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GEOLOGY OF THE EAST-CENTRAL PORTION OF THE NELSON QUADRANGLE

CLARK COUNTY, NEVADA

BY

TEDRAL KANTOR

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THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

MASTER OF SCIENCE, GEOLOGY MAJOR

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1961

Approved by

Paul Dean Proctor (advisor) Richard R. Kennedy

James C. Maxwell Gerald B. Rupert

ABSTRACT

The purpose of this investigation was to determine the unusually complex geology of a little-known area south of the Eldorado mining district, southern Clark County, Nevada. The area, mapped at a scale of 1:24000, comprises a segment of the northerly-trending Eldorado mountains in the southeast corner of the Great Basin. This rugged desert area is on a drainage divide between the Great Basin and the Colorado River. The rocks of the area consist of Precambrian gneisses and schists invaded by successive generations of Upper Cretaceous (?) - Tertiary igneous rocks. The older rocks, mainly biotite-chlorite gneisses, have resulted from high-grade regional metamorphism followed by partial retrograde effects. A medium-grained quartz monzonite grades migmatically into these rocks. A later, essentially contemporaneous complex of acidic rocks, chiefly fine-grained quartz monzonite and rhyolite-andesite porphyry, occur as a large easterly-trending pluton, and numerous dike swarms and chonoliths. Intermediate-basic intrusions, chiefly of andesite-latite porphyry, follow in close succession. Andesite flows locally occur in the north, nonconformably overlying gneiss and quartz monzonite. Quaternary surficial deposits cover parts of the area.

The gneissic foliation, extremely variable in trend and attitude, tends to parallel the strike of the large pluton near the gneiss-pluton contact. A profusion of dike swarms, joints and faults are present in the area. These all show preferred trends, chiefly northerly. The most prominent faults uplift the western part of the Eldorado Mountains,

i.e. the Ireteba Peaks, above the surrounding country. The periods of igneous intrusion and fracturing overlapped. A few mineralized fissure zones (epithermal gold-silver-quartz), cutting andesite, gneiss and schist, are concentrated in the northern part of the area.

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I. INTRODUCTION

A. Purpose and Scope of Report

The purpose of this investigation was to determine the geologic setting of an unusually complex area on the fringe of a once-productive gold mining district. Since previous work has been limited to brief reconnaissance trips, this report represents the first attempt to work out the hitherto unknown petrographic and structural details of the area. The report is based upon field mapping with the aid of 9'' x 9'' airphotos (Scale 1:54,000), a laboratory study of collected rock samples, and a review of the available geologic literature.

Field work was completed in 38 days, during the period June 22 - September 5, 1959. Mapping consisted of: 1) Correlation of photo and field features, 2) Foot traverses, across observed features, establishing the various rock types, 3) Determining interrelations among rocks along cliffs and arroyos where small structural features were less obscured by the mechanical weathering which prevails over most of the land surface.

Geological details were plotted on transparent overlays covering 2x enlargements of the above-mentioned airphotos, both during and after the field season. The well-exposed rock masses of this rugged desert area were ideally suited for photogeologic mapping. In fact, broad structural features, not readily apparent at close range, showed up very clearly on the photographs. The final geologic map (Plate I) was prepared at the scale of 1:24,000, on a base provided by an enlarged portion of the Nelson 15-minute topographic quadrangle (USGS). The photo-map was adjusted to topographic controls with the aid of a vertical sketchmaster.

Sixty representative rock specimens were collected at the end of the field season in order to select the most typical samples. Laboratory work consisted of a microscopic examination of 50 thin sections.

Field and laboratory results were interpreted with the aid of the available geologic literature.

B. Location and General Geography

The mapped area covers 34 square miles, near the south end of Clark County, Nevada (see Fig. 1). The area is bounded by latitudes 35° 36' and 35° 40', and by longitudes 114° 45' and 114° 53'. It overlaps Townships 26 and 27 south and Ranges 64 and 65 east.

Access is from the partly-paved Nevada Route 60. Several dirt roads branch from this highway and partially penetrate the area. These roads, for the most part, are passable only on foot or by four-wheel drive vehicles. Nelson, the nearest settlement (pop. 26), lies on Route 60, about 3 miles north of the area. See Fig. 2.

Geographically, the area lies in the southeast corner of the Great Basin, a region characterized by northerly-trending, dissected block mountain ranges separated by aggraded desert plains (Fenneman, 1931, pp. 326-67). The mapped area comprises a segment of one such range, the Eldorado (locally named "Opal") Mountains. These extend roughly from Searchlight to Boulder City and are flanked on the east and west by lowland plains. The area is about 3-1/2 miles west of the Colorado River. Elevations range from 1,600 to 5,072 feet above sea level. Topographic details are discussed in a later section.

The climate (Visher, 1954) is warm and arid. Summer temperatures very often exceed 110°F in the afternoon, but may fall to 70° at night.

Winter temperatures normally range from 32° to 60°F. The annual rainfall is less than 6 inches.

Vegetation is sparse; it includes various species of sagebrush, cactus and yucca. Wildlife is abundant, consisting of small rodents, jackrabbits, cottontails, lizards, snakes, coyotes, bighorn sheep, and numerous types of birds. No people inhabit the mapped area. Prospectors have entered the area in the past, as evidenced by a few exploratory pits. A well has been dug in the NW 1/4 Sec. 28, T. 26 S., R. 64 E. Mines of the once-productive Eldorado district lie immediately north of the area.

C. Previous Work

The first geologic observation in the area was made by G. K. Gilbert in 1871, during the Wheeler topographic survey. On a reconnaissance map of 8 miles to the inch (War Dept. 1881, Atlas Sheet No. 66) Gilbert showed the area as an Archaean complex flanked by Pleistocene detritus. This work was later included in a report by Spurr (1903, pp. 15-17, 138-9, Plates I and II).

Ransome (1907, pp. 63-68), in a brief reconnaissance of the Opal Mountains, recognized a much-disturbed mass of gneisses and schists, cut by quartz monzonite, aplite, pegmatite and andesitic porphyries, and flanked in places by Tertiary eruptives. He correctly noted that the Opal Mountains in the mapped area consisted mainly of quartz monzonite. Lincoln (1923, pp. 20, 25) summarized Ransome's findings.

Bowyer, Pampeyan and Longwell (1958) in a reconnaissance map (1:200,000) of Clark County, Nevada, show this area of the Opal Mountains as an undifferentiated Precambrian complex cut by a Cretaceous-Tertiary pluton.

Figure 1.

Index map Showing Location of Mapped Area

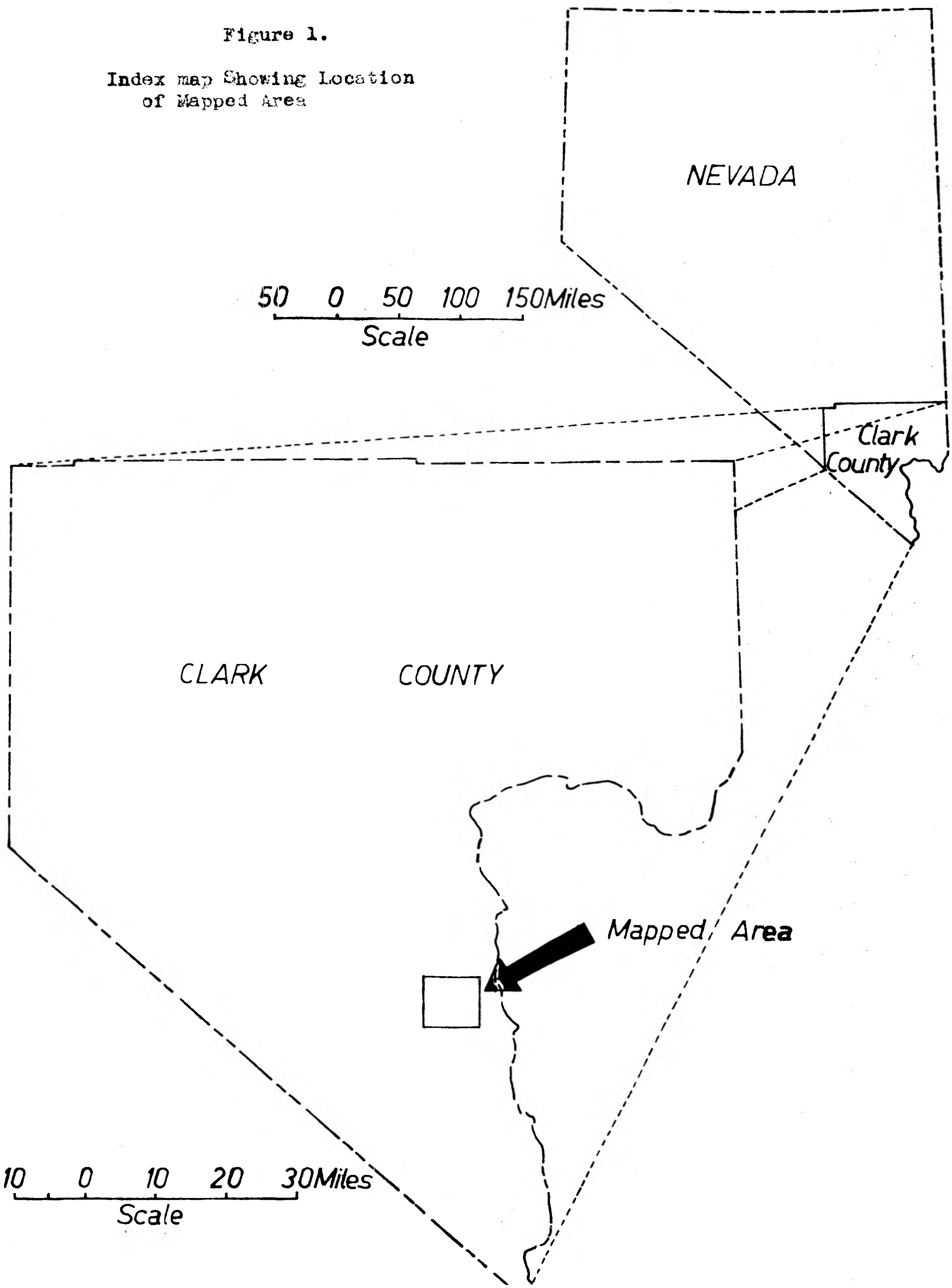

Figure 2 - View of the Central Part of Nelson, Nevada -

A Tertiary lava flow appears in the background.

D. Acknowledgements

Thanks are due Dr. Paul D. Proctor, Chairman of the Missouri School of Mines Geology Department,who introduced the writer to the study of this area, and whose helpful and friendly guidance made possible its completion. Thanks are also due other staff members and students, at the Geology Department, for many small but useful suggestions. The writer is especially indebted to his esteemed colleagues, Messrs. Spenst M. Hansen and Robert L. Biddulph for their many acts of cooperation during the undertaking of this problem. Cordial thanks are also extended to the inhabitants of Nelson, Nevada, for their many deeds of kindness during the writer's stay in the field. Lastly, the writer is indebted to the Missouri School of Mines authorities for a research fellowship covering the period October 1, 1959 - February 29, 1960, and for the granting of loans which enabled him to complete this problem.

II. TOPOGRAPHIC FEATURES

Within the mapped area the Eldorado Mountains consist of a mass of crystalline rocks, essentially a quartz monzonite pluton along with numerous dikes which invade gneisses and schists. Faulting and erosion have carved these rock masses into numerous rugged ridges separated by narrow valleys. A sinuous, north to northwesterly-trending canyon divides the range into two distinct east and west blocks. See Fig. 3.

The east block appears to be a former destructional plain which has been uplifted, tilted (?) to the east, and dissected. In its northern half, average upland elevations diminish progressively eastward from 4,000 to 2,000 feet in 4-1/2 miles. This forms a fairly uniform slope of 5 degrees. In the southern half of the block, average upland elevations similarly range from 3,000 to 1,750 feet eastward in 3-3/4 miles with a slope of 3-1/2 degrees. The resistant mass of quartz monzonite gives the north half of the block the higher elevation. The south half is mainly underlain by the less-resistant gneisses and schists (see Plate I).

The original upland surface of the east block is completely dissected into numerous sharp-crested spurs connected by narrow v-shaped ravines. The spurs and their connecting ravines have an average slope of 13 degrees and culminate in sharp peaks. The resulting mountains are separated by a few deeply-cut main canyons, such as Aztec Wash. The local relief, between the high peaks and main canyons, averages 800 feet. The main canyons, unlike the small tributary ravines, are not perfectly v-shaped, but possess floors. The latter are covered with alluvial deposits, which are of mappable size only in the lower parts of the canyons. The main canyons have an average easterly gradient of 4 degrees.

All points on the east block drain into the main canyons, and from there, via a lowland plain, into the Colorado River. This plain, only partly shown on the map, is a bajada composed of coalescing alluvial fans derived from erosion of the highlands. Intermittent streams have dissected these fans. The bajada has a 3 degree slope, at the foot of the range, which progressively diminishes toward the river. See Figure 4.

The west block is a northerly-trending serrated ridge, comprising the Ireteba Peaks. The block stands steeply above the surrounding lowlands. The crest elevation averages 4,700 feet. The highest point, 5,072 feet, is near the south end of the crest. The elevation of the base, at the east side of the block, ranges from 2,400 feet in the south to 4,000 feet at Tule Spring. The base elevation at the west side of the block is fairly uniform, averaging 3,750 feet. The sides of the block slope respectively eastward, at angle ranging from 24 degrees in the north to 13 degrees in the south; and westward 11 degrees. Both sides of the block are dissected into east-west trending spurs connected by v-shaped ravines. Rapid weathering and mass movement, along these steep slopes, has produced a rockslide breccia which covers most of the block.

