GEOLOGY OF THE WEST SIDE OF PEAVINE MOUNTAIN, WASHOE COUNTY, NEVADA

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Larry H. Godwin

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APPROVED

E. B. Larson

Director of Thesis

APPROVED

Lloyd B. Clemmons

Major Professor

APPROVED

Jos. W. Wood

Chairman of Graduate Committee

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GEOLOGY OF THE WEST SIDE OF PEAVINE MOUNTAIN, WASHOE COUNTY, NEVADA

by

Larry H. Godwin

A B S T R A C T

The oldest rocks exposed on the west side of Peavine Mountain are Mesozoic metamorphosed sedimentary and volcanic rocks. The latter have tentatively been assigned to the Jurassic on fossil flora found in a black shale. Epidote surrounded by bleached haloes is common in the meta-volcanic rocks. Piedmontite, a manganese epidote, has been found in close proximity to quartz veins.

A granodiorite stock intrudes the metamorphic complex. Earlier writers referred to the stock as quartz-monzonite, however, modal analysis has proven it to be granodiorite.

Tertiary andesites lie unconformably on the deeply weathered granodiorite. The andesites, which range from basic pyroxene andesite with basaltic texture to hornblende-mica andesite, have been tentatively correlated with the Alta Andesite and the Kate Peak Andesite of the Virginia City quadrangle. Near surface alteration by acids has caused local bleaching of the andesites and granodiorite in the southeastern portion of the mapped area. A reconnaissance map of the bleached areas in the southern half of the Reno quadrangle has been prepared.

Lake deposits of the Pliocene Coal Valley Formation lie on a weathered surface of the Kate Peak Andesite without marked angular relationship. On Rakota Hill, northeast of Verdi, the Coal Valley diatomite and sandstone have been oxidized brick red. There are also unusual areas where they have been fused to black glass.

Olivine basalts, the youngest volcanic rocks in the mapped area, overlie and, in part, interfinger with the Coal Valley Formation.

The characteristic structural features of the Peavine area are block faults. The mountain is a tilted fault block with a topographic displacement of 2000 feet on the fault on the northeastern side. Most of the Basin-Range faulting is post-Coal Valley Formation and post-olivine basalt.

Numerous surfaces which have been planed by the Truckee River have been tilted and deeply dissected by tributary streams. Pleistocene glacial gravels have been deposited on some of these surfaces.

I N T R O D U C T I O N

LOCATION AND ACCESSIBILITY

Peavine Mountain, northwest of Reno, Washoe County, Nevada (Figure 1), is an outlying peak of the Sierra Nevada of California. King (1869, p.849) described Peavine Mountain:

> "---somewhat isolated, forming a prominent landmark in the immediate region, partly from its striking outlines, which offer marked contrasts to the forms of the Tertiary volcanic outbursts, which characterize the Virginia Range and the country to the east."

Only the western half of Peavine Mountain was mapped by the writer. The 32 square-mile area is bounded on the west by the California State Line, on the south by the Truckee River, on the east by a north-south line through the summit of Peavine, and on the north by the northern boundary of T. 20 N., R. 18 E., and U. S. Highway 395.

Reno is the supply center for a large portion of western Nevada. The Western Pacific Railroad and U.S. Highway 395 extend northwest from Reno around the eastern and northern sides of Peavine Mountain into California, while the Southern Pacific Railroad parallels U. S. Highway 40 through the Truckee River canyon south of Peavine Mountain.

Many jeep roads extend into the foothills, and one graded road has been built to Peavine Peak. During summer and early fall, the area is readily traversed from the north and east. However, roads into the area from the west and south are cut by gullies and may be impassable.

