurrence: plug-like feeder between two sills

Microscopic description: hypidiomorphic-seriate with anhedral phenocrysts of orthoclase and plagioclase. Principal grains range in size from .19 x .40 mm to .50 x 1.75 mm. Anhedral orthoclase and plagioclase phenocrysts range from 1.10 x 2.85 mm to 3.25 x 3.25 mm and are poikilitic with inclusions of all other minerals in the slide.

Minerals	Per Cent
Plagioclase (Ab_{61})	43
Orthoclase	25
Hornblende	10
Augite	6
Magnetite	5
Biotite	4
Sphene	3
Actinolite	2
Quartz	1
Apatite	tr

Remarks: Plagioclase crystals are partly kaolinized and sericitized. Phenocrysts are partly kaolinized. Hornblende crystals are slightly altered to a dirty clay-like material. Plagioclase is twinned according to both the carlsbad and albite laws. Zoning of plagioclase is common. Orthoclase and plagioclase phenocrysts are untwinned. Megascopically, the rock is microphaneritic, fine-grained with pale green hornblende crystals, biotite flakes and light gray feldspar.

Sample No. OM-13

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: allotriomorphic-seriate with principal grains ranging in size from .07 x .30 mm to .57 x 2.04 mm.

Minerals	Per Cent
Plagioclase (Ab_{67})	28
Orthoclase	26
Augite	20
Biotite	8
Magnetite	7
Uralitic hornblende	6
Nepheline	4
Sphene	tr
Apatite	tr

Remarks: Feldspar minerals are entirely unaltered. Plagioclase is only very rarely twinned. Augite is partly resorbed and commonly is rimmed by biotite. A few augite crystals are both twinned and uralitic. Megascopically, the rock is microphaneritic with small black augite crystals and small dark blue-gray feldspar crystals.

Sample No. OM-102

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: allotriomorphic-seriate to hypidiomorphic-seriate. Grains range in size from .08 x .30 mm to .75 x 1.25 mm.

Minerals	Per Cent
Plagioclase (Ab_{52})	40
Orthoclase	38
Augite	16
Sphene	2
Magnetite	2
Apatite	1
Nepheline	tr
Zircon	tr

Remarks: Feldspar crystals are very slightly kaolinized and sericited. Some plagioclase crystals are zoned and many are twinned according to the albite law. Both plagioclase and orthoclase are twinned according to the carlsbad law. Orthoclase forms overgrowths on plagioclase and some orthoclase crystals are poikilitic with inclusions of plagioclase, augite and sphene. Megascopically, the rock is fine-grained and medium gray.

Sample No. OM-122

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock (from border area)

Microscopic description: hypidiomorphic-seriate, with principal grains ranging in size from .24 x .48 mm to 1.25 x 4.00 mm. Interstitial material resembles salt-and-pepper-like microcrystalline material in the outlying sills and laccoliths. The constituents of this material average .03 mm in diameter.

Minerals	Per Cent
Plagioclase (Ab_{68})	35
Orthoclase	30
Augite	15
Nepheline	4
Magnetite	3
Sphene	2
Apatite	tr
Hematite	tr
Microcrystalline interstitial material	10

Remarks: Plagioclase is slightly sericitized. Microcrystalline interstitial material is kaolinized. Much of this material is augite. Some orthoclase crystals are poikilitic with inclusions of plagioclase. Many magnetite grains are rimmed by sphene. Megascopically, the rock is medium-gray, appears to be phanerocrystalline with conspicuous medium greenish black hornblende crystals. Medium feldspar crystals are also readily apparent.

Sample No. [illegible]

Rock name: [illegible]

Mode of occurrence: [illegible]

Microscopic description: [illegible]

[illegible] 1.25 x [illegible] mm. [illegible]

[illegible]

[illegible]

material [illegible]

[illegible]

[illegible]

Remarks: [illegible]

crystalline [illegible] material [illegible]

of these material [illegible]

are [illegible]

magnetite grains [illegible]

the [illegible]

with [illegible]

[illegible]

[illegible]

Sample No. OM-123

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: allotriomorphic-seriate to hypidiomorphic-seriate, with principal grains ranging in size from .72 x .84 mm to 3.00 x 3.50 mm.

Minerals	Per Cent
Plagioclase (Ab_{63})	38
Orthoclase	32
Augite	14
Biotite	5
Sphene	4
Magnetite	4
Nepheline	2
Apatite	tr

Remarks: Plagioclase phenocrysts are partly saussuritized and kaolinized. Some plagioclase crystals are zoned and many are twinned according to the albite law. Mafic minerals are partly resorbed. Megascopically, the rock is microphaneritic with medium dark green augite, black biotite and light gray small to medium feldspar crystals.