The crest is a drainage divide within the mapped area. The east side of the block drains into the Colorado Valley. The west side drains into the lowland plain on the west, and from there into Searchlight Playa, a dry lake bed not shown on the map. The lowland plain, in the area, is a pediment which slopes 2 degrees west-southwest. Coalescing alluvial fans, derived from the west block, only thinly cover the fairly flat-lying

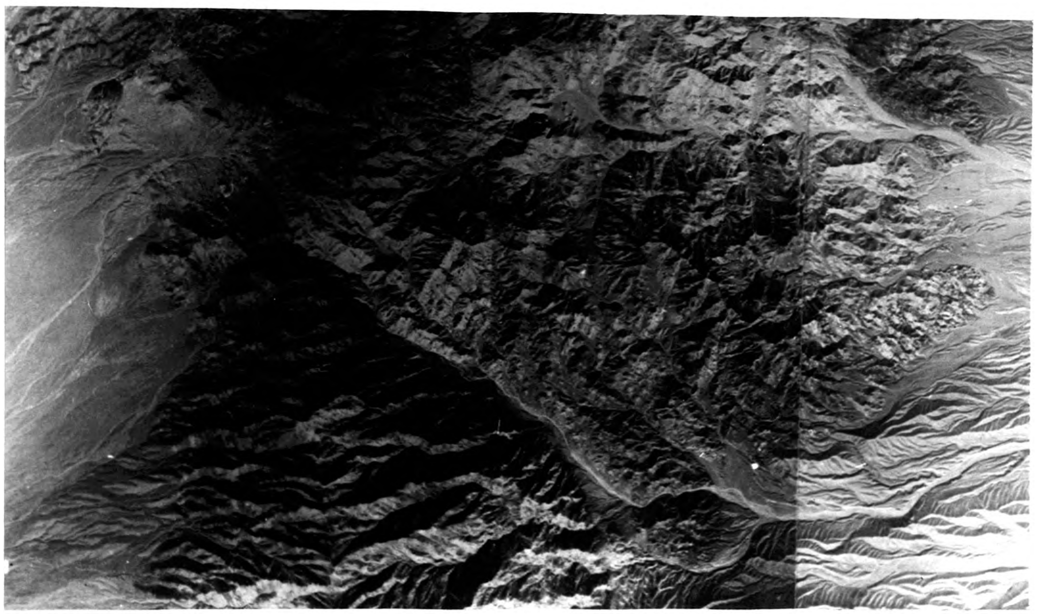

Figure 3 - Air Photograph of Mapped Area

Figure 4 - Bajada On East Flank of Eldorado Mountains -
View is toward the southeast. Aztec Wash runs through the middle of the picture. The Colorado River, and the Black Mountains of Arizona are in the background.

pediment, and patches of bedrock are locally present. Directly north of the Iretaba Peaks, the pediment consists wholly of bedrock. Here, a few residual hills (inselberge) rise above the general plain surface. Of these, Knob Hill shows the greatest relief of about 500 feet.

The topographic features of the area are due primarily to the combined effects of faulting and erosion, presumably by intermittent streams. The structural significance of the landforms is discussed in Chapter IV. The area appears to be in a late youthful stage of erosion.

III. ROCKS

A. Preliminary Statement

The rocks in the area consist of Precambrian gneisses and schists invaded by Upper Cretaceous (?) - Tertiary igneous rocks. Quaternary surficial deposits cover portions of the area.

The rock classification used in the report follows that of Williams, Turner, and Gilbert (1954). Aphanitic and glassy igneous rocks are classified on the basis of their phenocrysts. The altered condition of the cryptocrystalline groundmass prevented determination of the mineral composition by staining methods (Chayes, 1952; Keith, 1939). Listed mineral percentages are based on visual estimation. Note that the grain size terms used throughout the chapter include: fine = less than 1 mm., medium = between 1 and 5 mm., coarse = between 5 and 30 mm., very coarse = greater than 30 mm.

B. Precambrian Metamorphic Rocks

1. Introductory statement

The Precambrian metamorphic rocks comprise a complex of gneisses and schists distributed around an easterly trending prong-shaped intrusive mass. They occupy approximately 20% of the mapped area.

Biotite-chlorite gneiss is the most prevalent of these rocks. This grades into weakly foliated granitic rocks and also into quartz-chlorite-mica-schists. Hornblende schists and quartzofeldspathic gneisses occur locally. The gneisses and schists are everywhere invaded by intrusive dikes and chonoliths of varying size. Tertiary volcanic flows overlie the Precambrian rocks in the northeastern corner of the area.

Results of thin-section study suggest the following: An early period of high temperatures and pressures produced rocks of the almandine amphibolite facies. Some retrograde metamorphism followed, and resulted in rocks of the greenschist facies. The original rock types were not determined. The regional setting suggests a Precambrian age for these rocks.

On weathering, the more typical gneiss breaks down into angular fragments of boulder or cobble size. The schists, richer in mafic minerals, tend to weather into smaller fragments, usually with a clayey soil matrix. Brown limonite stains often cover the gneisses and schists. The following descriptions apply to fresh rock surfaces.

2. Descriptions of Rocks

a. Biotite-chlorite-gneiss

The biotite-chlorite-gneisses in hand specimen are pink or grey. Parallel, discontinuous green streaks give them a mottled appearance. Less commonly they consist of alternating grey and green bands of irregular and variable thickness. The texture is medium to fine (sometimes coarse) -grained gneissic. The pink or grey portions of the rock consist of visible quartz and altered feldspar. The greenish streaks or bands consist of chloritized biotite. Occasional traces of muscovite and garnet are visible.

With increasing amounts of micaceous material the rocks become more closely banded, grading into chlorite-mica-schists. With decreasing amounts of micaceous material, they grade into granitoid rocks, sparsely streaked with chloritized biotite. The alignment of biotite flakes gradually gives way to a random orientation. Locally, the biotite-chlorite gneiss may grade into a coarse-grained quartzofeldspathic gneiss.

Samples from the following localities were studied in thin sections:

	Locality
Sample No. 15	SE 1/4, Sec. 22, T. 26 S., R. 64 E.
Sample No. 29	SW 1/4, Sec. 20, T. 26 S., R. 64 E.
Sample No. 30	SW 1/4, Sec. 20, T. 26 S., R. 64 E.
Sample No. 24	SW 1/4, Sec. 20, T. 26 S., R. 65 E.
Sample No. 18	SW 1/4, Sec. 20, T. 26 S., R. 65 E.

Under the microscope the rocks show intimate intergrowths, of quartz and feldspars, enclosing parallel trains or segregated clots of highly chloritized biotite, generally with subordinate amounts of muscovite and/or sillimanite. Magnetite, leucoxene, and occasional traces of ilmenite, sphene, garnet, and limonite are also present.

Quartz occurs as medium and fine, anhedral grains usually elongated parallel to the schistosity. It shows wavy extinction and brecciation in samples 15 and 18. The feldspars consist of oligoclase, usually intergrown with orthoclase (Samples 18 and 30) or microcline (Sample 15). The feldspar of sample 24 is altered beyond recognition. The feldspars are medium to fine-grained and anhedral to subhedral. The plagioclase shows albite twin lamellae, most of which appear much thinner than the twin lamellae encountered in igneous rocks. No zoning is present at all. The microcline shows grid-iron twinning. Alteration of feldspar varies as follows: The oligoclase of Sample 30 is relatively fresh and unaltered; in Sample 18 it is moderately kaolinized, with a little sericite developed along cracks; in Samples 29 and 15, it shows moderate and strong sericitization respectively. The plagioclase (?) of Sample 24 is so strongly altered to a cryptocrystalline aggregate (of albite and epidote?) that its original character is now unrecognizable. Orthoclase and microcline show slight and moderate kaolinization respectively. The orthoclase of Sample 18 shows a little sericitization along cracks.

The feldspars are not as strikingly brecciated or strained as the quartz, except in Samples 15 and 24 where feldspar grains are bent and crushed.

Biotite occurs in clusters of fine subhedral to euhedral plates. It is strongly altered to chlorite with a little anhedral magnetite and leucoxene. A few tiny euhedral and anhedral grains of magnetite also occur scattered throughout the rock in Samples 30 and 15. Muscovite is present, in Samples 18, 30, and 24, as segregated masses of plates, associated with and having the same habit as biotite. Sillimanite occurs as patchy aggregates of fine needle-shaped grains in Samples 30, 15, and 24, associated with the micas; it partially replaces muscovite in Sample 24.

Ilmenite and sphene occur as scattered, fine, subhedral to euhedral grains in Sample 15. They are partly altered to leucoxene. Minor garnet, fine-grained and subhedral to euhedral, is associated with chlorite in Sample 30. Limonite fills a few tiny veinlets parallel to the schistosity in Sample 15.

One type of biotite-chlorite gneiss is so peculiar in its mineralogy as to warrant special attention. An outcrop of this rock (Sample 46) is present in the NW 1/4, Sec. 30, T. 26 S., R. 64 E. Unless examined closely, it strongly resembles the more common gneiss and may possibly occur at other localities within the area. Megascopically it is predominantly medium to coarse-grained, grey, and gneissic, with dark green streaks and bands which give it a mottled appearance. The grey portion contains quartz, feldspar, granular epidote, and euhedral crystals of lawsonite which range up to 7 mm. in diameter. The lawsonite is conspicuous with its tabular crystals, 3-directional cleavage, and hardness. Glaucophane, which typically accompanies lawsonite, is conspicuously absent. The dark green streaks appear to consist of fine-grained chlorite. A few fine euhedra of sphene are also present.

The rock, viewed in a thin section (Sample 46), is essentially an intimate intergrowth of epidote, quartz, albite, microcline, lawsonite, and sphene. Subparallel streaks of chlorite with magnetite, leucoxene, and biotite are also present. The epidote is cryptocrystalline to medium-grained, anhedral, and varies in hue from colorless to green. Quartz is fine to medium-grained and anhedral. Albite is fine to medium-grained and anhedral. It shows only faint polysynthetic twin lamellae. Microcline is fine to medium-grained and anhedral. It, likewise, is only faintly twinned. Both albite and microcline are fresh and unaltered. Lawsonite is fine to coarse-grained and euhedral. Sphene is fine to medium-grained, euhedral, and is partly altered to leucoxene. Chlorite occurs as fine subhedral plates and cryptocrystalline aggregates, associated with fine anhedral magnetite and leucoxene. Biotite occurs as a few fine, subhedral to anhedral relict grains within the chloritic material to which it has been altered.

b. Quartz-chlorite-mica-schists

Quartz-chlorite-mica-schists are typically greenish grey, fine to medium-grained, and strongly schistose in texture. Quartz, chloritized biotite, and muscovite are visible in hand specimens. The alternating layers of light and dark minerals give the rocks a very closely banded appearance. These schists grade into gneisses as the banding progressively coarsens.

Microscopic study of thin sections was completed on the two following rock samples:

	Locality
Sample No. 19	SW 1/4, Sec. 20, T. 26 S. R. 65 E.
Sample No. 33	NW 1/4, Sec. 29, T. 26 S., R. 64 E.

Under the microscope the rocks show essentially quartz which encloses or alternates with parallel trains of micaceous minerals. The quartz is anhedral, and medium to fine-grained. It is unstrained and fresh in appearance. Parallel layers of quartz, less than 0.25 mm. thick, alternate with micaceous layers in Sample 33.

The micaceous minerals consist of biotite, chlorite, and muscovite. These occur as fine euhedral flakes. Chlorite partly replaces biotite in Sample 33, and almost completely replaces it in Sample 19. Fine-grained, euhedral to anhedral magnetite, and anhedral leucoxene are associated with chlorite. Fine-grained traces of anhedral epidote (?); euhedral to anhedral ilmenite (partly altered to leucoxene); rounded crystals of garnet; and aggregates of sillimanite needles occur in Sample 33.

A quartz-chlorite-mica schist of rather distinctive character is present at SW 1/4, Sec. 20, T. 26 S., R. 65 E. The rock is pale grey, medium to fine-grained, and schistose. Quartz, greenish aphanitic matrix, and muscovite are visible in hand specimens. Thin section study (of Sample 5) shows parallel trains of quartz, less than 0.5 mm. thick, enclosed in a predominantly cryptocrystalline matrix. The quartz is anhedral, brecciated, and shows wavy extinction. Aggregates of fine, euhedral plates of chlorite and muscovite are visible in the cryptocrystalline matrix. Chlorite almost completely replaces biotite. Relicts of the latter mineral are visible. Some of the larger plates of chlorite and mica are parallel to the quartz layers; others are randomly oriented. Fine anhedral grains of magnetite and ilmenite, partly altered to leucoxene, are also present.

e. Hornblende schists

Hornblende schists are dark green and fine-grained, with a poorly defined schistose texture. Hornblende is the most abundant mineral visible in hand specimens. It possesses a planar schistosity, but lacks lineation. Irregular, sub-parallel bands of a calcareous, green aphanitic matrix are also present. Microscopic study of Sample 17 from SE 1/4, Sec. 22, T. 26 S., R. 64 E., shows a preponderance of fine-grained hornblende, with lesser amounts of fine-grained tremolite, diopside, chlorite, calcite (with epidote?), garnet, sphene, magnetite, albite, and phogopite.

Hornblende occurs as euhedral to subhedral prisms. It is non-pleochroic. A few intergrowths of tremolite, euhedral prisms of diopside, and traces of secondary chlorite are intimately associated with hornblende. Cryptocrystalline streaks of calcite (with epidote?)

occupy spaces between the hornblende prisms. Rounded crystals of garnet, traces of euhedral sphene, anhedral magnetite, anhedral to subhedral albite (polysynthetically twinned), and euhedral phlogopite are dispersed throughout the rock. A gneissic variety of hornblende schist occurs sporadically along the Ireteba Peaks. Bands of grey, medium to fine-grained feldspar, alternating with dark bands of fine to medium-grained hornblende and minor chloritized biotite characterize the rock in hand specimen. The dark minerals show foliation, but not lineation. Due to its limited occurrence, no samples were collected for thin section study.

d. Quartzofeldspathic gneisses

The quartzofeldspathic gneisses are predominantly coarse-grained, irregularly banded rocks. They consist mainly of alternating sub-parallel lenticules of grey quartz and white feldspar. Study was restricted to hand specimens; however crushed mineral fragments from a typical sample (No. 31, Locality: SW 1/4, Sec. 20, T. 26 S., R. 64 E.) were examined in immersion oils under the microscope.

The quartz is coarse to fine-grained, and anhedral. Feldspar (oligoclase), partially kaolinized, occurs as coarse to very coarse lenticules and also as euhedral crystals. A few feldspar crystals cut across the banding. Traces of fine-grained chloritized biotite are engulfed in the feldspar. Neither the quartz nor the feldspar show any effects of strain. Minor traces of fine-grained muscovite and granular epidote are also present in the rocks.

A rather peculiar-looking quartzofeldspathic gneiss is present at the SW 1/4, Sec. 4, T. 27 S., R. 64 E. Only its megascopic features were studied. The rock is grey, coarse to fine-grained and irregularly banded; it consists mainly of sub-parallel, coarse to very coarse quartz lenticules, alternating with layers of medium-grained quartz and altered feldspars in a green aphanitic (chloritic?) matrix. Nodules of fine to medium-grained, euhedral quartz crystals cut across the banding. The nodules range up to 40 mm. in diameter. See Fig. 5.