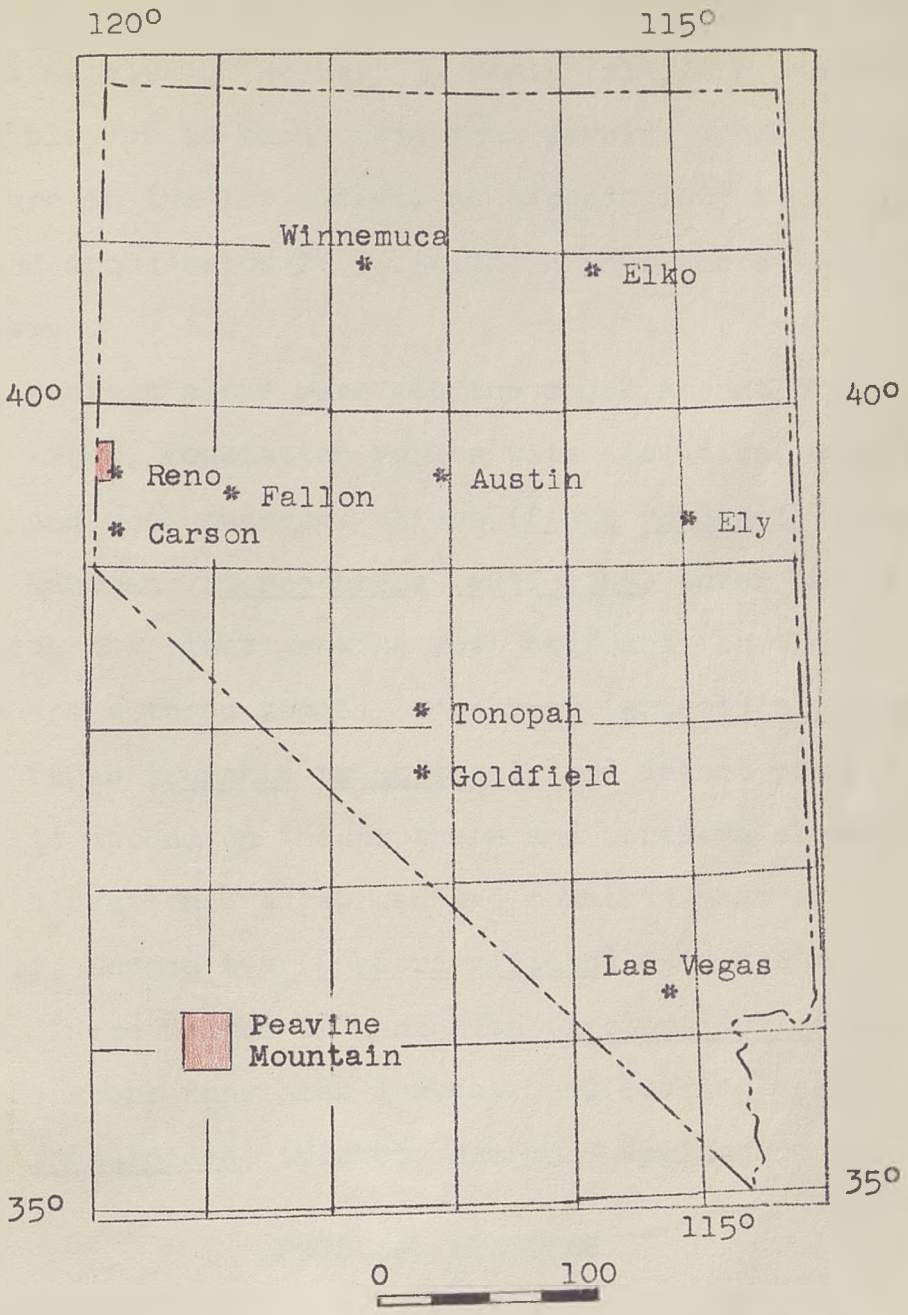


FIGURE 1. Index map showing location of Peavine Mountain.

CLIMATE AND VEGETATION

The climate is semi-arid, with an annual precipitation of approximately 10 inches. In early fall, the peak becomes inaccessible due to snowdrifts that persist until June. The temperature in the low elevations exceeds 100° F. in mid-summer and drops below 0° F. in the higher elevations during the winter.

The western slope receives the major amount of precipitation. Thus, vegetation varies with elevation, direction of slope and rock outcrop. Pines (Pinus ponderosa) and mountain mahogany (Cercocarpus ledifolius) cover the western hills, with the pines growing most profusely on the granitic outcrops and altered zones. Sagebrush (Artemisia tridentata), antelope brush (Purshia tridentata), and desert peach (Prunus andersonii) abound on the northern and southern slopes. In the high elevations, sagebrush and mountain mahogany grow abundantly, Mormon tea (Ephedra viridis) dots the granitic outcrops, large hedges of manzanita (Arctostaphylos sp.) mark areas where snow lies longest, and quaking aspen (Populus tremuloides) thickets surround springs.

PHYSICAL FEATURES

The lowest elevation (4728 feet) is in the southeastern corner of the area at the Truckee River, while the highest elevation (8266 feet) is at Peavine Peak, five miles to the north. The maximum elevation differential is 3538 feet.

The northern area is characterized by steep slopes that flatten into a playa north of U. S. Highway 395. The northeastern portion is a steep fault-line scarp which terminates at the apex of an alluvial fan; the highlands are a rejuvenated old erosion surface with poor drainage; and the southern slopes are a deeply dissected young surface.

Drainage is provided by a large number of intermittent streams and one perennial stream, Bull Ranch Creek, which drains the southwestern flank of Peavine Peak. The streams in the northern half of the area drain north into the playa, northwest into Long Valley, or northeast into Lemmon Valley. Streams on the southern slopes have developed a dendritic pattern and flow into the Truckee River.

INDUSTRY

Cattle ranching is the major industry of the area, however, during early summer, the higher elevations are grazed by sheep. The Hines Ranch is located in the lowlands to the north, while in the south, small cattle ranches and dairys line both sides of the Truckee River.

Mining was once the major industry. The Red Metals copper mine was operating in 1915. Julius Redelius is re-exploring the property.

METHOD OF INVESTIGATION

In the summer of 1957, six weeks were spent mapping the geology. During the following school year, additional weekends were required to check the field work. The geology was plotted on aerial photographs of scale 1:20,000 and later transferred to a base map. The latter had been enlarged photographically from the Reno, Nevada U. S. G. S. Topographic map of scale 1:62,500 to a scale of 1:31,250 onto a film dipositive[1] which was then reproduced in an ozalid type duplicator.

Rock specimens were collected, and 40 thin sections were cut and examined under the petrographic microscope. The universal stage was used to measure 2V, twin axes, and compositional changes in zoned crystals. Anorthite content of the plagioclase feldspars was determined by the universal stage and the revised plagioclase curves described by Slemmons (1958).

SCOPE OF INVESTIGATION

The structure, petrology, and geologic history of the units present on the west side of Peavine Mountain are the primary objectives of this investigation. The units consist of igneous, metamorphic and sedimentary rocks. Only a cursory examination of the latter has been attempted.

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1 The Cartwright Photographic Company, 2574 21st Street, Sacramento, California, specially prepared the 18 x 10 inch film dipositive for ozalid reproduction at a cost of $14.50.

PREVIOUS INVESTIGATIONS

The Peavine mining district has been investigated by many persons since it was laid out in 1863, but little has been written concerning the area west of Peavine Peak.

The first mention of the Peavine district was by Browne (1868, p.316) in his report on the operating mines of western Nevada. King (1869, p.849) in the Fortieth Parallel Survey, mapped Peavine Mountain as an Archeozoic metamorphic and intrusive complex. Later, Louderback (1907, p.662) wrote on the geology of the Peavine area. He discussed the bedrock complex (which he considered to be Mesozoic and Paleozoic), the great unconformity, the intrusive rocks, the Tertiary lavas, and the Truckee Formation (Coal Valley Formation). He did not publish a geologic map. Hill (1915, p.184) visited the operating mines and prepared a sketch map of the Peavine mining district. Anderson (1910, p.475) in investigating petroleum possibilities in the Reno area described the Truckee (Coal Valley) Formation. Jones and Gianella (1933, p.96) also mention Peavine Mountain.