Sample No. OM-124

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: (this sample is typical stock rock, but it also contains a segregate of chiefly mafic minerals). The rock itself is hypidiomorphic-granular with principal grains ranging in size from .25 x .85 mm to 1.00 x 2.00 mm. One large poikilitic nepheline crystal is 5.10 x 13.50 mm (plate IV-B). In the segregate augite is parallel prismatic and ranges in size from .30 x 2.00 mm to .75 x 9.50 mm. Feldspars in the segregate range in size from .25 x .55 mm to .70 x .90 mm but most are about .30 x .80 mm (plate VI-A).

Rock:

Minerals	Per Cent
Plagioclase (Ab_{69})	39
Orthoclase	33
Augite	12
Nepheline	8
Sphene	3
Magnetite	3
Biotite	1
Apatite	tr
Hematite	tr

Segregate:

Minerals	Per Cent
Augite	46
Plagioclase (Ab_{69})	28
Orthoclase	10
Apatite	8
Magnetite	6
Biotite	1
Sphene	1

Remarks: Plagioclase is only very slightly kaolinized and is commonly twinned according to the albite law. Augite is partly resorbed. The large nepheline crystal in the rock is poikilitic with inclusions of every other kind of mineral in the slide (plate IV-B). Orthoclase is also poikilitic. The border of the segregate is marked by abundant apatite. Megascopically, the rock is microphaneritic with medium dark green augite, small black biotite and light gray small to medium feldspar crystals. The segregates are dark greenish black and generally are only three or four inches in diameter.

Sample No. OM-252

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: hypidiomorphic-seriate with principal grains ranging in size from .33 x .70 mm to 1.32 x 1.56 mm.

Minerals	Per Cent
Plagioclase (Ab_{55})	28
Orthoclase	28
Uralitic hornblende	14
Augite	12
Biotite	7
Nepheline	6
Apatite	3
Sphene	2

Remarks: Feldspar crystals are only very slightly kaolinized. Plagioclase is invariably twinned according to the albite law and is also often twinned according to the carlsbad law. Orthoclase is invariably untwinned. A few augite crystals are twinned and many are rimmed with uralitic hornblende (plate IV-A). Megascopically, the rock is microphaneritic with medium black, tabular augite crystals and light gray, medium feldspar crystals.

Sample No. OM-254

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: allotriomorphic-seriate with principal grains ranging in size from .24 x .78 mm to 1.00 x 1.55 mm.

Minerals	Per Cent
Plagioclase (Ab_{61})	36
Orthoclase	34
Augite	16
Biotite	6
Magnetite	5
Sphene	1
Nepheline	1
Zircon	tr

Remarks: Feldspar crystals are only very slightly kaolinized. Plagioclase crystals are invariably twinned according to the albite law; many are also twinned according to the carlsbad law and some display zoning. Orthoclase is not twinned. Megascopically, the rock is microphaneritic with small black tabular grains of augite and small bluish gray feldspar crystals.

Sample No. OM-257

Rock name: nepheline-augite monzonite

Mode of occurrence: stock

Microscopic description: hypidiomorphic-seriate with subparallel arrangement of feldspar crystals. Principal grains range in size from .12 x .17 mm to .30 x 1.26 mm.

Minerals	Per Cent
Plagioclase (Ab_{61})	32
Orthoclase	27
Augite	18
Nepheline	10
Uralitic hornblende	7
Magnetite	4
Sphene	1
Apatite	tr

Remarks: Feldspars are only very slightly kaolinized. Plagioclase is commonly twinned according to both the carlsbad and albite laws. Orthoclase is untwinned. Mafic minerals are partly resorbed. Megascopically, the rock is microphaneritic with small black tabular augite and dark bluish gray feldspar crystals.

Sample No. OM-264

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: allotriomorphic-seriate with principal grains ranging in size from .14 x .48 mm to .84 x 1.92 mm.

Minerals	Per Cent
Plagioclase (Ab_{65})	38
Orthoclase	36
Augite	20
Sphene	2
Magnetite	2
Carbonate	1
Nepheline	tr
Biotite	tr
Apatite	tr
Hematite	tr

Remarks: Feldspar crystals are slightly kaolinized. Plagioclase is twinned according to the carlsbad and albite laws. Orthoclase is untwinned. Carbonate is interstitial and also partly replaces augite, which is partly resorbed. Some augite is partly altered to chlorite and a dirty clay-like material. Megascopically, the rock is microphaneritic with pale green small augite and very light gray feldspar crystals.