3. Origin of the gneisses and schists

Whether the gneisses and schists are of sedimentary or igneous parentage is unknown. A comparison of representative chemical analyses of various rock types from the literature suggests that the gneisses and mica-schists may have been derived from sandstones and shales, or from acidic igneous rocks. Hornblende schists may be derived from iron-magnesium bearing limestones, or from basic igneous rocks (Clarke, 1924, pp. 432, 442-3, 455, 460-65, 470-71, 552, 603, 628, 630-31).

In order to delineate the parent rocks more closely, relict features, inherited from the parent rocks, must be present. No such relict features were noted in the course of this study.

An attempt to determine the original rock types from geologic descriptions of surrounding areas has likewise yielded no conclusive results. Only Hewett (1956) and Longwell (1936) have attempted to account for the parentage of gneisses and schists in nearby areas. Hewett (1956, pp. 17-25) generally regards the gneisses and schists of the Ivanpah Quadrangle as metamorphosed intrusives and sediments respectively. Longwell (1936, pp. 1404-06) observed structures suggestive of original bedded sediments and possibly some lava flows, in some of the less-

Figure 5 - Quartz Nodules Cutting Across Banding of Quartzofeldspathic Gneiss

deformed gneisses and schists along the Colorado River. He was unable to determine the original rock types in the more intensely deformed gneisses and schists.

A tentative estimate of metamorphic conditions can be made, although too few samples have been studied to determine these conditions precisely. The mineralogy, fabric, and widespread occurrence of these and similar rocks throughout the southern Great Basin, indicate regional metamorphism. Pre-existing rocks, subjected to high temperatures and pressures, re-crystallized as gneisses and schists.

Persistent layers of unstrained quartz, parallel to the schistosity, suggest that crystallization was accompanied by deformation. A few crushed grains of quartz and feldspar parallel to schistosity, and a few feldspar crystals cutting across schistosity, also suggest that some crystallization preceded and followed deformation respectively.

Correlating the rocks with metamorphic facies establishes the relative intensity of metamorphism (Fyfe, Turner, and Verhoogen, 1958, pp. 3-20, 149-185, 199-239). Individual rock samples of this area contain mixed assemblages and are difficult to restrict to any definite facies. However, the persistence of certain mineral assemblages within these rocks gives clues as to their history.

The repeated occurrence of the assemblage ''oligoclase-orthoclase or microcline-quartz-biotite-muscovite or sillimanite'' in the biotite-chlorite-gneiss suggests high-grade regional metamorphism under conditions of the almandine amphibolite faces. Chloritization of biotite indicates an incipient retrograde metamorphism which was generally too weak to eliminate the high-grade minerals (oligoclase, orthoclase, and sillimanite). Sample 46 is a local exception. Here, retrograde metamorphism eliminated the high-grade minerals, and produced a low-grade greenschist assemblage, ''epidote-quartz-albite-microcline-chlorite.'' The additional presence of lawsonite in this rock suggests a transition into the glaucophane schist facies. The latter probably forms at similar temperatures as the greenschist facies, but at higher pressures.

The quartz-chlorite-mica-schists contain a greenschist assemblage, ''quartz-muscovite-chlorite-biotite,'' with chlorite replacing biotite in varying proportions. Sillimanite, in Sample 33, which shows less chloritization of biotite than the other schist samples, suggests previous metamorphism under conditions of the almandine amphibolite facies.

The complex mineral assemblage of the hornblende schists cannot be pigeonholed into any present facies scheme. The presence of diopside, however, suggests a grade of metamorphism at least as high as that of the almandine amphibolite facies. Chlorite and albite indicate retgrograde metamorphism toward the greenschist facies.

The quartzofeldspathic gneisses were not studied in detail. However, the paucity of micas in these rocks suggest possible metamorphism under conditions of the granulite facies. Minor amounts of epidote and chlorite indicate subsequent retrograde effects.

The above-mentioned features suggest that the gneisses and schists formed at a grade at least as high as that of the almandine amphibolite facies. They were later affected by retrograde metamorphism which was locally strong enough to produce low-grade rocks of the greenschist facies. Igneous intrusion and hydrothermal activity have complicated the history of these rocks.

The general transition of the foliated gneisses into non-foliated quartz monzonite intrusives suggests that metamorphism was accompanied and/or followed by migmatization. Such a process occurring after the main period of metamorphism could conceivably modify the original metamorphic assemblages. Later igneous activity undoubtedly modified the rocks further.

Local thermal metamorphism possibly produced the quartz nodules and feldspar crystals cutting across foliation in the quartzofeldspathic gneiss.

Hydrothermal activity, as well as low-grade regional metamorphism, produced the retrograde effects which are marked chiefly by the chloritisation of biotite. There is widespread chloritic alteration of the younger igneous rocks, which must have similarly affected the gneisses and schists to some extent.

4. Age of the Gneisses and Schists

Direct stratigraphic evidence of the rocks' ages is lacking in the area. However, similar rocks in surrounding areas have been classified as Precambrian. The two nearest places yielding direct evidence of a Precambrian age are the Ivanpah Quadrangle (immediately west of the area) and the South Virgin Mountains (about 50 miles northeast of the area).

Hewett (1956, pp. 17-18) observed Upper Precambrian or Lower Cambrian sedimentary rocks unconformably overlying gneisses and schists in places throughout the Ivanpah Quadrangle. Longwell (1936; pp. 1404-06; Figs. 4, 7, and 8; Plates 5, 9, and 21) observed Lower Cambrian sandstone overlying gneisses and schists in a few places, along an easterly course, from the South Virgin Mountains to the Grand Canyon.

Therefore, the gneisses and schists in the area are best regarded as Precambrian in age.

C. Upper Cretaceous (?) - Tertiary Igneous Rocks

1. Introductory Statement

Igneous rocks occupy about 60% of the area. Three mappable units are recognized. In decreasing order of abundance these include: 1) Acidic intrusives, 2) Intermediate and basic intrusives, 3) Andesite flows.

Each of these map units consists of several rock types which are superficially similar, but markedly different when examined closely. In the mapped area several different rock types may occur within the space of a few hundred feet. Because of the small scale of mapping, it was mandatory to lump the various rock types into units based upon broad compositional classes, marked chiefly by similarities in color.

These units evolved in the following general sequence, with minor overlapping taking place: 1) Acidic intrusives, 2) Intermediate and basic intrusives, and Andesite flows.

2. Acidic intrusives

a. Rock types and their distribution

The acidic intrusives consist of medium-grained (early) quartz monzonite, intruded by a younger, largely contemporaneous, complex of fine to medium-grained (late) quartz monzonite, rhyolite-andesite porphyries and quartz diorite-monzonite porphyries. Minor veins of aplite and pegmatite are also present. These rocks occur as numerous dikes and chonoliths, and as a large easterly-trending prong-shaped mass (see Plate I).

The dikes and chonoliths are generally complex, intimate admixtures of the above rock types. Rhyolite-andesite porphyries are predominant, however. Individual dikes range up to about 300 feet in thickness and a mile in length. Most individual dikes are too small to map, but swarms (Billings, 1954, p. 307-8) of such dikes can often be delineated.

Trends of dikes are variable. They strike in all directions. However, the most persistent trends are NNW to NNE; a NNW to NNE trend is especially prevalent along the Ireteba Peaks. Dips are likewise variable, ranging from zero to 90° in all directions. Dips of 50° to 90° are most common, however.

The large easterly-trending mass consists mainly of late quartz monzonite. Other acidic rocks, occurring as sporadic minor intrusions in the inner part of this mass, are abundant near the outer margins.

b. Early quartz monzonite

The early quartz monzonite is of unknown age. However, as contacts between this and younger acidic rocks cannot be delineated without the closest scrutiny, it was impracticable to map it as a separate unit. For this reason, it is mapped and discussed with the Upper Cretaceous (?)-Tertiary acidic intrusives.

Early quartz monzonite is best exposed on the pediment surface in the immediate vicinity of Knob Hill, and also in the south end of the Ireteba Peaks. Outcrops are badly weathered, resulting in grus-covered slopes dotted with rounded boulders. The rocks are yellowish brown on weathered surfaces, and pale grey on fresh surfaces. Medium-grained quartz, feldspars and partly chloritised biotite are visible in hand specimens.

Two samples were studied in thin sections. Under the microscope the rocks show hypidiomorphic-granular texture. They consist of quartz, oligoclase-andesine, orthoclase, biotite, and minor traces of other minerals. Percentages of main constituents are shown below:

Table 1. Early Quartz Monzonite - Mineral Composition

	Quartz	Oligoclase-Andesine	Orthoclase	Biotite	Minor Access.	Location
Sple. 2	41%	28%	26%	2%	3%	NW 1/4, Sec. 28, T. 26 S., R. 64 E.
Sple. 34	33%	35%	30%	1%	1%	NW 1/4, Sec. 29, T. 26 S., R. 64 E.

Quartz is medium to fine-grained, anhedral to subhedral, and intimately associated with feldspars. Oligoclase-andesine is medium to fine-grained, and subhedral to anhedral. A few crystals are normally zoned. The plagioclase shows moderate sericitization along cracks, and intense sericitization in the cores of zoned crystals. Slight kaolinization is visible in Sample 2.

Orthoclase is medium to fine-grained, and moderately to strongly kaolinized. It is subhedral in Sample 2. Anhedral orthoclase, containing minute bubble inclusions and intergrown with quartz, encloses oligoclase-andesine crystals in Sample 34.

Biotite is fine to medium-grained, euhedral to subhedral, and partly altered to chlorite, magnetite and leucoxene. Biotite contains minute inclusions of apatite in Sample 2.

Fine-grained traces of euhedral magnetite and ilmenite, partly altered to leucoxene, are scattered through the rocks. Euhedral hornblende, partly altered to biotite and magnetite, occurs in Sample 2.

Leucoxene, pseudomorphic after euhedral sphene, and subhedral muscovite occur in Sample 34.

Zoned plagioclase suggests an igneous origin for the early quartz monzonite (Turner and Verhoogen, 1951; pp. 289, 302). However, this rock grades into Precambrian gneisses, with no sharp contacts between the two. Random orientation of biotite gradually gives way to parallel alignment. Biotite content then gradually increases as the parallel flakes pass into aggregated streaks and bands. This relationship, apparent wherever gneisses are exposed, is most prominently displayed along the western flank of the Ireteba Peaks. The transition, so gradual as to be almost imperceptible, strongly suggests granitization in the contact zones between the two rock types. Partial fusion (Eskola, 1933) of the metamorphic rocks may have produced the magma which resulted in the early quartz monzonite. No clear-cut evidence to confirm this possibility was noted, however.

c. Late quartz monzonite

The late quartz monzonite occupies the great bulk of the easterly-trending prong-shaped mass. It also occurs as chonoliths and dikes throughout the rest of the area.

The rock typically weathers into sharp, craggy pinnacles, flanked by slopes consisting of angular to rounded boulders, with little grus. The late quartz monzonite is not as intensely fractured or weathered as the other rocks; it appears relatively fresh.

The rock is pale grey to yellowish brown on weathered surfaces and pale purplish grey on fresh surfaces. Its texture is fine to medium-grained phaneritic. Quartz, potash feldspar, plagioclase, biotite and occasional hornblende are visible in hand specimens. A few coarse euhedral feldspar crystals are occasionally present, and give the rock a porphyritic appearance.

Biotite, common less than 5% of the rock, locally occurs in larger amounts as segregations of varying size. An increase in biotite is also present at the outer contact between quartz monzonite and younger diorite intrusions, at the north end of the Ireteba Peaks. This gives the quartz monzonite a darker grey color than it usually has.

Five samples were studied in thin sections (see Table 2.). Under the microscope, the rocks show a seriate, hypidiomorphic-granular texture. Sample 35 shows small areas of xenomorphic texture which suggest a transition into aplite. The rocks consist mainly of orthoclase, sodic plagioclase, and quartz, all intimately associated. Minor amounts of biotite, magnetite, ilmenite, and sphene are also present. Traces of hornblende, epidote, and rutile are sometimes present. Table 2 is a summary of the main constituents.

Table 2. Late Quartz Monzonite - Mineral Composition

		Plagioclase				Magnetite		
Sple.	Ortho-clase	Albite	Oligo-clase	Quartz	Bio-tite	& Ilmenite	Other Access.	Location
200	46	--	30	20	1	2	1	SE 1/4, Sec. 20, T. 26 S., R. 64 E.
300	42	--	32	24	1	tr.	tr.	
700	40	--	31	26	2	1	tr.	
35	54	23	--	20	2	tr.	tr.	NW 1/4, Sec. 29, T. 26 S., R. 64 E.
20	54	26	--	15	2	2	1	SE 1/4, Sec. 19, T. 26 S., R. 65 E.

Orthoclase is fine to medium-grained, anhedral to euhedral, and strongly kaolinized. Plagioclase is fine to medium-grained, mostly subhedral, and slightly to moderately sericitized along cracks. A few plagioclase crystals show oscillatory zoning. A few crystals are enclosed by jackets of orthoclase in samples 200, 300, and 700. Plagioclase occurs mainly as perthitic patches within orthoclase in Samples 35 and 20. Quartz is fine to medium-grained and anhedral.

Biotite is fine to medium-grained, euhedral to subhedral, and sometimes contains minute, rounded inclusions of apatite. Biotite is slightly altered to chlorite, magnetite, and leucoxene. Magnetite occurs also as fine, anhedral to euhedral grains scattered through the rocks. A few fine grains of anhedral ilmenite and euhedral sphene, both partly altered to leucoxene, are also present. Traces of fine-grained, euhedral hornblende occur in Samples 20 and 35. A trace of fine-grained anhedral epidote is present in Sample 20. A few fine needles of rutile occur in Sample 35.

Microscopic features show these rocks, similar in their field relations and appearance in hand specimens, to actually represent two distinct facies. The samples from Knob Hill (200, 300, and 700) are true quartz monzonites. The other samples are actually transitional between granite and quartz monzonite.

These rocks intrude the early quartz monzonite and the older gneisses and schists. They grade into finer-grained porphries at their outer margins, cutting across the older rocks in sharp contacts. Flow structure, shown by sub-parallel alignment of biotite flakes, appears sporadically near the outer margins. Angular, randomly oriented, dark colored xenoliths (see p. 45) are engulfed in late quartz monzonite, 1/4 mile northwest of Tule Spring. The xenoliths range in width up to about 5 feet, and in length up to many tens of feet.