ACKNOWLEDGEMENTS

Dr. E. R. Larson was instrumental in the decision to study the area. He assisted the writer in the field and edited the manuscript. Dr. David B. Slemmons gave continual assistance in the laboratory, took frequent trips into the field, giving special emphasis to the metamorphic problem, and edited the manuscript. Dr. Joseph Lintz advised on the paleontologic problem, and Dr. Alexis Von Volbroth, Dr. Robert L. Rose, Dr. Harve Nelson and Christe P. Zones accompanied the writer into the field and made important suggestions. Dr. Vincent P. Gianella contributed to the report with his comments and suggestions.

Miss Lorraine Godwin identified the modern flora, Dr. Daniel I. Axelrod identified the paleo-flora and Mrs. Mary Zadra, Mackay School of Mines Librarian, spent many hours assisting in research.

REGIONAL GEOLOGY

In the Reno region, according to Louderback (1907, p.663), the bedrock complex consists of granitic rocks intruded into more or less metamorphosed sedimentary and volcanic rocks. This complex is found in the Sierran front, in Peavine Mountain, in the Truckee canyon east of Sparks, in the Carson Range to the south, and in the small ranges north of Reno. With a few exceptions, the bedrock complex is exposed only west of the Virginia Range.

The Tertiary volcanic rocks which are unconformable on deeply eroded granitic material are chiefly andesites, however, rhyolites and basalts are common. These volcanic rocks occur on the southern and eastern flanks of Peavine Mountain, on the northern slope of the Carson Range, in the low hills north and south of Reno, and in the Virginia Range.

Louderback (1907, p.664) states that many of the andesites have been altered by solfataric action or mineralization. The large areas of bleached rocks are near Virginia City, along the Geiger Grade, in the Virginia Range south of Vista, in the low hills north of Reno, and on the southeastern slopes of Peavine Mountain.

Basalts appear to be the latest volcanic rock in the region. They overlie all other types, are only slightly affected by erosion, and are not bleached except in the Steamboat Springs area.

In the Truckee canyon east of the California State Line,

the Pliocene Coal Valley Formation rests unconformably on weathered granite or andesite and appears to be entirely fresh-water or subaerial. The sediments antedate the block faulting of the range, as outcrops are found in the valleys and in the summit region of the Carson and Virginia Ranges.

Hill (1915, p.189) mentions that the Truckee Meadows and Lemmon Valley are underlain by fine sands and silts of Quaternary age. The playa north of Peavine Mountain is also covered by Quaternary alluvium. Near Copperfield, highway and railroad cuts expose the Coal Valley Formation in fault contact with the later sediments.

In the Truckee canyon, probable glacial outwash is found on some of the high planed surfaces. Sierra Nevada granitic boulders up to 10 feet in diameter lie on the tilted and beveled Coal Valley Formation or on the Tertiary volcanic rocks.

Basin-Range faulting lifted the Virginia Range to its present height. The Carson Range and Peavine Mountain are rotated fault blocks, tilted respectively north and south, while the included lowlands are badly shattered into small blocks which show normal and high angle reverse relationships. The lowlands became the channel for the Truckee River. Subsequent erosion has obscured many of the faults, but the northeastern face of Peavine Mountain is still a striking example of a fault-line scarp.

METAMORPHIC ROCKS

GENERAL

The metamorphic rocks consist of meta-sediments with varying amounts of schistosity and foliation and of meta-volcanic rocks which have addition of epidote clots surrounded by bleached zones 1 to 4 inches wide and fragments which show stretching.

The metamorphic rocks compose the basement rock of the northern portion of the map area (PLATE 1) and crop out over approximately 10 square-miles. The silicic rocks are resistant to weathering and stand out as ridges. The more friable slates and meta-tuffs crumble readily on weathering and commonly form gentle slopes and canyons.

King (1869, p.849) referred to the metamorphic complex as being:

> "---formed of a series of highly altered quartzites and fine-grained feldspathic rocks, which have been referred to the Archaean series; but their definite relations to other crystalline rockmasses has not been made out nor can they be referred to any beds of precisely similar petrographical habit. They stand at a highly inclined angle, with a strike varying from north 50 to 65 degrees east, agreeing approximately in strike with the Archaean rocks of the west Humboldt and Pah-Ute Ranges."

Louderback (1907, p.663) described the metamorphic rocks as follows:

> "The chief sedimentary types are perhaps, quartzites and mica schists, including muscovite-schists. A petrographically interesting meta-dacite is found at intervals for at least 12 to 15 miles north of Reno."

Hill (1915, p.185) stated:

> "The oldest rocks in this area are schists, composed of highly compressed sediments and irruptive rocks. They form the major part of Peavine Peak."

The metamorphic rocks contain graywackes and volcanic rocks. The poorly sorted conglomerates, sandstones and slates contained impure lenses of limestone which have been recrystallized to garnet and epidote. Interbedded with the sediments are tuffs, flows, breccias and partly rounded volcanic sediments.

The sedimentary and volcanic rocks have been folded and regionally metamorphosed to the greenschist facies. Near the intrusion, the contact metamorphism increases to the amphibolite facies. There has been recrystallization and introduction of epidote. The calcareous bands have altered to epidote-wollastonite-garnet skarns, with the occasional introduction of primary sulfides, carbonates and silicates of copper.

The metamorphic rocks are cut by randomly oriented quartz veins which are rich in tourmaline. Although prospect holes have been dug in almost every quartz outcrop, no commercial lodes have been discovered.