Sample No. OM-265

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: allotriomorphic-granular with sub-parrallel arrangement of feldspars. Principal grains range in size from .13 x .55 mm to .83 x 1.20 mm (plate V-B).

Minerals	Per Cent
Plagioclase (Ab_{65})	35
Orthoclase	30
Augite	18
Biotite	8
Nepheline	4
Magnetite	4
Sphene	tr
Apatite	tr

Remarks: Feldspar crystals are essentially unaltered. Plagioclase is occasionally twinned according to the albite law. Orthoclase is untwinned. Mafic minerals are partly resorbed. Biotite occurs as individual minerals and as rims around magnetite and augite. It also fills cracks in the augite. A few augite crystals are twinned. Megascopically, the rock is microphaneritic with small black biotite flakes, small to medium augite and small feldspar crystals.

Sample No. OM-268

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: allotriomorphic-seriate to hypidiomorphic-seriate with principal grains ranging in size from .32 x .66 mm to 1.25 x 1.85 mm.

Minerals	Per Cent
Plagioclase (Ab_{62})	33
Orthoclase	26
Augite	16
Biotite	9
Nepheline	9
Magnetite	5
Sphene	tr
Carbonate	tr
Apatite	tr

Remarks: Feldspar crystals are only very slightly kaolinized. Practically all plagioclase crystals display albite twinning. Orthoclase is untwinned and poikilitic with inclusions of plagioclase, augite, apatite and magnetite. A few augite crystals are twinned and many are both rimmed and replaced along fractures by biotite. Megascopically, the rock is microphaneritic with small biotite flakes, small to medium black tabular augite and small bluish gray feldspar.

Sample No. OM-271

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock

Microscopic description: hypidiomorphic-granular with a sub-parallel arrangement of plagioclase crystals. Principal grains range in size from .15 x .32 mm to .60 x 2.20 mm.

Minerals	Per Cent
Plagioclase (Ab_{67})	30
Orthoclase	24
Uralitic hornblende	17
Augite	13
Nepheline	6
Magnetite	4
Biotite	4
Apatite	1
Sphene	tr
Hematite	tr

Remarks: Feldspars are essentially unaltered. Plagioclase is invariably twinned according to both the albite and carlsbad laws. Orthoclase is untwinned. Biotite occurs as replacements along fractures in augite and hornblende. Mafic minerals are partly resorbed. Megascopically, the rock is fine-grained and microphaneritic with black flakes of biotite, black tabular crystals of augite and bluish black feldspar crystals.

Sample No. OM-272

Rock name: nepheline-bearing augite monzonite

Mode of occurrence: stock with large stoped xenolith

Microscopic description: allotriomorphic-seriate with principal grains ranging in size from .25 x .60 mm to 1.00 x 2.75 mm.

Minerals	Per Cent
Plagioclase (Ab_{61})	43
Orthoclase	37
Augite	10
Magnetite	4
Nepheline	2
Sphene	2
Biotite	1
Apatite	tr
Zircon	tr

Remarks: Feldspar crystals are slightly kaolinized and sericitized. Augite crystals are partly resorbed. Plagioclase is twinned according to both the carlsbad and albite laws. This slide was cut across an irregular contact of the nepheline-bearing augite monzonite and a large stoped xenolith of hornfels (probably Mesaverde shale). In thin-section the hornfels displays a granoblastic texture in which the principal grains are randomly oriented and are about .05 x .10 mm. These grains include other grains less than .01 mm in diameter of magnetite and medium-birefringent minerals, probably pyroxene. The hornfels contains numerous porphyroblasts of andesine, orthoclase, augite, hornblende and sphene that range in size from .20 x .25 mm to 1.25 x 1.50 mm.

Photographs and Photomicrographs

Abbreviations used on the photomicrographs are explained as follows:

A - - - - augite

C - - - - carbonate (probably calcite)

Ch - - - - chlorite

M - - - - magnetite

MG - - - - microcrystalline groundmass

N - - - - nepheline

O - - - - orthoclase

P - - - - plagioclase (andesine)