The late quartz monzonite is intruded in turn by acidic to basic dikes. It is also overlain non-conformably by andesite flows at the NW 1/4, Sec. 24, T. 26 S., R. 64 E.

d. Rhyolite-andesite porphyries

Rhyolite-andesite porphyries are widely distributed throughout the area and are exceeded only by late quartz monzonite in abundance. Rhyolite-andesite porphyries are generally weathered into a rubble of variable-sized angular rock fragments. Some outcrops, however, stand out sharply against older rocks (see Figure 6).

The porphyries are brownish yellow on weathered surfaces, and pale pink on fresh surfaces. Their texture is aphanitic porphyritic. Megascopic phenocrysts, usually less than 2 mm. in diameter, consist predominantly of white feldspar with subordinate chloritized biotite and occasional quartz. The phenocrysts constitute 5 to 40% of the rocks. Parallel alignment of phenocrysts, indicating flow structure, is sometimes present. The groundmass generally has a chalky, altered appearance.

Five samples were studied in thin sections (see Table 3). Under the microscope the rocks show a felsophyric texture. Phenocrysts of highly altered plagioclase and orthoclase, quartz, chloritized biotite, and magnetite occur in a cryptocrystalline groundmass. Traces of ilmenite, hornblende, augite, sphene, and apatite are sometimes present. The relative abundance of the various phenocrysts differs widely, and gives the rocks an apparent compositional range from rhyolite to andesite.

Figure 6 - Rhyolite-andesite Dikes Cutting Precambrian Gneisses and Schists -
View is west from the SW 1/4, Sec. 23, T. 26 S., R. 64 E. Both the resistant ridges and the white patches are of rhyolite-andesite porphyry. Medium-toned material is gneiss and schist. Dark patches are of andesite-latite. Note northerly trending fault in foreground.

Table 3. Rhyolite-andesite Porphyries - Mineral Composition

Sple.	Olig.	Olig.-Andes.	Andes.	Orth.	Qtz.	Bio-tite	Access-ories	Crypto-xlline gmass.	Location
28	tr.	--	--	2	2	tr.	1	95	SW 1/4, Sec. 20, T. 26 S., R. 65 E.
7	--	8	--	19	7	tr.	1	65	SE 1/4, Sec. 22, T. 26 S., R. 64 E.
22	--	25	--	--	17	tr.	2	56	SE 1/4, Sec. 19, T. 26 S., R. 65 E.
40	--	--	39	12	tr.	3	2	44	NW 1/4, Sec. 21, T. 26 S., R. 64 E.
9	--	--	25	18	10	2	3	42	SE 1/4, Sec. 22, T. 26 S., R. 64 E.

Plagioclase laths, fine to medium-grained and euhedral to subhedral, vary in composition from oligoclase to andesine. The larger laths are andesine, and the smaller ones oligoclase, in Sample 7. Orthoclase is fine to medium-grained, and euhedral to anhedral. All the feldspars show distinct altered characteristics as follows:

Sample 7 - Slight kaolinization; slight sericitization

28 - Moderate kaolinization;

9 - Intense kaolinization; moderate sericitization

40 - Intense sericitization

22 - Intense saussuritization

Quartz occurs mainly as fine to medium-grained, euhedral phenocrysts in Samples 28, 7, and 22. Small amounts of quartz are graphically intergrown in orthoclase in Sample 28. Some quartz appears as blebs in the groundmass of Sample 22. Quartz is restricted to fine, anhedral blebs in the groundmass of Samples 40 and 9.

Biotite is fine-grained and euhedral to anhedral. It is strongly altered to chlorite and magnetite. Magnetite occurs also as minute, euhedral to anhedral grains scattered through the groundmass.

Fine-grained, euhedral to anhedral ilmenite, partly altered to leucoxene, occurs in the groundmass of Samples 22, 40 and 9. Fine-grained hornblende is present in Samples 40 and 9. It is subhedral and largely altered to a cryptogranular aggregate of chlorite, calcite and epidote in Sample 40. Hornblende occurs as euhedral inclusions in the plagioclase of Sample 9.

Augite is present in Sample 40. It is fine-grained, anhedral to subhedral, and strongly altered to an aggregate of chlorite, calcite and epidote. Fine-grained, euhedral sphene and apatite are also present in Sample 40.

The cryptocrystalline groundmass is packed with microlites(mainly altered feldspars?). Spherulites, probably of intergrown alkali feldspar and silica, occur in the groundmass of Samples 28, 7, and 40. Spherulitic rims surround a few feldspar phenocrysts in Sample 28. Abundant interstitial glass is also present in the groundmass of Sample 28. Fine-grained, anhedral calcite and epidote, probably of secondary origin, are closely associated in the groundmass of Samples 22, 9, and 40. They also fill tiny fissures in Sample 40.

Rhyolite-andesite porphyries occur as a chilled and gradational border phase of late quartz monzonite. Dikes and chonoliths of the porphyries also intrude late quartz monzonite and subsequent andesite flows, as well as the older rocks. These relationships suggest that the rhyolite-andesite porphyries represent either a long-continued period of intrusion, or two separate periods of intrusion which yielded identical rock types. A few minor flows of this composition, too small to map, are also present. One such flow overlies andesite extrusives at the NW 1/4, Sec. 24, T. 26 S., R. 64 E. Another flow (Sample 28) overlies Precambrian schist at the SW 1/4, Sec. 20, T. 26 S., R. 65 E. All other samples are from dikes.

Intermediate to basic intrusives and stringers of pegmatite invade the rhyolite-andesite porphyries. The latter grade locally into quartz diorite-monzonite porphyries and andesite-latite porphyry (p. 40).

e. Quartz diorite-monzonite porphyries

Quartz diorite-monzonite porphyries occur sporadically throughout the area. Outcrops resemble those of rhyolite-andesite porphyries, but are generally darker, coarser-grained and less weathered.

The rocks are pale red to reddish brown on weathered surfaces, and purplish red on fresh surfaces. In hand specimens they are strongly porphyritic. Phenocrysts, of pale grey feldspars and minor biotite, up to 5 mm. in diameter, comprise about 15% of the rocks. An aphanitic to medium-grained groundmass contains feldspars, quartz, biotite, and occasional hornblende.

Under the microscope the rocks show porphyritic texture. They consist of plagioclase, quartz, biotite, occasional orthoclase, and traces of magnetite, sphene, apatite, and zircon. Traces of hornblende and epidote sometimes occur. Feldspars, quartz, and biotite occur as phenocrysts, but are also present in the groundmass along with the minor accessory minerals. Abundant cryptocrystalline matrix, probably an admixture of altered feldspar and silica with minor mafic minerals, also appears in the groundmass. The latter shows a seriate, hypidiomorphic to felsitic texture. Mineral percentages are shown below.

Table 4. Quartz Diorite-monzonite Porphyry - Mineral Composition

Sample	Plagio-clase	Quartz	Biotite	Ortho-clase	Minor Acc.	Crypto-xlline matrix	Locality
21	25	12	2	33	1	27	SE 1/4, Sec. 19, T. 26 S., R. 65 E.
32	63	6	2	—	2	27	SW 1/4, Sec. 20, T. 26 S., R. 64 E.

Plagioclase is medium to fine-grained, and euhedral to subhedral. Crystal faces show progressively poorer development with diminishing grain size. A few phenocrysts show oscillatory zoning. Plagioclase, in Sample 32, is not of uniform composition; oligoclase-andesine predominates, but a few phenocrysts of labradorite are also present. The plagioclase is andesine in Sample 21. Plagioclase phenocrysts show slight to moderate kaolinization; groundmass laths are partly saussuritized.

Fine-grained quartz occurs as anhedral intergrowths with groundmass feldspars, and also as phenocrysts. The latter are largely rounded and embayed; few of them are euhedral. Biotite is fine to medium-grained and subhedral to euhedral. It is partly altered to chlorite, magnetite and leucoxene. Fine-grained kaolinized orthoclase is in Sample 21, mainly as anhedral intergrowths with groundmass quartz, and also as euhedral phenocrysts and rims enveloping andesine laths.

Fine-grained, euhedral to anhedral magnetite is scattered through the groundmass. Magnetite is partly altered to hematite in Sample 32. Fine-grained euhedral sphene, partly altered to leucoxene, is also present in the groundmass. Fine-grained, euhedral inclusions of apatite and zircon occur in biotite. Apatite is also present, as inclusions in plagioclase and as minute crystals scattered through the groundmass in Sample 32. Zircon inclusions appear in quartz in Sample 21.

Fine-grained hornblende and epidote are present in Sample 32. Hornblende is euhedral to subhedral, and partly altered to chlorite. Epidote, anhedral to euhedral, occurs within the groundmass, and as an alteration product of plagioclase.

Quartz diorite-monzonite porphyries grade into and also intrude late quartz monzonite, in a similar manner as the rhyolite-andesite porphyries. They also grade into the latter rocks.

f. Minor acidic intrusions

Minor intrusions of aplite and pegmatite are widespread, but are quantitatively insignificant and too small to map.

The small, steeply-dipping aplite dikes generally range from about an inch to less than a foot in thickness and up to 50 feet in length. Two large prominently outcropping aplite dikes occupy near-vertical faults directly south of the large extrusive in the eastern part of the area. These dikes range in thickness from about 15 to 30 feet and extend 5,500 and 3,400 feet in length.

Aplites superficially resemble rhyolite-andesite porphyries and, unless examined closely, may be misidentified. Aplites are brownish yellow on weathered surface, and pale pink on fresh surfaces. They have a fine-grained sugary texture. Quartz, feldspar, and traces of biotite and epidote are barely distinguishable in hand specimens. Sparse patches of micropegmatite, less than a few inches square, appear in the rocks. Micropegmatites consist of larger crystals, of the above minerals, ranging up to 3 mm. in diameter.

Table 5. Aplite - Mineral Composition

Sample	Ortho-clase	Quartz	Albite	Allanite	Minor Acc.	Location
44	67	25	5	1	2	SE 1/4, Sec. 32, T. 26 S., R. 64 E.
45	64	32	tr.	2	2	SE 1/4, Sec. 32, T. 26 S., R. 64 E.

Under the microscope the rocks show xenomorphic-granular to micropegmatitic texture. They consist mainly of intimately associated, fine-grained orthoclase and quartz, with minor albite and allanite. Traces of fine-grained biotite, muscovite, magnetite, and zircon are also present.

Both orthoclase, strongly kaolinized, and quartz are anhedral to euhedral. A small amount of quartz is graphically intergrown in some of the larger orthoclase crystals of Sample 45. Albite is subhedral to anhedral. It is strongly kaolinized in Sample 45. Allanite is anhedral and altered to a smoky-brown mineraloid. Biotite and muscovite are euhedral to subhedral. Biotite is strongly altered to chlorite and magnetite. Additional euhedral to anhedral magnetite is scattered through the rocks. Euhedral zircon is also present.

The aplite dikes intrude early and late quartz monzonites. They also intrude biotite diorite (p. 43) dikes at the north end of the Ireteba Peaks.

Small irregular veins of pegmatite occur sporadically throughout the area. These range up to 4 feet in thickness and up to 30 feet in length. They most often appear as stringers only a few inches thick and a few feet long. The rocks are predominantly coarse-grained. Study was restricted to hand specimens. However, crushed mineral fragments from a typical sample (No. 16, SE 1/4, Sec. 22, T. 26 S., R, 64 E.) were examined in immersion oils under the microscope.

Feldspar and quartz, in widely varying proportions, characterize the rocks. Anhedral to euhedral, yellowish-white microcline feldspar contains microperthitic albite. Feldspars are kaolinized; minor sericite is also present. Bluish grey anhedral quartz replaces feldspar. Minor amounts of granular or fibrous green epidote sometimes occur in the pegmatite.

Pegmatites intrude gneisses and schists in the Ireteba Peaks and along the northern boundary of the area. They also intrude early and late quartz monzonites and biotite diorites in and around Knob Hill. Other intermediate and basic dike rocks (p. 40) and acidic porphyries, both north and west of Knob Hill, are cut by pegmatite dikes. The pegmatites fill fissures and often include xenoliths of brecciated wallrock. Some pegmatites occur as minor sill-like protuberances along foliation planes of gneiss and schist, and also as irregular isolated masses in the Knob Hill quartz monzonite. In the latter instance, the pegmatites appear to grade into the wallrock.

3. Intermediate and basic intrusives

a. Rock types and distribution

Dark-colored intermediate and basic dikes, plugs and chonoliths are distributed throughout the entire area. Individual intrusions, like those of the acidic rocks, are mostly too small to map, but often occur in swarms which can be delineated. In decreasing order of abundance, the rocks include andesite-latite porphyry, biotite diorite, diabase, propylite, dacite prophyry, hornblende andesite porphyry, and gabbro. Trends of dikes are similar to those described for the acidic intrusives. These rocks, with minor exceptions are later than the acidic intrusives.

b. Andesite-latite porphyry

Dikes and chonoliths of andesite-latite porphyry, commonly present throughout the area, weather into variable-sized angular rock fragments. The rocks are green to reddish-brown on weathered surfaces, and red-grey on fresh surfaces. Texture is aphanitic porphyritic. Phenocrysts of white feldspar and minor chloritized biotite in a red-grey aphanitic groundmass characterize the rocks in hand specimens. Phenocrysts range up to 5 mm. in diameter, and comprise 5 to 20% of the rocks. The rocks may superficially resemble quartz diorite-monzonite porphyries, but are finer-grained and more intensely weathered.

Four samples were studied in thin sections (see Table 5). Under the microscope the rocks show a felsophyric texture. Feldspar, biotite,

te, and occasional traces of hornblende, augite, sphene, and ilmenite occur as phenocrysts. Feldspars, quartz, epidote, calcite, zeolites (?), and interstitial glass are distinguishable in the predominantly cryptocrystalline groundmass.

Table 6. Andesite-latite Porphyry - Mineral Composition

Sple.	Albite-Oligoclase	Andesine	Sanidine	Orth.	Qtz.	Bioti	Access.	cryptoxlline matrix	Location
8	—	12	4	—	5	2	2	75	SE 1/4 Sec. 22,
10	—	8	—	—	tr.	tr.	2	90	T. 26 S., R 64 E.
41	—	79	—	5	5	tr.	1	10	NW 1/4, Sec. 21, T. 26 S., R. 64 E.
36	2	—	2	—	5	tr.	1	90	NW 1/4, Sec. 29, T. 26 S., R. 64 E.