The metamorphic rocks are composed of three major types: sediments, flows, and pyroclastic rocks. Poor outcrops make the thorough study of the metamorphic rocks difficult. Therefore, the lithologic types will be discussed separately but will not be differentiated on the geologic map.

SEDIMENTARY ROCKS

General

Banded sedimentary rocks are exposed near the igneous contact approximately one half mile south of Peavine Peak, while thin lenses of sandstone and conglomerate are scattered throughout the metamorphic rocks. A fossiliferous black slate which crops out near the mine in section 9, T. 20 N., R. 18 E., contains fossil flora tentatively dated Jurassic by Axelrod (personal communication, April 1958).

The sedimentary rocks are graywacke lutites, arenites and rudites which appear to be intercalated with the flows and pyroclastic rocks. Metamorphism varies from the biotite zone, greenschist facies, far from the pluton, to the amphibolite facies at the granodiorite contact.

Petrography

The sedimentary rocks show graded bedding, from rudites with well rounded pebbles to medium or fine-grained arenites. Black banding caused by primary deposition of magnetite may also be present. In thin section, the arenite (1605) shows good sorting. The grains are smaller than 1 millimeter and consist essentially of quartz and feldspars. The latter are altered by recrystallization so that it is difficult to determine the feldspars, except where twinning is preserved.

The quartz grains show good rounding and sphericity; the majority of the grains are round or diamond-shaped; though some show tabular form like the plagioclase grains.

(Figure 2).

Some layers contain sufficient magnetite grains to give the sediment a micro-banded appearance. The magnetite has partially oxidized to hematite and limonite. The latter colors the clastic rock a yellow hue.

The matrix probably consisted of argillaceous cement. Recrystallization has formed a microcrystalline quartz-albite-muscovite-biotite groundmass with but slight alteration of the quartz grains.

Secondary minerals, either introduced or recrystallized as a result of metamorphism, are anhedral tourmaline, pleochroic pink to blue, and euhedral zoisite.

The banded sediments, close to the intrusion, have been contact metamorphosed to the amphibolite facies (Figure 3). Relict megascopic banding has been retained (1604, 1618) by semi-parallel arrangement of optically oriented biotite and hornblende separated by layers of quartz and plagioclase. Euhedral magnetite is also present as is chlorite.

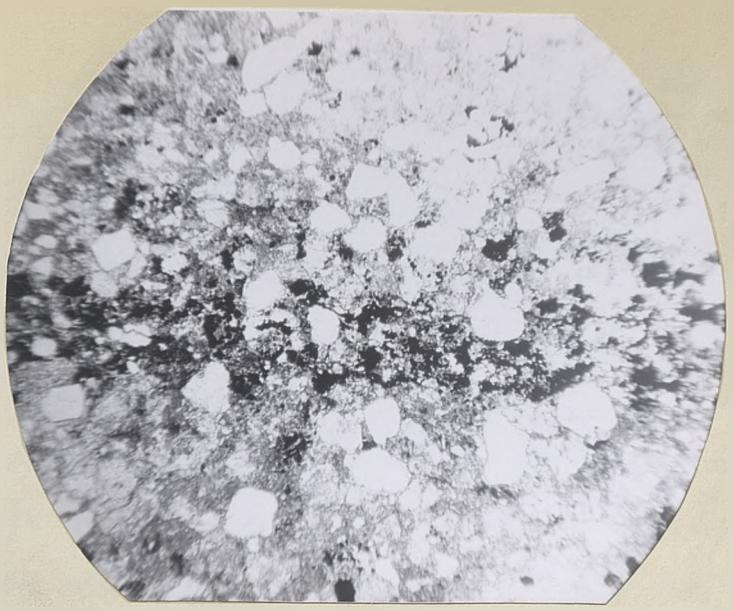


Figure 2. Slide 1605. Regionally metamorphosed sediment. Quartz and feldspar sand grains lie in a fine-grained biotite groundmass. Magnetite accumulations give a banded appearance (25x).



Figure 3. Slide 1618. Contact metamorphosed sediment. Quartz, andesine, biotite and hornblende show relict banding in a hornfels (25x).

FLOW ROCKS

General

Macroscopically, the flows form ridges and hill tops due to resistance to erosion and weathering. The outcrops are light gray and easily discernible on the aerial photographs from the darker surrounding rocks. The flows are dacitic in compostion as determined by phenocryst composition. However, chemical analysis would probably show them to be rhyolites. The outcrops form narrow bands and are widely disseminated throughout the metamorphic area.

Petrography

The fine-grained porphyritic extrusive rock (1613) varies in color from light to dark gray and contains large euhedral phenocrysts (5-8 mm) of plagioclase and quartz. The albite (An 12) phenocrysts are altered to sericite. The matrix is fine-grained, felsitic containing anhedral quartz, orthoclase, plagioclase and microcrystalline green amphibole. The amount of ferromagnesian minerals controls the color index of the rock. Small patches of green chlorite with an ultra-blue birefringence replaces the ferromagnesian minerals. Small grains of secondary epidote and tourmaline are disseminated throughout the rock. Epidote is rarely seen in the hand specimen as contrasted with the pyroclastic rocks where it is invariably megascopic. Euhedral apatite and subhedral magnetite are disseminated throughout the specimen.

PYROCLASTIC ROCKS

General

Acid pyroclastic rocks cover an extensive portion of the northern slopes of Peavine Mountain. The outcrops are massive and show little bedding. Fractures which strike N. 60-70° E. appear to be the bedding that Hill (1915, p.185) mapped. The true bedding, although quite difficult to discern, is indicated by variation in fragment size, direction of long axis of fragments, and trend of belts of varying lithology.

The volcanic breccias which vary in composition from rhyolites to dacites are interbedded with thin layers of pale colored tuffs and a black shale which contains fossil flora.