Q - - - - quartz

S - - - - sphene

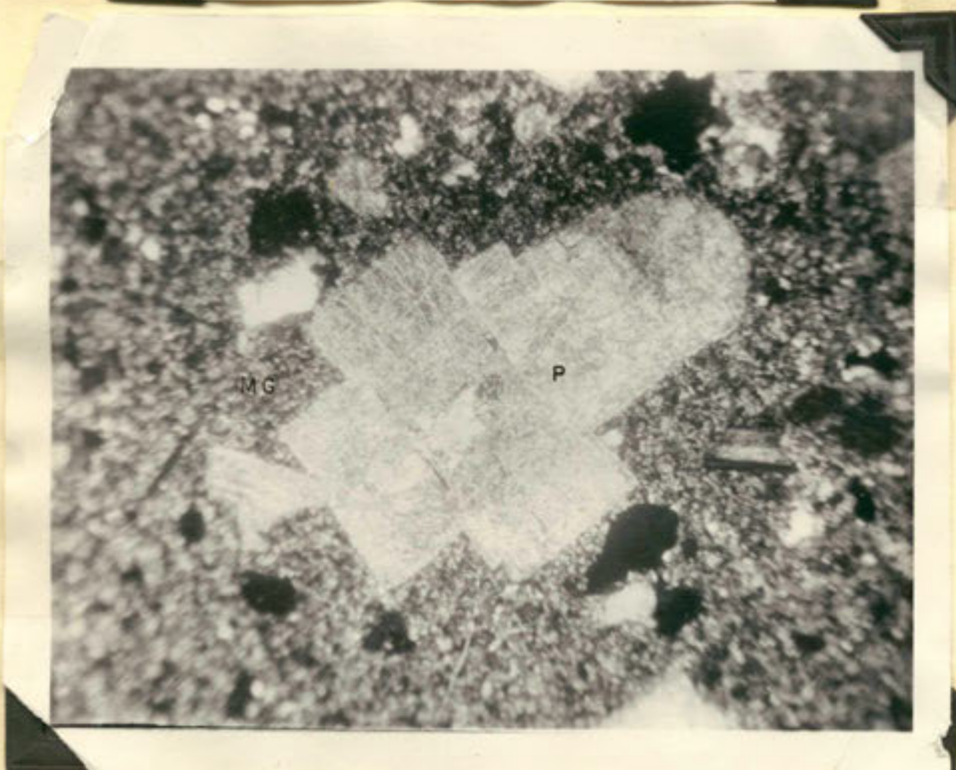
UH - - - - uralitic hornblende

A. View looking east at Placer Mountain from the west side of the mountains.

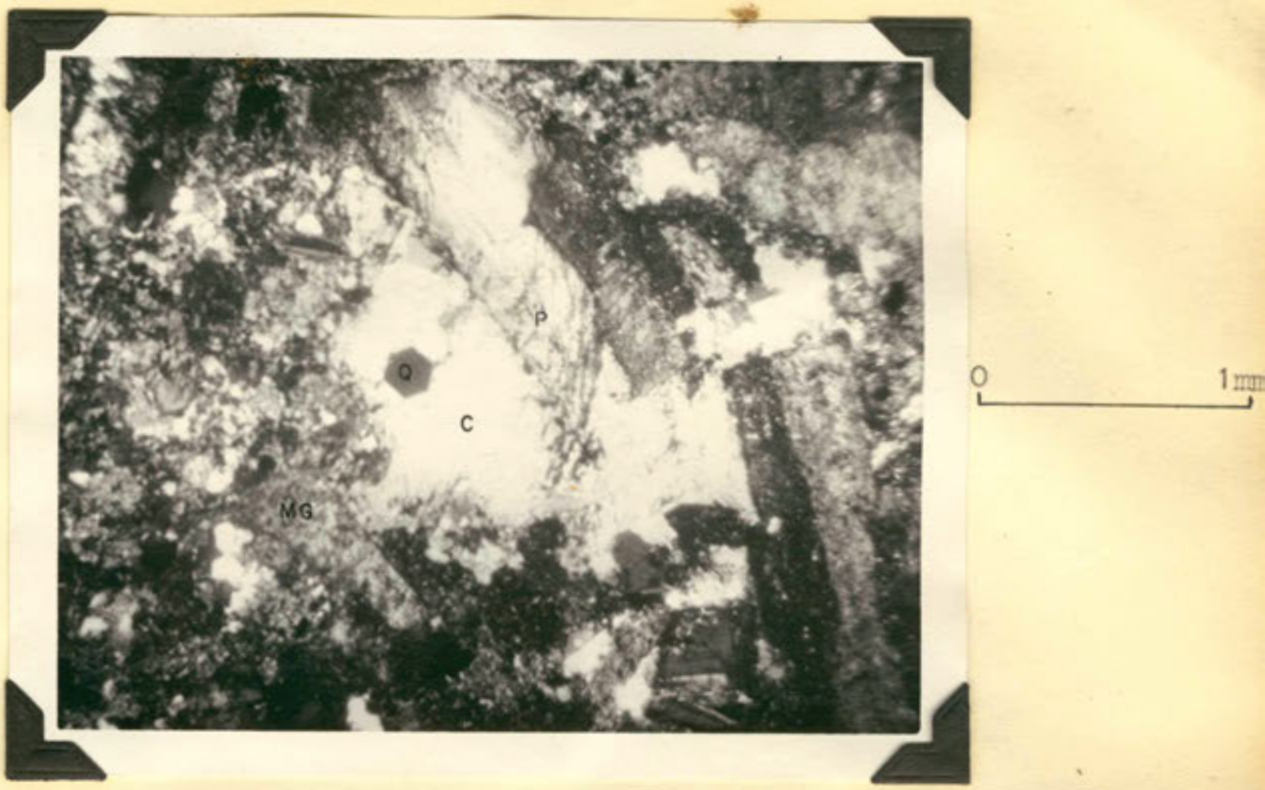
B. View of porphyry, quartzite, and hornfels xenoliths in vent rock in Cunningham Gulch area.