Plagioclase, fine to medium-grained and euhedral to subhedral, occurs as phenocrysts; it also appears as tightly-woven microlites in the groundmass of Sample 41. The plagioclase is albite-oligoclase in Sample 36; it has an average composition of andesine in all the other samples, ranging from labradorite in the larger crystals to oligoclase-andesine in the smaller crystals. A few crystals show normal zoning. Plagioclase is strongly kaolinized, with some saussurite also present.

Euhedral sanidine phenocrysts, fine to medium-grained, are slightly kaolinized along cracks. Fine-grained orthoclase occurs as anhedral kaolinized blebs intergrown with quartz in Sample 41.

Fine-grained anhedral quartz is present in the groundmass; it also appears as rounded inclusions in the plagioclase of Sample 8. Biotite, fine to medium-grained and euhedral to anhedral shows slight to intense chloritization. It contains zircon and apatite inclusions in Sample 8. Magnetite is fine-grained and euhedral to anhedral; a few grains are partly altered to hematite.

Hornblende is present in Samples 8 and 41. It is fine-grained, euhedral to subhedral, and partly chloritized. Augite, fine-grained and euhedral to anhedral, appears in Samples 10 and 41. It is partly replaced by chlorite and epidote (?). Fine-grained, euhedral sphene, partly altered to leucoxene, is present in samples 8 and 41. Fine-grained, euhedral to subhedral ilmenite, partly altered to leucoxene, occurs in Sample 8.

Traces of secondary fine-grained epidote are present in groundmass of Samples 8, 10, and 36. Traces of fine-grained anhedral calcite and euhedral zeolites (?) are associated with epidote in Sample 10. Interstitial glass is present in the groundmass of Samples 10 and 36.

The andesite-latite porphyry intrudes gneisses, schists, quartz monzonites, biotite diorite, and rhyolite-andesite porphyry. The rock also grades into rhyolite-andesite porphyry northwest of Tule Spring. This suggests that the intrusion of andesite-latite followed that of the rhyolite-andesite in a continuous succession without any great time gap. Andesite-latite may possibly grade into the similar-appearing quartz diorite-monzonite porphyry as well, although its relationship to the latter rock was not noted in the field. Pegmatite veins, in turn, intrude the andesite-latite porphyry.

c. Biotite diorite

Plugs and dikes of biotite diorite are present the west flank of the Eldorado Mountains, and near the north margin of the prong-shaped intrusiv . Most outcrops are badly weathered to pebble-sized fragments. A few outcrops form resistant ridges. The rocks are dark greenish-grey, both on weathered and fresh surfaces. They are fine to medium-grained phaneritic and show feldspars, abundant chloritized biotite, minor pyroxene, and aphanitic carbonates in hand specimens.

Under the microscope, the rocks show a panidiomorphic seriate texture. They consist of plagioclase, biotite and augite; minor magnetite, quartz and apatite; with occasional orthoclase, sphene, and a crypto-crystalline matrix of secondary minerals.

Table 7. Biotite Diorite - Mineral Composition

Sple.	Plag.	Orth.	Bio-tite	Augite	Magn.	Minor Acc.	Crypto-xlline matrix	Location
11	72	1	22	3	1	1	—	SE 1/4, Sec. 22, T. 26 S., R. 64 E.
14	71	—	14	7	2	1	5	SE 1/4, Sec. 22, T. 26 S., R. 64 E.

Plagioclase is fine to medium-grained, and euhedral to anhedral. It is mostly oligoclase-andesine, but a few crystals of labradorite are also present. Plagioclase is intensely saussuritized. A few crystals show normal zoning. Orthoclase occurs in Sample 11. It is fine-grained, anhedral to euhedral, and strongly kaolinized.

Biotite is fine-grained, euhedral to subhedral, and strongly altered to chlorite, magnetite and leucoxene. Augite is medium to fine-grained, and euhedral to subhedral. It is strongly altered to chlorite, calcite, magnetite and leucoxene. Additional magnetite, fine-grained and anhedral to euhedral, is scattered through the rocks. Traces of fine-grained anhedral quartz fill interstices between feldspar grains. A little fine-grained euhedral apatite is present. Traces of fine-grained euhedral sphene occur in Sample 11. A predominantly cryptocrystalline matrix contains fine-grained, anhedral to subhedral chlorite, anhedral magnetite, and cryptocrystalline calcite. This matrix has probably resulted from the alteration of biotite and augite.

A somewhat more acidic facies of this diorite occurs as minor dikes sparsely distributed throughout the area. The rock is green on weathered surfaces and medium grey on fresh surfaces. It is fine-grained phaneritic, and shows feldspar and chloritized biotite in hand specimens. Some of the biotite grains are clustered into ovoid segregations. Aphanitic carbonates are also present in the rocks.

Sample No. 23 from SE 1/4, Sec. 19, T. 26 S., R. 65 E. shows a hypidiomorphic seriate texture under the microscope. It contains fine-grained plagioclase (72%), orthoclase (7%), quartz (7%), biotite (7%), and a cryptocrystalline matrix (6%). Traces of augite and magnetite are also present.

Two types of plagioclase, oligoclase-andesine and subordinate labradorite, are present. Plagioclase is mostly subhedral, and moderately kaolinized. A few crystals show oscillatory zoning. Both orthoclase, moderately kaolinized, and quartz are anhedral to euhedral. Biotite is euhedral, and contains minute inclusions of apatite and zircon. Biotite is partly altered to chlorite, magnetite and leucoxene. Augite is subhedral and partly altered to chlorite, magnetite, leucoxene, and calcite. Magnetite occurs also as tiny euhedral to anhedral grains scattered through the rock. Cryptocrystalline matrix, probably consisting largely of calcite, occupies intergranular spaces and minute fissures in the rocks.

Biotite diorite intrudes gneisses, schists, early and late quartz monzonites. At the north end of the Ireteba Peaks, the intrusion of diorite into late quartz monzonite has been accompanied by biotitization of the country rock within several feet of the contacts. The diorite is intruded by dikes of aplite, pegmatite, rhyolite-andesite and andesite-latite porphyries.

At 1/4 mile northwest of Tule Spring, biotite-rich xenoliths, strongly resembling diorite, are engulfed in late quartz monzonite. These may be explained by one of the following possibilities: 1) The periods of intrusion of quartz monzonite and diorite were not everywhere separated by a clear-cut time gap, but rather overlapped locally, 2) Two separate generations of biotite diorite are present in the area, 3) An older basic rock (e.g., hornblende schist), upon being engulfed in acid magma, was converted into biotite-rich aggregates of intermediate composition.

d. Diabase

Diabase dikes occur along the western flank of the area. They sometimes resemble diorite or andesite-latite in weathered outcrops, but generally show a greater tendency to form resistant ridges. The diabase is pale to dark green on weathered surfaces, and dark green on fresh surfaces. Texture is aphanitic to fine-grained phaneritic, though an occasional grain may attain a diameter of 2 mm.

The rocks appear to consist largely of a chloritic matrix. Laths of dark-colored striated plagioclase and subordinate pyroxene are visible in hand specimens. Traces of quartz, hornblende, and aphanitic calcite are occasionally found.

Under the microscope the rocks show an intersertal texture. They consist mainly of interlocking plagioclase laths with a chloritic matrix filling the interstices between laths. Relict grains of pyroxene and hornblende occur within this matrix. Minor amounts of other minerals are also present. All of the minerals are fine-grained.

Table 8. Diabase - Mineral Composition

Sple.	Plag.	Pyr.	Horn.	Bio-tite	Chlor.	Magn.	Minor Acc.	Crypto-xlline matrix	Location
38	45	5	tr.	--	7	2	1	40	NW 1/4, Sec. 29, T. 26 S., R. 64 E.
39	57	tr.	tr.	1	10	tr.	1	29	NW 1/4, Sec. 29, T. 26 S., R. 64 E.

Plagioclase is mainly andesine-labradorite, with minor bytownite also present. A few laths show oscillatory zoning. Plagioclase is subhedral to euhedral, and moderately to strongly saussuritized. Pyroxenes are mostly subhedral; a few anhedral and euhedral grains are also present. Pyroxene is mostly augite with subordinate hypersthene. Hornblende is euhedral to anhedral. Euhedral to anhedral biotite is present in Sample 39. The pyroxene, hornblende and biotite all show intense alteration to chlorite and magnetite. Chlorite is the most abundant of the recognizable mafic constituents. It appears as subhedral to euhedral flakes, and also as partial pseudomorphs after the other mafics, particularly pyroxene.

The mafic minerals occur in a cryptocrystalline groundmass which fills the interstices between plagioclase laths. This cryptocrystalline aggregate probably consists of such secondary minerals as chlorite, calcite, and epidote. Small amounts of glass, and traces of anhedral quartz and euhedral to anhedral magnetite are scattered through this matrix. Traces of euhedral to anhedral orthoclase, and euhedral epidote, apatite and garnet are present in Sample 39.

Diabase dikes intrude gneisses and schists southwest of Knob Hill. They intrude gneisses, schists and rhyolite-andesite porphyries in the southern half of the Ireteba Peaks. They cut early and late quartz monzonites in the northern end of the Ireteba Peaks and in the E 1/2, Sec. 28, T. 26 S., R. 64 E. The relation of diabase to other rock types was not determined. However, it is assuredly younger than the acidic intrusives.

e. Propylite (Deuterically altered intrusive)

Small dikes and knobs of propylite, a few feet across, are distributed throughout the entire area. The rocks are dark greenish brown, both on weathered and fresh surfaces. They are aphanitic in hand specimens, but sometimes show traces of fine-grained quartz and pyrite. They effervesce slightly, when treated with acid, indicating the presence of carbonates.

Samples from the following localities were studied in thin sections:

Sample 6 - SE 1/4, Sec. 22, T. 26 S., R. 64 E.

Sample 42 - NW 1/4, Sec. 21, T. 26 S., R. 64 E.

Sample 6 consists mainly of fine-grained anhedral feldspar which has been almost completely altered to a saussuritic aggregate, so that its original composition is no longer discernible. Segregated patches of epidote and chlorite are also present. The epidote is cryptocrystalline. Chlorite is mostly cryptocrystalline, but some of it occurs as readily distinguishable subhedral flakes. Minute anhedral grains of magnetite and leucoxene are associated with chlorite. Traces of subhedral garnet are also present. Tiny veinlets of pyrite, almost completely replaced by limonite, cut across the rock.

Sample 42 consists mainly of rounded intergrowths of anhedral quartz and albite, set within a cryptocrystalline matrix. This matrix consists of segregated patches of chlorite, calcite and epidote, in decreasing order of abundance. These constituents show a sub-parallel layering suggestive of relict flow structure. Subhedral plates of relict biotite are associated with the chlorite. Anhedral grains of magnetite, leucoxene and sphene also appear in the rock. The rock is cross-cut by fine veinlets of limonite.

These rocks intrude gneisses, schists, quartz monzonites, and rhyolite-andesite porphyries. Propylite is intruded by veins of pegmatite, to the north and northeast of Knob Hill.

The propylite has resulted from intense hydrothermal alteration, of a pre-existing basic or intermediate dike rock. This alteration, virtually obliterating the original features of the dikes, has nowhere affected the country rock to such a great extent. This strongly suggests that the propylites resulted from the deuteric activity of fluids trapped within them prior to their final cooling. Supergene waters later affected the rocks, as shown by the replacement of pyrite by limonite.

f. Dacite prophyry

Dikes of dacite prophyry are sparsely distributed throughout the area. They appear fairly resistant to weathering, and stand out sharply against older rocks. Dacite is grey on weathered surfaces, and purple on fresh surfaces. Texture is aphanitic porphyritic. Megascopic phenocrysts of white feldspar and colorless quartz, up to 2 mm. in diameter, comprise about 2% of the rocks. The aphanitic groundmass is dark purple, but locally shows a reddish cast. The rocks show conspicuous flow structure.

Sample 37, from NW 1/4, Sec. 24, T. 26 S., R. 64 E., under the microscope shows phenocrysts of oligoclase-andesine (2%), quartz (1%), magnetite and hematite (1%), orthoclase (tr.) and biotite (tr.), in a cryptocrystalline to glassy groundmass (96%). Phenocrysts show parallel alignment (flow structure).

Oligoclase-andesine is fine to medium-grained, euhedral to anhedral, and intensely saussuritized. Quartz occurs as fine-grained, rounded and embayed anhedra. Fine-grained, euhedral to anhedral magnetite, and anhedral hematite are scattered through the groundmass. Orthoclase is fine-grained, euhedral to anhedral, and strongly kaolinized. Biotite is fine-grained, euhedral, and partly altered to chlorite, magnetite and leucoxene.

The groundmass consists mainly of cryptocrystalline aggregates, probably of feldspar and silica. Abundant interstitial glass, crowded with unidentified microlites, is also present. In plain light, parallel trains of green microlites appear to follow flow directions.

The dacite intrudes quartz monzonite between Knob Hill and the north end of the Ireteba Peaks. Dacite dikes also intrude rhyolite-andesite porphyry 1-1/2 miles northwest of Tule Spring, and gneiss west of Knob Hill.

g. Hornblende andesite porphyry

Minor dikes of hornblende andesite porphyry occur 1/2 mile north of Tule Spring and in the southwestern part of the Ireteba Peaks. They are pale green on weathered surfaces and chocolate-brown on fresh surfaces. Fine to medium-grained phenocrysts of striated plagioclase and hornblende are sparsely distributed in an aphanitic groundmass. Due to the apparently limited occurrence of these rocks, they were not studied in further detail. The dikes intrude early and late quartz monzonite.

h. Gabbro

A few small rounded knobs of gabbro, less than 6 feet in diameter, are sparsely distributed along the Ireteba Peaks. The rocks are dark green, medium-grained, and consist of plagioclase and pyroxene. No samples were collected for thin-section study. The gabbro intrudes gneisses, schists and early quartz monzonite. It may be related to the diabase.

4. Andesite extrusives

An extrusive andesite body occurs in the northeast corner of the area in the vicinity of the Capitol Camp group of mining claims. This fairly flat-lying extrusive shows pronounced flow structure and columnar jointing, best displayed along the road in the W 1/2 Sec. 20, T. 26 S., R. 65 E. Here the extrusive shows a maximum thickness of about 120 feet. It thins out northeastward and locally exposes inliers of older rock. Remnants of similar flows, too small to map, occur intermittently along the northern boundary of the area on the higher hills.