Petrography

The pyroclastic rocks may be dark gray, cream, light gray, or red. They are composed of lithic fragments in a fine-grained matrix that contains quartz and feldspar phenocrysts. Specimen 1624 is a pyroclastic dacite from the biotite zone of the greenschist facies. It contains angular ejecta and euhedral crystals of embayed quartz, plagioclase, microcline and orthoclase in a microcrystalline groundmass of quartz, albite and muscovite. The matrix has relict vitroclastic texture (Figure 4). The feldspar phenocrysts have been altered to clay and sericite and the ferromagnesian minerals have been altered to chlorite, epidote, magnetite and fine-grained amphibole.

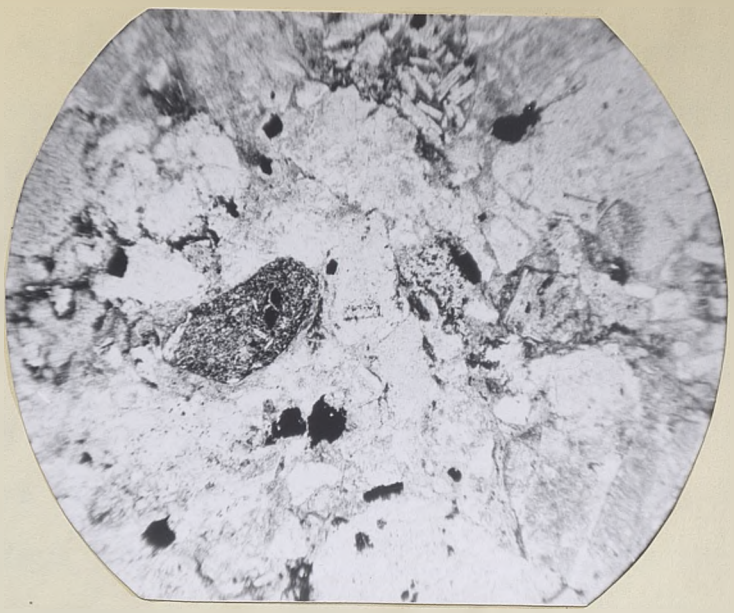


Figure 4. Slide 1624. Dacite pyroclastic rock. Lithic fragments, magnetite and altered plagioclase phenocrysts lie in a vitroclastic matrix (25x).

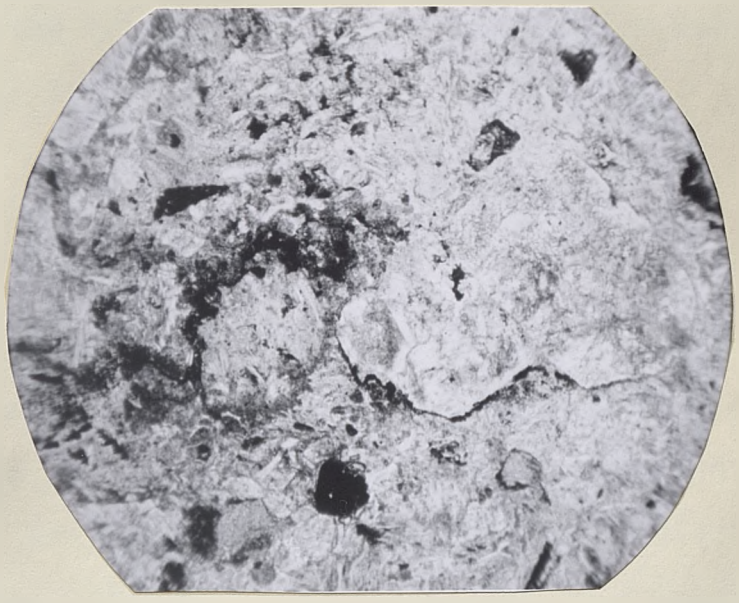


Figure 5. Slide 1611. Rhyolite pyroclastic rock. Quartz and microcline phenocrysts, lithic fragments, and magnetite lie in a microcrystalline matrix which shows relict vitroclastic texture (25x).

In a red rhyolite tuff (1611), the relict vitroclastic texture is pronounced (Figure 5). Piedmontite and tremolite-actinolite are present, and most of the magnetite has been oxidized to hematite. With the above exceptions, the red rock is similar to the dark gray volcanic breccias.

An interesting feature is the amount of epidote found throughout the meta-volcanic rocks. The epidote forms green clots which are surrounded by bleached zones. The clots vary in size from minute specks to six inches in diameter and generally have bleached haloes up to four inches in width. The amount of epidote present varies greatly with lithology and proximity to mineralized zones and the intrusion. Perhaps, the original calcite controlled the occurrence of epidote, for the latter and garnet replace what appear to have been thin limestone lenses.

EPIDOTE MINERALS

Pistacite

In the epidote group, the variety pistacite is the most common replacement mineral in the pre-Tertiary rocks. The color, in hand specimen, varies from pistachio green to deep olive-green. In thin section (1628), the pistacite has a high relief, $n_x = 1.725$, pleochroism from colorless to greenish-yellow, $2V = 66^o$, dispersion and strong birefringence.

Piedmontite

A red pyroclastic rock (1611) that contains pistacite

transitional to piedmontite is found in section 9, T. 20 N., R. 18 E., At one end of a uniformly thick slide (1611), the epidote mineral is pleochroic from greenish-yellow to pale orange. Toward the other end of the slide, the intensity of the pleochroism increases until normal pleochroism for piedmontite is reached. Universal stage measurements indicate for the intermediate variety, a $2V_x = 74^o$ and an index of refraction $n_x = 1.725$. By plotting the optical data on a graph (Troger, 1956, p.46) the following approximate formula is obtained: $4(Ca_{100}Mn_0)\cdot 3(Al_{85}Fe_0Mn_{15})_2O_3\cdot 6SiO_2\cdot H_2O$.