A. View of vent rock xenolith in nepheline-bearing augite monzonite 75 yards north of Ortiz mine.

0 1mm



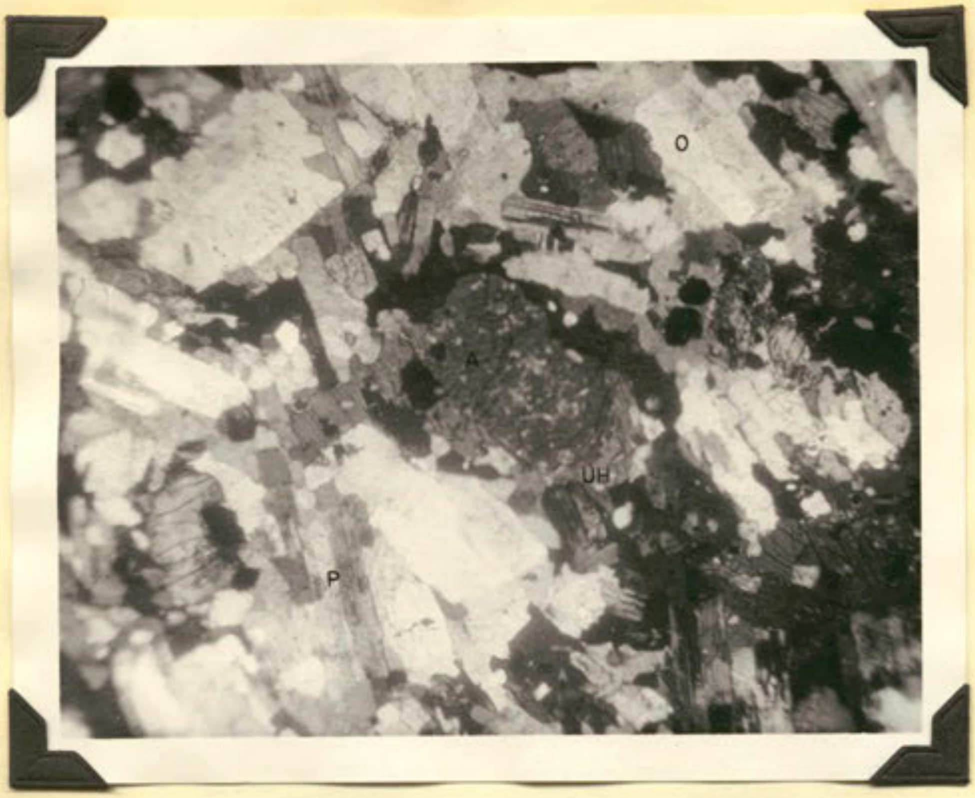
B. Photomicrograph of cross-like intergrowth of plagioclase in latite-andesite porphyry (sample number OM-107).



A. Photomicrograph of euhedral quartz inclusion in carbonate in latite-andesite porphyry (sample number OM-116).

B. Photomicrograph of rhyodacite porphyry as illustrated by sample number OM-105.

0 1mm



A. Photomicrograph of nepheline-bearing augite monzonite showing augite crystal rimmed by uralitic hornblende (sample number OM-252).

0 1mm

B. Photomicrograph of poikilitic nepheline crystal with inclusions of augite, plagioclase, sphene, and magnetite (sample number OM-124).

A. Photomicrograph of sub-parallel feldspar crystals demonstrating linear flow structure (sample number OM-265).

B. View of black spots in a weathered cobble of nepheline-bearing augite monzonite.

C. View of basic segregate found in the northwestern part of the nepheline-bearing augite monzonite stock (sample number OM-124).

A. Photomicrograph of feather-like augite crystals in basic segregate (sample number OM-124).

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