The extrusive weathers to a brown clayey soil containing occasional pebbles of the original rock. The rocks are variegated on weathered surfaces, and drab greenish-grey to red on the freshest surfaces. They are aphanitic porphyritic. Megascopic phenocrysts of white plagioclase comprise 0-10% of the rocks. Phenocrysts are mostly fine-grained, but occasionally range up to 3 mm. in diameter. A few of them show zoning. The rocks contain abundant aphanitic carbonates.

Samples were taken from the following localities:

Sample 12 - SE 1/4, Sec. 22, T. 26 S., R. 64 E.

Sample 25 - SW 1/4, Sec. 20, T. 26 S., R. 65 E.

Under the microscope they show fine-grained phenocrysts of altered plagioclase, and magnetite in a glassy to cryptocrystalline groundmass. Small amounts of calcite and hematite sometime appear. The plagioclase is euhedral to anhedral, and so highly saussuritized that the exact species is undeterminable. Much of the plagioclase occurs only as skeletal crystals in Sample 12. Plagioclase shows parallel alignment indicative of the known flow structure. Magnetite is euhedral. Glass occupies most of the groundmass in Sample 12, but is subordinate in Sample 25. The cryptocrystalline matter is green and probably contains abundant chlorite. Some calcite is present in the groundmass of Sample 25. The latter rock is cut by a few fine veinlets of hematite.

The extrusive near Capital Camp is extremely altered in places to a quartzose aggregate. The latter is dark purple and mottled with variegated colors on weathered surfaces. On fresh surfaces it is grey, with sub-parallel brownish streaks due to relict flow structure. Texture is aphanitic to medium-grained phaneritic. The grey portion consists mainly of quartz. The brownish streaks consist largely of muscovite in an aphanitic matrix. Aphanitic carbonates are also present. Biotite, chlorite and epidote are occasionally visible. The rocks are cross-cut by tiny veinlets of limonite which contain an occasional grain of pyrite.

Two samples (26 and 27) from this locality were studied in thin sections. Under the microscope the rocks show mainly fine to medium-grained anhedral quartz. Patches of the following minerals fill the interstices between quartz grains: fine-grained subhedral chlorite, associated with anhedral to euhedral magnetite, anhedral leucoxene, and subhedral biotite; fine to medium-grained, euhedral to subhedral muscovite; a cryptocrystalline matrix probably of calcite; and traces of fine-grained subhedral prisms and fibers of epidote. The rocks are cut by minute veinlets of hematite, and of limonite which replaces pyrite.

The extrusives overlie gneisses and schists near Capitol Camp. Elsewhere along the northern margin of the area, extrusive outliers nonconformably overlie gneisses, schists, early and late quartz monzonite. The andesite is, in turn, intruded by dikes of rhyolite-andesite porphyry. A flow of the latter overlies the former in the NW 1/4, Sec. 24, T. 26 S., R. 64 E. According to Hansen (personal communication, 1961) the andesite extrusives are part of the lower Patsy Mine volcanic series exposed along Eldorado canyon, north of the mapped area.

5. Concluding statement

The igneous rock types in the area show the following sequence:

Table 9. Sequence of Igneous Rocks

(Most abundant and widely distributed rock types are capitalized.)

EARLY QUARTZ MONZONITE	———— —?
LATE QUARTZ MONZONITE	————
RHYOLITE-ANDESITE and Quartz diorite-monzonite porphyries	————
ANDESITE-LATITE and Dacite Porphyries, and extrusive andesite	————
Aplite and pegmatite	?— — — — — — — — —?
Biotite diorite	—
Gabbro	?— — — — — — — —?
Diabase, propylite and hornblende andesite porphyry	———

A detailed account of the genesis of the igneous rocks is beyond the scope of this report. However, a few remarks may be made, on the basis of the gathered data, in accordance with the principles set forth by Turner and Verhoogen (1951, pp. 66-76, 111-123, 212-24, 258-367). It is apparent that a complex scheme of magmatic evolution must have taken place. If these rocks had evolved along a simple line of descent (i.e. fractional crystallization from a single parent magma), the more basic rocks would have crystallized first, and the more acidic rocks would have crystallized later. Table 9 shows that such is not the case in this area. In fact, Plate I clearly indicates that the basic and intermediate rocks are mostly later than the acidic rocks. It is tentatively suggested that the intrusion of acidic magma was closely followed in an overlapping sequence, by that of a more basic magma from a deeper portion of the earth's crust. During this time, magmas were possibly contaminated by intermixing and/or by wallrock assimilation. This statement is supported by: 1) Wide mineralogical variations within rhyolite-andesite and quartz diorite-monzonite porphyries, 2) presence of orthoclase, labradorite, and euhedral quartz within same rock (biotite diorite), 3) oscillatory zoning of plagioclase.

Hydrothermal alteration has affected the igneous rocks. Chloritization of mafic minerals pervades the entire area. Feldspars almost invariably show some alteration to sericite or saussurite, and to ''kaolin'' (the last may be at least partly due to weathering, however). Propylite, extrusive andesite, diabase and biotite diorite are the most intensely altered rocks. Late quartz monzonite is least altered, probably because it is cut by fewer fissures than the other rocks.

No direct proof of the rocks' age exists in the mapped area. Longwell (1936, pp. 1413-19; 1950, pp. 427-8) regards the post-Precambrian igneous rocks of eastern Nevada as probably Tertiary, although perhaps older, on the basis of their regional setting in the Basin and Range Provience. Bowyer, Pampeyan and Longwell (1958) have assigned Cretaceous-Tertiary and Tertiary ages respectively to the intrusive and extrusive rocks of Clark County, except for granites of the Precambrian complex. Hewett (1956, pp. 51-2, 73-92, 110) considers the quartz monzonite and associated dike rocks as Upper Cretaceous - Early Tertiary, and most of the extrusives as Middle Tertiary, in the neighboring Ivanpah Quadrangle. Elsewhere, in the vicinity of the mapped area, the extrusives and shallow intrusives have been regarded, with varying degrees of assurance, as Tertiary (Ransome, 1907, pp. 65-7; Ferguson, 1929, pp. 131-5; Callaghan, 1939, pp. 148-9; Lausen, 1931, pp. 26, 43).

An Upper Cretaceous (?) - Tertiary age is thus suggested for those igneous rocks younger than the early quartz monzonite. The age of the latter rock is more questionable. The early quartz monzonite is mineralogically similar to some facies of the Upper Cretaceous - Early Tertiary intrusive described by Hewett (pp. 61-66) but, unlike the latter, it exhibits no sharp contacts with the gneisses and schists; it instead displays migmatitic features suggestive of deeper-seated Precambrian granites. Furthermore, Longwell (1936, pp. 1404-6) and Bowyer, Pampeyan and Longwell (1958) include granitic intrusives as part of the Precambrian basement. Therefore the early quartz monzonite may possibly be Precambrian, although it is mapped with the more assuredly Upper Cretaceous (?) - Tertiary rocks for the reasons mentioned earlier in this chapter.

D. Quaternary Surficial Deposits

A thin veneer of loose rock fragments, with more or less soil, covers most of the bedrock in the area; where the debris is in place and has had little or no transportation, it is mapped as part of the original bedrock. However, transported detritus, accumulated in such a way as to obscure the position of the underlying bedrock contacts, is mapped separately as alluvium and rockslide breccia.

The alluvium is a poorly sorted mixture of angular to subrounded rock fragments ranging in size from sand to boulders. It is indurated, in places, by a carbonate cement.

The alluvium forms piedmont slopes on the lowland plains which flank the Eldorado range. The detritus is thickest on the east flank. In the southeast corner of the area, dissection of the piedmont slopes, by easterly-flowing intermittent streams, shows the alluvium to be as much as 100 feet thick. The detrital cover is much thinner on the west flank of the area. Here, the thickness ranges from zero, where local patches of bedrock (pediment surfaces) are exposed, to about 15 feet in some southwesterly-trending arroyos. Isolated valleys in the center of the area, and dry washes extending from the mountains on to the lowland plains are also floored with alluvium (see Plate I).

Rockslide breccia covers the eastern and northwestern portions of the Ireteba Peaks except for inliers of bedrock appearing at the NW 1/4, Sec. 10, T. 27 S., R. 64 E. Breccia is also present near the center of the area about 2 miles east of Tule Spring. It consists of angular blocks, up to many tens of feet in diameter, chaotically strewn about in a soil matrix. The blocks are mainly quartz monzonite and acidic porphyries. Abundant blocks of intermediate and basic dikes and gneisses also occur on the Ireteba Peaks. Many blocks are slickensided. The thickness of the breccia is unknown, but it probably varies considerably. Rapid mechanical weathering along fault scarps has produced this breccia.

IV. STRUCTURE

A. General Statement

The structural features of the mapped area consist of foliation in the metamorphic rocks, igneous bodies, joints, and faults.

Good exposures of foliated metamorphic rocks with persistent trends were noted only at a few widely spaced localities. While details of the foliated structures are lacking, the northerly strike appears to give way to an east strike in the vicinity of the large easterly-trending pluton. This suggests a genetic relation between the two.

The easterly-trending pluton's contacts with the older rocks are extremely irregular. A medium-grained phase grades through a migmatite into the country rock, whereas numerous discordant apophyses of a finer-grained phase fray out into the country rock. Numerous smaller intrusions, generally occurring as swarms, cut the older rocks at variable, but generally steep, angles. The swarms show preferred trends, following those of joints. The dominant trends are northerly. Minor, fairly flat-lying flows occur, chiefly in the northeast corner of the area.

Joints show trends as shown in figures 7 & 8. They are mostly steeply dipping. Faults in the area show 3 main trends: 1) NW 2) N to NNE 3) ENE. These trends are somewhat similar to those of joints, and are likewise mostly steep-dipping. Movement along major northerly-trending faults appears to have tilted the Eldorado Mountains to the east. Subsequent movement along the prominent northwest-trending Tule Spring hinge fault lifted the Ireteba Peaks above the surrounding rock masses. Periods of igneous intrusion and faulting have overlapped.

B. Foliation

Foliation of the Precambrian metamorphic rocks is shown by a subparallel layering of their constituents, particularly the micas and chlorite. Minor wrinkles occur in the foliated rocks, but are not sufficient to give the rocks any noticeable lineation. Foliation, which often displays a banded appearance on airphotos (Smith, 1943, p. 240), cannot be so distinguished in the mapped area, because of the profusion of fractures and dike swarms. Foliation is visible, however, in individual outcrops.

The trend of the foliation often varies radically within the space of several feet. These frequent changes in strike and dip are partly due to displacement by small faults, loosening of bedrock by surface weathering, and possibly intricate folding.

Along the northern and eastern margins of the area, some fairly persistent trends are present (see Plate I). Foliation symbols on the map represent 8 or more readings at each of the localities noted. In the northern part of the area, the strikes range from N. 70° E. to N. 85° E. Dips range from 45° to 90°, both north and south. About 1-1/2 miles southwest of Tule Spring, the foliation strikes N. 30° E. and dips 75° SE. Near the south end of the Ireteba Peaks it strikes N. 10° W. and dips 60° NE.

The apparent parallelism between the trends of the foliation and large pluton in the vicinity of the pluton-gneiss contact suggest a genetic relationship between the foliation and intrusion. The precise nature of this relationship was not determined in the course of this study. Much more detail is needed to adequately determine the structure of the metamorphic rocks.

C. Igneous Bodies

Upper Cretaceous (?) - Tertiary igneous bodies (Chapter III) consist of a large easterly-trending pluton, numerous dikes and irregular intrusions, and minor flows. See Plate I.

The pluton in ground plan is an elongated, roughly arcuate, prong-shaped body, essentially of quartz monzonite. It occupies about 15 square miles, 11 of which lie within the mapped area. The pluton is about 6 miles long and averages about 2-1/2 miles in width. Its trend is northeasterly throughout most of its extent, but swings toward the southeast in the eastern part of the area. The dip is not readily ascertained since its contacts with the older rocks are extremely irregular. A medium-grained phase of the pluton grades in migmatite-fashion, into the Precambrian gneisses. Numerous apophyses, predominantly of finer-grained porphyries, extend from the pluton into the surrounding country rock.

Numerous smaller, heterogeneous intrusive bodies, of acidic to basic composition, everywhere cut the Precambrian gneisses and schists; a few of them cut the large pluton and the flows. These smaller intrusives occur as dikes, plugs and irregular masses. Minor stringers of pegmatite are locally concordant with schistosity. Intrusives are generally multiple and composite; simple dikes are rare.

Individual dikes range up to 300 feet in thickness and a mile in length, but are usually much smaller. They occur in such profusion as to constitute swarms. They follow pre-existing fracture directions as shown in Plate I, and figures 7 & 8. Dips range from 0 to 90° in all directions, but most commonly are 50 to 90°. Along the Ireteba Peaks the most common inclination is eastward.

Andesite extrusives nonconformably overlie gneisses, schists and quartz monzonite. They occur in the northeast corner of the area near Capitol Camp. Small outliers of these flows, too small to map, are present along the northern margin of the area. The flows are fairly flat-lying. They strike N. 30° E. and dip 0-2° SE near Capitol Camp. The outliers strike in various directions, dipping 0 to 3°. Minor intrusions of rhyolite-andesite porphyry cut the flows. These intrusions, themselves, locally reach the surface as small, discontinuous flows.

The igneous rocks are subsequently cut by joints and faults.

D. Joints

Joints are prevalent throughout the area and occur in all rock types. Individual joints range in length up to thousands of feet. They show variable trends. The preferred trends range from north-northeast to north-northwest in the Precambrian rocks, Northeasterly trends are predominant in the Upper Cretaceous (?) - Tertiary intrusives. Figure 7 indicates, in a semi- quantitative way, the frequency of the various joint trends. Figure 8 shows the distribution of joint trends in different parts of the mapped area. Dips of the joints are variable, and range up to 90° in all directions. The most prevalent dips are 50 to 90°.

In addition, the late quartz monzonite shows conspicuous flat-lying joints which may be due to sheeting (Billings, 1954, pp. 121-3). Joints of variable trends and dips are locally invaded by intrusives.