The piedmontite is easily discernible in hand specimens (1601, 1629) which were collected from the above mentioned locality. Aggregates of piedmontite (1629) attain a length of 3/4 inches. In thin section, the pleochroism is extreme, from deep carmine to yellow and lilac. The $2V_x = 72^o$ and the index of refraction $n_x = 1.735$. The birefringence was not determined since it is obscured by the intense pleochroism and dispersion.

The piedmontite appears to have been emplaced through selective replacement of fragments of a lithic rhyolite tuff. Possibly the fragments were inclusions of calcite that had been incorporated by the volcanic material as it was ejected (Figure 6 and 7).

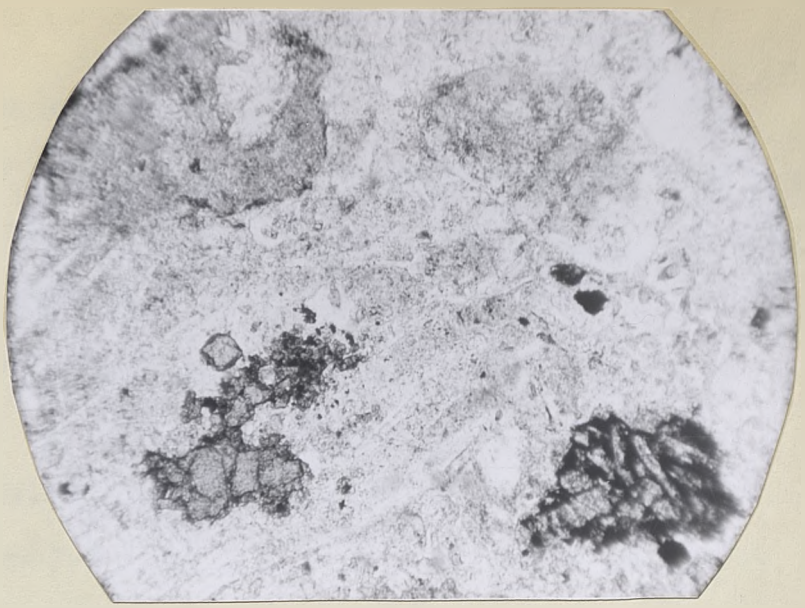


Figure 6. Slide 1611. Piedmontite, lithic fragments and microcline phenocrysts lie in a vitroclastic matrix (25x).

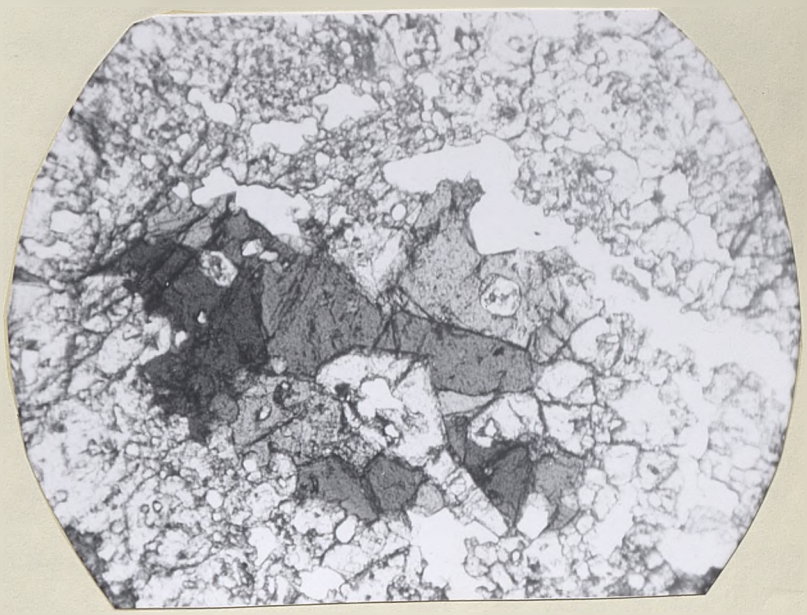


Figure 7. Slide 1601. Piedmontite, showing pleochroism, is surrounded by garnet and quartz (25x).

METAMORPHISM

Regional Metamorphism

There are at least two ages of metamorphism present in the pre-Tertiary rocks. The regional metamorphism predates the intrusion of the granodiorite pluton. Whether the regional metamorphism is a result of dynamic forces which culminated in the western Sierra Nevada batholithic intrusion approximately 140 million years ago (Evernden, Curtis and Lipson, 1958), or similar forces which came before or during the eastern Sierra Nevada batholitic intrusion approximately 80 to 100 million years ago (Evernden, Curtis, and Lipson, 1957, p.2123), or both has not been determined.

The pre-Tertiary rocks were deformed into broad folds. Recrystallization, although incomplete, was leading to equilibrium in the biotite zone of the greenschist facies. Most of the rocks are acid and fall into the quartzo-feldspathic grouping, thus, little change is noted in the mineralogy (1613, 1615, 1624). The glass contained in the volcanic rocks has been devitrified and the feldspar phenocrysts clouded by alteration to sericite and clay. There were, probably, few ferromagnesian minerals in the volcanic rocks, but, where present, they have altered to epidote, magnetite or hematite, and chlorite. The amount of epidote formed depended on the availability of calcium for combination; consequently, the more siliceous rocks have less epidote. In the groundmass of the sediments fine-grained biotite and tremolite have formed.

Contact Metamorphism

Contact zones have a higher grade of metamorphism than the regional metamorphosed rocks. Near the granodiorite pluton, black shales which are only slightly metamorphosed by regional metamorphism have been converted by contact metamorphism to phyllites and mica schists. While these types are generally referred to regional metamorphism (Turner and Verhoogen, 1952, p.465), the phyllites and mica schists in the Peavine area are associated only with the contact between the pluton and the metamorphic rocks; therefore, they appear to be the result of amplification of relict textures.