E. Faults

Faults occur throughout the area, and some 77 faults, both known and inferred, have been mapped. These range in length up to as much as

6 miles. In addition, numerous smaller faults are present. The mapped faults appear on airphotos as linear features, thousands of feet long, which cut indiscriminately across ridges and valleys alike. These lineaments represent crushed zones, fractures in bedrock, silicified ridges, alignments of vegetation, and abrupt rock contacts. They show definite patterns of trend, assuring a structural origin.

The faults, with few exceptions, can be classified into 3 groups according to trend: 1) NW 2) N to NNE 3) E to ENE. Measured dips are steep, generally ranging from 60 to 90°. The lack of good markers prevents determination of the displacement. In some cases, however, the small offsets of recognizable units suggest a very slight displacement. In other instances, the displacement is appreciable.

A minority of the noted lineaments were proven to be known faults. Most of the faults are inferred (see Plate I). Some of the latter might actually be joints. However, it seems unlikely that no movement has occurred along such large fractures, in view of the crustal instability of the region. The known faults are indicated by additional features, as shown in the following paragraphs.

A belt of discontinuous (?), en-echelon, normal faults bounds the west flank of the Eldorado Mountains. The faults trend northerly and dip 90° to 60° west. The gradual eastward slope of accordant summits (see Chapter II) suggests that relatively recent movement along these faults tilted the mountains eastward.

The known and proved faults are indicated by faceted spurs and a breccia zone of chaotically arranged, badly sheared blocks. In the extreme southwest corner, the actual fault trace lies west of the escarpment, and indicates that the latter is an erosional feature. On the pediment, about 1-1/2 miles west of the mountains and the above faults, an airphoto lineament suggests the presence of an additional fault of this set. Another northerly-trending fault, just below the crest of the Ireteba Peaks, exhibits a peculiar change in dip from steep westerly to steep easterly in the SE 1/4, Sec. 4, T. 27 S., R. 64 E. This may be due to local upthrusting, or subsequent deformation.

A set of inferred faults, trending ENE, cuts the northerly-trending faults. On two of the former, and in the northwest corner of the area, an apparent offset of northerly-trending faults and NNW-trending dikes suggests a left-handed strike-slip movement.

The most prominent fault in the area, called the Tule Spring fault, marks a sinuous, northwest course through the canyon separating the east and west blocks (see also Chapter II). This fault dips steeply eastward. It is a relatively recent feature and along most of its extent shows a demonstrably true fault scarp, the east flank of the Ireteba Peaks. It is less dissected than the west flank of the peaks. The Ireteba Peaks, comprising an upthrown horst block, is a complex of gneisses and schists invaded by numerous dikes. It rises well above the more erosion-resistant quartz monzonite pluton on the downthrown side.

The fault scarp is eroded back to a slope of 13 to 24 degrees, and shows at its base a series of triangular facets. An extensive zone of badly sheared rock, comprising a breccia of chaotically arranged blocks, some of which are slickensided, marks the present fault scarp. This material, torn loose by rapid weathering of the original scarp, is mapped, along with similar material on the west flank of the block, as a rockslide breccia (p. 56).

Other features along the fault trace include Tule Spring, marked by an unusually thick clump of vegetation, and thin veinlets of coarsely crystalline red calcite along the fault trace. Throughout most of its extent along the canyon floor, the actual trace of the fault is covered by alluvium.

The fault appears to be a hinge fault, with the amount of displacement increasing southward. Between Tule Spring and the crossroads north of Knob Hill, the fault is marked by low, discontinuous, slickensided scarps of quartz monzonite. North of the crossroads, beyond the mapped area, the topographic expression of the fault becomes more subdued, and dies out within 1-1/2 miles. South of Tule Spring, the scarp becomes progressively higher, reaching a maximum of 2872 feet in the southern part of the mapped area. The fault continues for at least 6 miles south of the mapped area according to Biddulph (personal communication, 1960).

Other faults of this north-westerly set, both known and inferred, run for apparently discontinuous distances along the east flank of the Ireteba Peaks. One such fault, joins the main fault 1/2 mile southeast of Tule Spring, and extends southeastward for 2 miles. It exhibits a peculiar change in dip. This fault, vertical at its ends, dips 40° E in the middle. Still other faults of this set possibly occur beneath the breccia cover, and may actually constitute a distributive fault zone.

The east block is cut by an intricate network of faults, mostly inferred, of north, east-northeast, and northwest trends. They are vertical to steeply dipping. The 2 largest faults trend north, and extend at least 3 miles from the middle of the area and possibly further. They dip 90°. In each case, the west wall is downthrown. Intermittently, along their strike, they exhibit polished faceted spurs, minor subsidiary faults and stringers of red calcite. They are marked along their entire extent by continuous linear depressions. The latter cut across erosion-resistant quartz monzonite, but are also locally diverted around masses of this rock. This suggests that they are at least partly due to erosion along the fault lines rather than exclusively due to the faulting itself. A zone of breccia occurs between the faults near their south end. The more westerly of these faults is intersected by a northeast-trending fault about 2-1/2 miles long. The latter dips 80° NW. It is marked by slickensided, triangular-faceted spurs (see figure 9).

A northerly-trending inferred fault extends along the east margin of the area, and the adjacent areas as well. This fault, visible only as an airphoto lineament on the bajada, lies just outside the mapped area.

The following sequence of fault movement is suggested in the west block: 1) Northerly 2) East-northeast 3) Northwest. This sequence is not uniformly developed throughout the entire block. Some recurrent movement probably took place during a later time of faulting, blurring the original sequence. A similar situation was noted by Biddulph (personal communication, 1960) in the southeast portion of the Nelson Quadrangle.

The sequence noted above is not apparent in the east block. Here the various fault trends were essentially of contemporaneous origin, or the amounts of movement were too slight to give a clear-cut pattern of offsets. In any case, recurrent movement must have taken place. The faults cut the large pluton and many smaller intrusive masses. Yet, apophyses of this pluton, as well as other dikes of similar and younger age, trend parallel to the later fault patterns. These features tend to support the concept of recurrent movement. Longwell (1950, p. 426) believes the original Basin and Range fracture patterns originated well before the epochs of Tertiary block-faulting. Movement along the older fractures has persisted into fairly recent times, as evidenced by the presence of a young fault scarp along the Tule Spring fault.

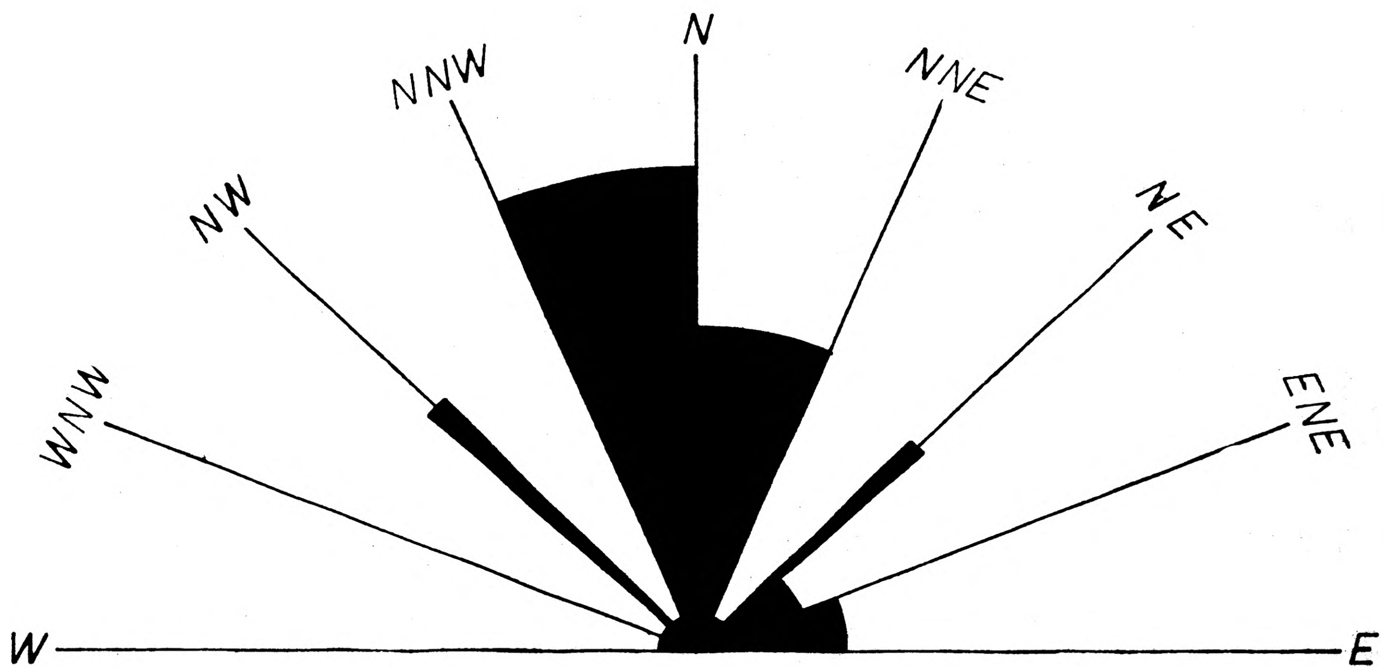

Figure 7. Schematic Diagram Showing Trends of Joints in Area-
Radius lengths indicate relative abundance.

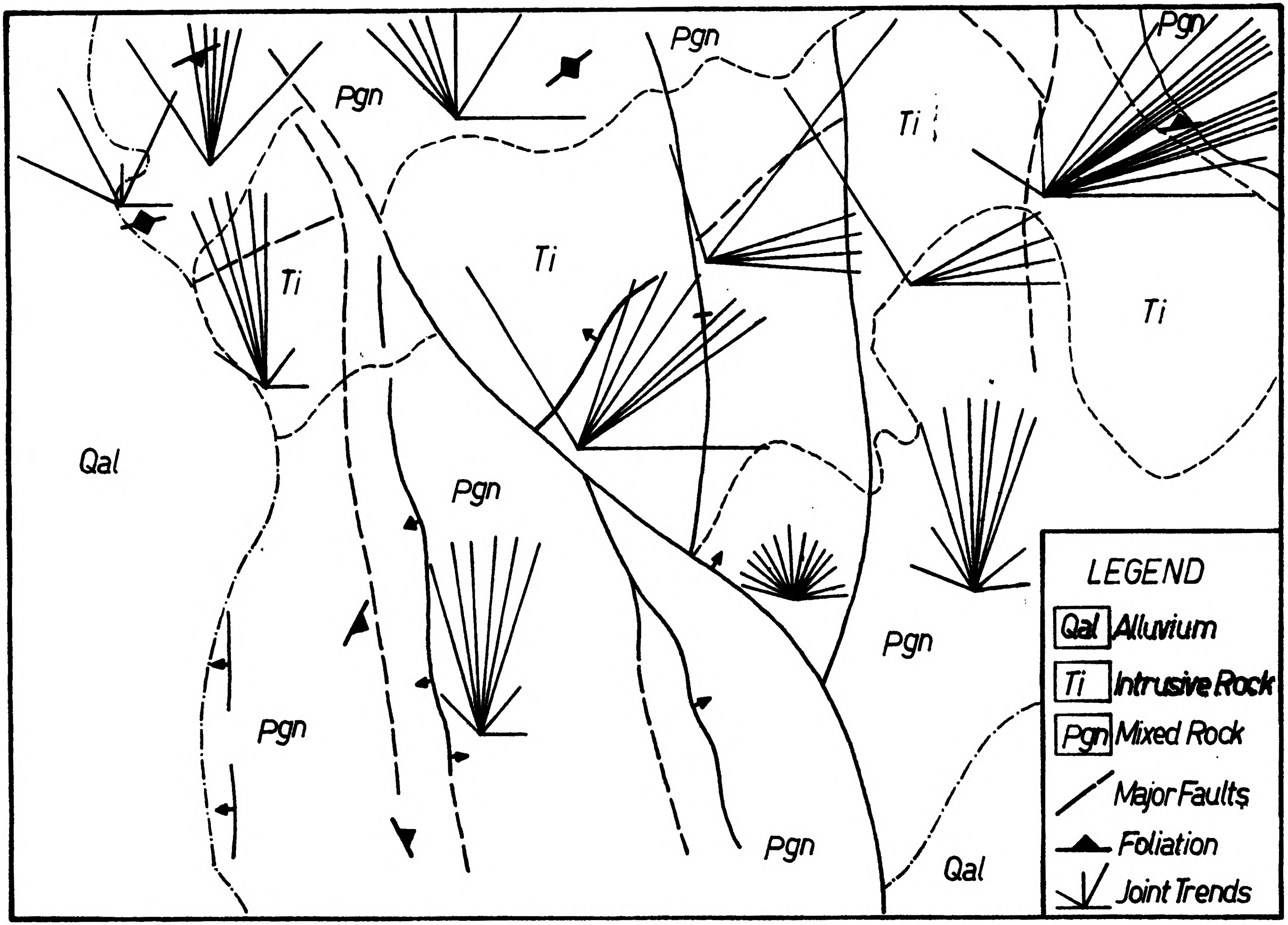

Figure 8. Schematic Fault, Joint and Foliation Structure Map of East-Central Portion of Nelson Quadrangle. Length of joint trend symbols indicates relative abundance.

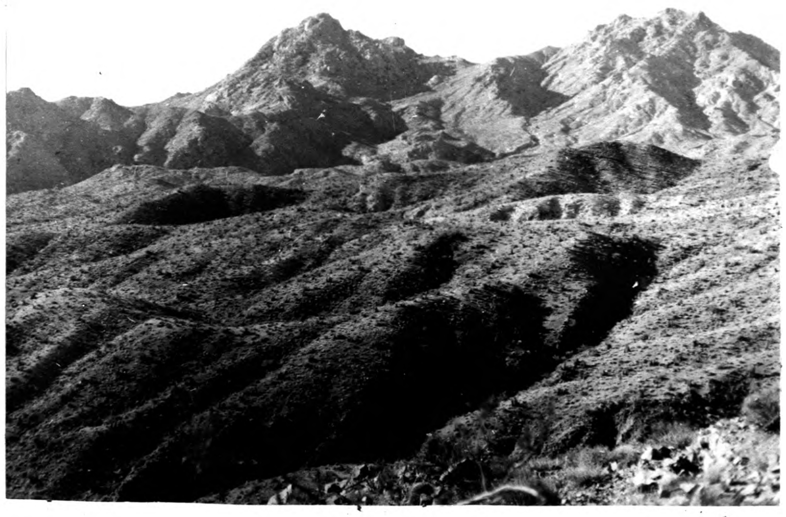

Figure 9 - Intersection of North and Northeast-Trending Faults in the NW 1/4, Sec. 26, T. 26 S., R. 64 E. -
View is toward the south. Note faceted spurs, on scarp of northeasterly-trending fault, in the left-central part of the photo.