The contact metamorphic effects vary radically. In some localities, the contact zone is less than 50 feet wide, while in others, it extends to one quarter mile from the contact. The variation may be due, in part, to rock type and permeability, and in part, to the depth of the intrusion beneath the present surface.

Some beds were more susceptible to metamorphism than others. The limestone beds, apparently, were almost completely converted to epidote-garnet skarns. These beds vary in thickness from $\frac{1}{2}$ inch to 20 feet. Primary copper sulfides, carbonates and silicates have been encountered in the skarns. Near the contact, fine-grained sediments have been converted to hornfels in the amphibolite facies (1618).

AGE RELATIONS AND ORIGIN

The exact age of the metamorphic rocks is not known. However, they pre-date the granodiorite pluton which probably belongs to the eastern Sierra Nevada batholith (Evernden, Curtis, Lipson, 1958). Fossil flora from a black shale bed has been tentatively dated Jurassic by Axelrod (personal communication, April 1958).

> "---There are two or three plants in the collection that can be identified only tentatively because they are quite scrappy and incomplete. These include a fern (Cladepblebis? or "Thrysopteris"), a cycadophyte (?Nillsonia), and possibly a ginkgo (??Ginkgo). If these identifications prove to be correct, then the flora is probably Jurassic. Similar plants are represented in the Trail Formation in the Taylorsville area, and also in the Jurassic of Oregon."

The layered sedimentary rocks appear to have been deposited in a eugeosyncline. They are graywacke sandstones, conglomerates and siltstones. The volcanic rocks may have been deposited on or near shore. Breccias and flows are intercalated with conglomerates, tuffs and water-lain volcanic rocks. Variations in the metamorphic rocks probably reflect both original differences in composition and varying degrees of metamorphism.

M E S O Z O I C I N T R U S I O N

GENERAL

Lindgren (1900, p.277) defines "granodiorite" as a quartz bearing rock intermediate between quartz-monzonite and quartz-diorite, containing potash feldspar in a ratio from 1/8 to 1/3 of the total feldspar. He then defines "quartz-monzonite" as a quartz bearing rock containing potash feldspar in a ratio of 1/3 to 2/3 of the total feldspar.

Louderback (1907, p.663) lists Peavine as part of the Sierran front, which consists of granites and, in part, granodiorites. Hill (1915, p.186) notes a rather coarsely granular feldspathic rock intrusive into the pre-Tertiary schists, which he calls quartz-monzonite.

The pluton is an essentially non-foliated igneous rock, probably of early Cretaceous age (Evernden, Curtis, Lipson, 1957, p.2123), which intrudes the metamorphic complex. The stock is exposed over a seven square mile area near the center of the map area (PLATE 1). It also crops out north of Mogul on a low hill that extends southeast across U. S. Highway 40 at the Nevada Highway Patrol Truck Stop. The plutonic rock is a biotite-hornblende granodiorite. The outcrops weather to large gray boulders stained pale brown and arkosic sand. The contact between the intrusive and the metamorphic rocks is cut by short potash-rich simple pegmatite veins composed of microcline and quartz in graphic intergrowth.

PETROGRAPHY

Four randomly collected samples (1602, 1608, 1612, 1621) were studied. The hand specimen is a light gray, holocrystalline, phanerocrystalline, coarse-grained, hypidiomorphic granular rock containing plagioclase feldspar, orthoclase, quartz, biotite and hornblende.

Chayes (1956) method of modal analysis indicates the pluton is a granodiorite (TABLE 1).

TABLE 1. Modal Analysis of Granitic rock.

Minerals	1602	1608	1612	1621
Plagioclase (An 30-38)..	43.36%	48.90%	53.35%	53.30%
Potash feldspar.....	18.31	20.15	9.50	6.10
Quartz.....	23.39	18.15	22.35	18.10
Biotite.....	9.17	4.30	7.17	7.35
Hornblende.....	5.02	6.30	4.85	7.30
Magnetite.....	tr	tr	1.30	2.00
Chlorite.....	0.40	tr	0.90	4.75
Tourmaline.....	tr	1.60	tr	tr
Minor Accessories.....	0.33	0.60	0.60	0.65
Total feldspar.....	61.67	69.05	62.85	59.85
% potash feldspar of total feldspar.....	29.67	29.18	15.12	10.94

The granodiorite contains: 43 to 53 percent andesine (An 30-38) in subhedral, zoned and complexly twinned crystals, subhedral orthoclase and microcline, 7 to 20 percent, and anhedral quartz, 18 to 23 percent. The mafic minerals, biotite and hornblende, compose the remaining 11 to 15 percent. Anhedral blebs of biotite, pleochroic from cream to dark brown, have been altered on the edges to chlorite and magnetite. The hornblende is spongy (Figure 8), has pleochroism yellow-brown, blue-green and yellow-green, and shows twinning. Accessory minerals include trace amounts of: zircon, sphene, tourmaline, apatite, magnetite and zoisite. Trace amounts of the following alteration products are also present: colorless euhedral iron-rich epidote, pleochroic to yellow green; anhedral chlorite, pleochroic green to cream with an ultra-purple birefringence; and muscovite-sericite which has altered from the plagioclase.