V. MINERAL DEPOSITS

A. Introduction

The once-productive Eldorado mining district, centered about Nelson, Nevada, fringes the north boundary of the mapped area. This district has been briefly discussed by Ransome (1907, pp. 63-68, 76-79), Lincoln (1923, pp. 19, 20), Ferguson (1929, p. 135), and Vanderburg (1937, pp. 26-34). Mr. S. M. Hansen, of the Missouri School of Mines Geology Department, is presently preparing a doctoral dissertation on the district.

This district, active between 1857 and 1942, yielded its principal values in gold and silver, with very little copper, lead and zinc. Accurate data for the earlier, more productive period are lacking. Production figures available for the period 1907-1935 show an average recoverable value of $14.22 per ton. The over-all estimated production for this period is $1,609,305 (Vanderburg, 1937, p. 29). Recent attempts to revive the district have not been successful.

B. Eldorado District Summary

Except for minor early placer mining near the Colorado River, all production from the Eldorado district has come from fissure zones cutting andesite, monzonite, gneisses and schists. The most productive mineralization has been near the contact between the Lower Patsy Mine (Tertiary) andesite flows and the underlying rocks.

Hypogene sulfides, chiefly pyrite with occasional minor galena, sphalerite, and chalcopyrite, are disseminated in fissure zones of brecciated country rock held together by stringers and bunches of quartz and calcite. Gold and silver are intimately associated with the sulfides. Wall rock shows propylitic alteration in the mineralized zones.

Subsequent weathering and oxidation have produced some supergene clay, limonite, jarosite, cerussite, anglesite (?), gypsum, cerargyrite, manganese oxide, and malachite. Oxidation of pyrite to limonite has released free-milling native gold, accounting for much of the values in the upper parts of the lodes.

The mineralized zones are usually 2 to 6 feet wide, but are irregular and may vary from a few inches to 40 feet, in places. They range in length up to thousands of feet, and in depth up to at least 600 feet from the surface as revealed in workings. They usually strike about east-west, less commonly northeast. Dips range from 0 to 90°, north or south, but most commonly are 40 to 85° north.

The deposits are classified as epithermal after Lindgren (1933, pp. 444-7).

C. Capitol Camp Occurrences

The Capitol Camp group of claims partly overlaps the northeast corner of the mapped area, in the W. 1/2, Sec. 20, T. 26 S., R. 65 E. A few small pits, and 3 shafts partly connected by underground workings, are in the prospect phase of development.

Mineralized fissure zones occur in the andesite flow and in the underlying gneiss and schist. The fissure zones consist of brecciated, altered wallrock cemented by stringers and pockets of quartz which locally merge into simple quartz veins. The quartz is milky-white to red, and varies from anhedral masses to fine euhedral prisms. The latter occur in vuggy interlacing networks, and sometimes as comb structures.

Native gold, alloyed with minor amounts of silver, is associated with limonite in the quartz. Assay values are reported by the owners to have averaged $30/ton, but the values are very erratic. Minute irregular grains of gold are sometimes visible to the eye. Much gold is believed to have been originally associated with pyrite (Hansen, personal communication, 1961). The latter, altered to limonite, is disseminated in the quartz. Oxidation of pyrite to limonite has released some free-milling native gold. Isolated grains of sphalerite and galena are occasionally present. Small amounts of cerussite, derived from the galena, have been reported.

Fissure zones range in width from a few inches to 20 feet, but are usually less than 3 feet. They have not been traced continuously along their lengths, but they occur in an east-trending belt at least 2,000 feet long. The mineralization appears to persist in depth to the lowest workings, 350 feet below the surface. The lodes strike east and dip steeply, at least 70° both north and south.

The altered andesite wallrock, described on p. 51, locally shows a few grains of pyrite in and near the veins, but these are generally oxidized to limonite. Where andesite has been locally altered to a quartz-muscovite aggregate (p. 52), the ore values diminish, according to Hansen (personal communication, 1961). In the gneiss wallrock, biotite appears completely chloritized, and feldspars show much alteration to epidote. A little limonitized pyrite appears in the gneiss.

Pale-grey to yellowish-white aphanitic aggregates of clays and carbonates, and occasional coarse-grained fibrous gypsum, all of supergene origin, locally coat the wallrock along the mineralized zones. Figure 10 shows a typical outcrop of a mineralized zone.

Figure 10 - Mineralized Fissure Zone in Gneiss and Schist at Capitol Camp -

View is toward the east. The mineralized zone dips steeply to the south. Also note fracture sets dipping moderately southward, and steeply northward. The wallrock is gneiss and schist. The light-colored material contains supergene clays and carbonates (note prospect pit in center). A thin cover of Tertiary andesite is barely visible at the top of the photo.

D. Other Occurrences

The Knob Hill group is immediately adjacent to the northwest corner of the mapped area. According to Ransome (p.76), Vanderburg (p. 33) and Hansen (personal communication), the deposits consist of narrow fissure zones in gneiss and schist. The fissure zones range up to a few feet in width, up to thousands of feet in length, and persist in workings 100 feet below the surface. They strike east-west and dip mostly 60° to 90° south. The fissure zones consist of brecciated, altered gneiss and schist, cemented by quartz. The ore consists of gold and silver associated with pyrite, galena, and sphalerite in a gangue of quartz and altered country rock.

Shallow lodes, related to this group, have been prospected in the northwest corner of the mapped area. The mineralogy is inferred largely from the best-looking dump material. The deposits appear to have consisted of fissure zones of brecciated, altered gneiss cemented by stringers and pockets of quartz. In the gneiss wallrock, the biotite has been completely chloritized, and much feldspar has been altered to epidote. A few fine specks of pyrite, associated with limonite, are also present.

Quartz is pale grey and massive; it also occurs as pockets of fine to medium-grained prismatic crystals arranged in an interlacing, vuggy network (see Fig. 11). Vugs are incrusted with limonite which contains an occasional speck of pyrite. Small amounts of chrysocolla are also visible. Vein material is coated in places by a supergene yellowish-white aggregate of clay and carbonates.

Four prospect pits, dug in such deposits, mark a 250 foot long, discontinuous (?) fissure zone in the SW 1/4, Sec. 20, T. 26 S., R. 64 E., about 7/10 mile N. 65 W. from Knob Hill. The mineralized zones range in width up to 4 feet at the surface, but pinch out abruptly at depths of 10 to 30 feet, and laterally as well. The fissures strike east and dip 69° north.

A steeply inclined shaft has been sunk in fissured, altered gneiss 1/2 mile west-southwest of the above deposits, in the SE 1/4, Sec. 19, T. 26 S., R. 64 E. No traces of mineralization can be seen in place. The shaft is 8' x 6' in cross-section, and extends to an unknown depth. A nearby adit probably reaches the shaft, but is caved and inaccessible. Fractures in the shaft strike N. 55 E. and dip 65° north.

A steeply inclined shaft, dug in a similar deposit, occurs near the crossroads in the E 1/2, Sec. 20, T. 26 S., R. 64 E. The shaft extends downward 25 feet and levels off, possibly connecting with other shafts immediately north of the mapped area. All of these workings are flooded at depths of 20 to 30 feet, and are inaccessible. The inclined shaft cuts a fissure zone striking N. 85 E., and dipping 75° N. A group of prospect pits occurs near the shaft. These pits average 4' x 6' at the surface, and range in depth from 2 to 10 feet. No mineralization from these pits was seen.

Three closely spaced prospect shafts occur in the SW 1/4, Sec. 4, T. 27 S., R. 64 E., 3 miles south of Knob Hill. The visible mineralization resembles that mentioned above, except for the additional presence of: a few specks of galena; incrustations of brochantite on rock fragments and in quartz vugs; and veinlets of blue-green chrysocolla. The prospect shafts are 4' x 6' at the surface and taper downward, pinching out at depths of 5, 12, and 30 feet.

Figure 11 - Vuggy Quartz From a Mineralized Zone Near Knob Hill - Note dark incrustations of limonite lining the vugs.

VI. CONCLUDING REMARKS

The geologic investigation brought out the following salient features. The many diverse rock types, of Precambrian and Upper Cretaceous (?) - Tertiary age, their mutual relations, and the broader structural features were ascertained for the first time in this area.

The oldest rocks are biotite-chlorite gneisses, quartz-mica-chlorite schists, hornblende schists, and quartzofeldspathic gneisses, all of metamorphic origin. The structure of the foliated rocks was not completely ascertained. The younger rocks comprise igneous intrusions, chiefly of quartz monzonite and related acidic porphyries. These are invaded in overlapping sequence by various intermediate-basic intrusives. Minor andesitic flows are also present.

The most notable discovery was the numerous dike swarms of preferred trend, mainly NNW to NNE. Also noteworthy were the numerous faults, both bounding and cutting through the Eldorado Range. Three sets are recognized: 1) N to NNE 2) NW 3) ENE. The first two are most abundant. These correspond closely to the trends of the dike swarms.

The Ireteba Peaks appear to be a prominent horst block, uplifted by a hinge fault above the surrounding rock masses. An unusual rock-slide breccia covers much of this block.

The gold mineralization in the mapped area is a minor feature as compared to the Eldorado mining district to the north. Veins are small, discontinuous, and do not show high values.

Many aspects of the geology of the area would make fruitful subjects for further detailed study. Three fundamental questions are not completely answered: 1) What is the structure of the foliated rocks? 2) What detailed form does the large pluton have? 3) By what mechanism was the pluton emplaced? While these questions were partly answered, better exposures and much more detailed work would be required to arrive at more exact answers.

The geologic data accumulated have presented a clearer understanding of the geologic setting of the east-central portion of the Nelson Quadrangle, and add information to an area formerly unknown geologically.

REFERENCES CITED

Biddulph, R. L. - Geology of the Southeast Portion of the Nelson Quadrangle, Clark County, Nevada, Missouri School of Mines Master's Thesis (in preparation)

Billings, M. P. (1954) - Structural Geology, 2nd ed., Prentice Hall, New York, pp. 121-3, 307-8

Bowyer, B., E. H. Pampeyan, & C. R. Longwell (1958) - Geologic Map of Clark County, Nevada, MF 138, US Geol. Surv.

Callaghan, E. (1939) - Geology of the Searchlight District, Clark County, Nevada, USGS Bull. 906D, pp. 148-9

Chayes, F. (1952) - Notes on the Staining of Potash Feldspar with Sodium Cobaltinitrate in Thin Section, Am. Miner. V. 37, pp. 337-40

Clarke, F. W. (1924) - Data of Geochemistry, USGS Bull. 770, pp. 432-631

Eskola, P. (1933) - On The Differential Anatexis of Rocks, Comm. Geol. Finlande Bull. 103, pp. 12-25

Fenneman, N. M. (1931) - Physiography of Western U.S., McGraw Hill, New York, pp. 326-67

Ferguson, H. G. (1929) - The Mining Districts of Nevada, Econ. Geol., V. 24, No. 2, pp. 131-5

Fyfe, W. S., F. J. Turner, & J. Verhoogen (1958) - Metamorphic Reactions and Metamorphic Facies, GSA Mem. 73, pp. 3-20, 149-85, 199-239

Hansen, S. M. - Geology of the Eldorado Mining District, Clark County, Nevada, Univ. of Missouri Doctoral Dissertation (in preparation)

Hewett, D. F. (1956) - Geology and Mineral Resources of the Ivanpah Quadrangle, California and Nevada, USGS Prof. Paper 275, pp. 17-25, 51-2, 61-6, 73-92, 110

Keith, M. L. (1939) - Selective Staining To Facilitate Rosiwal Analysis, Am. Miner. V. 24, pp. 561-5

Lausen, C. (1931) - Geology and Ore Deposits of the Oatman and Catherine Districts, Arizona, Ariz. Bur. Mines Bull. 131, pp. 26 & 43

Lincoln, F. C. (1923) - Mining Districts and Mineral Resources of Nevada, Nev. Newsletter, Reno, pp. 19-20, 25

Lindgren, W. (1933) - Mineral Deposits, 4th ed., McGraw Hill, New York, pp. 444-7

Longwell, C. R. (1936) - Geology of the Boulder Reservoir Floor, Arizona-Nevada, GSA Bull. V. 47, pp. 1393-1476

(1950) - Tectonic Theory Viewed From The Basin Ranges, GSA Bull. V. 61, pp. 426-8

Ransome, F. L. (1907) - Preliminary Account of the Goldfield, Bullfrog, and Other Mining Districts in Southern Nevada, USGS Bull. 303, pp. 63-8, 76-9

Smith, H. T. U. (1943) - Aerial Photographs and Their Applications, Appleton-Century-Crofts, New York, p. 240

Spurr, J. E. (1903) - Descriptive Geology of Nevada South of the 40th Parallel and Adjacent Portions of California, USGS Bull. 208, pp. 15-17, 138-9, Plates I & II

Turner, F. J. & J. Verhoogen (1951) - Igneous and Metamorphic Petrology, McGraw Hill, New York, pp. 66-76, 111-23, 212-24, 258-367

Vanderburg, W. O. (1937) - Reconnaissance of Mining Districts in Clark County, Nevada, USBM IC-6964, pp. 26-34

Visher, S. S. (1954) - Climatic Atlas of the U.S., Harvard Univ. Press, Cambridge, 403 pp.

War Dept. (1881) - U.S. Geographic Survey West of the 100th Meridian, Atlas Sheet No. 66

Williams, H., F. J. Turner, & C. M. Gilbert (1954) - Petrography, Freeman, San Francisco, 406 pp.

VITA

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In July 1952, Kantor enlisted in the U. S. Army. His main duty assignment was in Chemical Division, Headquarters U. S. Army in Europe, where he attained the rank of corporal. After 3 years of military service, he resumed his schooling, receiving Federal financial benefits as a veteran. He re-entered City College of New York, and graduated in 1958 with a B.S. in geology. He enrolled as a graduate student in the Missouri School of Mines in September 1958. He held a School of Mines Research Fellowship during the period October 1959 - February 1960.

Kantor is single, and has many interests, including travel in faraway places. His professional goals lie in mineral exploration. He is a student member of the American Institute of Mining, Metallurgical, and Petroleum Engineers, and an associate member of Sigma Xi.