Sphene, zircon and apatite have euhedral outlines; they were the first minerals to form. The plagioclase zoned as it crystallized from a melt of fluctuating composition. The hornblende and biotite are anhedral, altered on the edges to chlorite, and clustered together. They appear to have solidified after the plagioclase. Quartz and microcline formed last as anhedral blebs filling the interstices. The epidote, zoisite and tourmaline are deuteric. Tourmaline is present in each of the four slides, however, it is most abundant (3 percent) in slide 1608, which was collected near the contact with the metamorphic rocks. Hand specimen

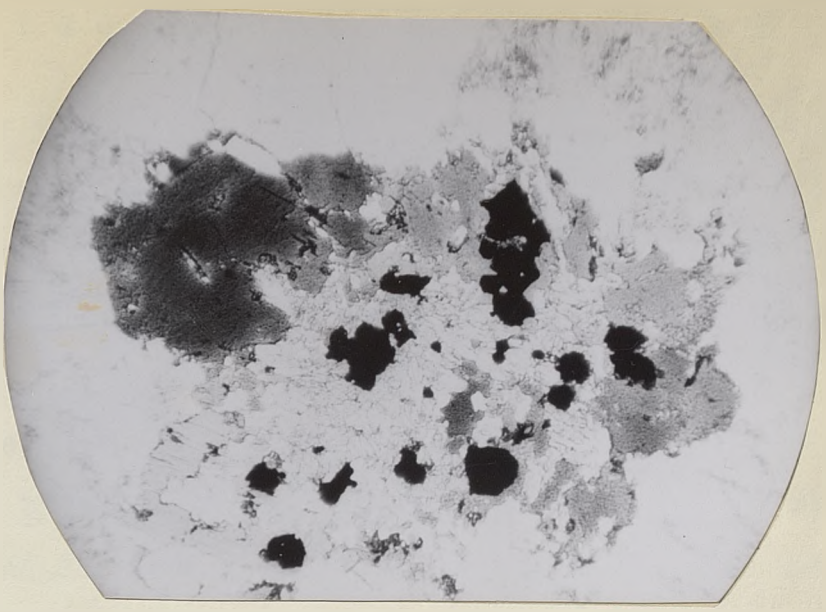


Figure 8. Slide 1608. Granodiorite. Hornblende, biotite and magnetite cluster surrounded by quartz plagioclase and orthoclase (25x).

1608 is darker in color than the other samples, but in thin section the only noted difference is the added amount of tourmaline and the fine dusty inclusions of hematite in the feldspars. The quartz-feldspar ratio is approximately constant in all the slides. Slide 1602 contains an excess of optically oriented microcline which resembles phenocrysts poikilitically enclosing plagioclase, biotite, hornblende, and magnetite. Since the specimen was collected near the contact with the metamorphic rocks, the added amount of microcline may be a result of deuteric potash metasomatism rather than an anomaly in the composition of the magma.

CENOZOIC VOLCANIC ROCKS

Unconformably overlying the eroded and weathered granodiorite and metamorphic rocks is a series of Tertiary volcanic flows and pyroclastic rocks. The extrusive rocks cover most of the southern and western portion of the map area (PLATE 1) and weather light gray or reddish-brown. The volcanic rocks are of varied composition, from dark basalts and basic andesites to light colored hornblende-mica andesites and dacites. Some of the andesites have been locally altered to rocks high in silica. These bleached areas are readily noted in the field by their pastel colors and hematite staining.

A weekend was spent in the Virginia City quadrangle comparing the Tertiary volcanic rocks in that region with the young volcanic rocks in the Peavine region. The lithologic types and successions closely resemble each other. The basic andesites found in the southeastern portion of the mapped area are similar both in field relationship and appearance to the Alta Andesite of the Virginia City quadrangle as described by Gianella (1936, p.53) and Thompson (1956, p.51). A hornblende-biotite andesite found in the mapped area appears to be correlative with the Kate Peak Andesite (Gianella, 1936, p.69 and Thompson, 1956, p.54). And, a basalt of probable Pliocene age may be correlative with the Lousetown Basalt as described by Thompson (1956, p.57). Dr. E. R. Larson and Dr. V. P. Gianella (oral

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communication, 1958) both have agreed that correlation of the Tertiary volcanic rocks in the Peavine area with the Tertiary volcanic rocks in the Virginia City area is reasonable. A tentative correlation of the above units has therefore been made.

ALTA ANDESITE

General

In the southern portion of the mapped area, basalts, olivine and pyroxene andesites, and hornblende andesites have been tentatively correlated with the Alta Andesite of the Virginia City area as described by Gianella (1936, p.53) and Thompson (1956, p.51). These propylitized and locally bleached volcanic rocks lie unconformably on weathered granodiorite and metamorphic rocks and are tilted strongly.

The lithology of the Alta Andesite varies radically in successive flows. Most of the latter are thin, generally less than 20 feet thick, and show a variety of color, from dark browns through purples, reds and grays.

No centers of activity for these volcanic rocks have been located in the mapped area. However, a few dikes which may have partly supplied the volcanic material were noted. One dike 20 feet thick cuts the granite in the bottom of Bull Ranch Creek.

McCrae (1953, p.88) mapped the basic andesites and basalts in sections 34 and 35, T. 20 N., R. 18 E., as pre-Tertiary basalts. He noted an intrusive relationship between the volcanic rocks and the pluton. In the area where he

collected the sample, a thin sliver of metamorphic rock crops out. It is felt by the writer that McCrae mistakenly assumed that the Tertiary volcanic rocks and the older metamorphosed volcanic rocks were identical. The outcrops are poor in this area; however, careful examination indicates that the Alta Andesite lies on eroded metamorphic rocks which are intruded by granodiorite.

Petrography

The Alta Andesite contains phenocrysts of orthopyroxene, clinopyroxene and or olivine with calcic plagioclase. The groundmass varies with each flow. Some approach an intergranular matrix, some are pilotaxitic, while others are glassy. Many of the rocks have been so badly propylitized that it is difficult to tell the original composition of the flow.

One fresh appearing basalt (1639) contains large euhedral twinned and zoned plagioclase (An 50-60) phenocrysts and augite phenocrysts poikilitically enclosing olivine which has partly altered to iddingsite (Figure 9). The groundmass has a modified intergranular texture and is composed of medium-grained olivine, augite, hypersthene, plagioclase (An 40) and magnetite. The olivine in the matrix is partly altered to iddingsite and the plagioclase is unzoned. The phenocryst composition of the rock names it a basalt; however, if the matrix plagioclase is considered, the rock is a basic andesite.

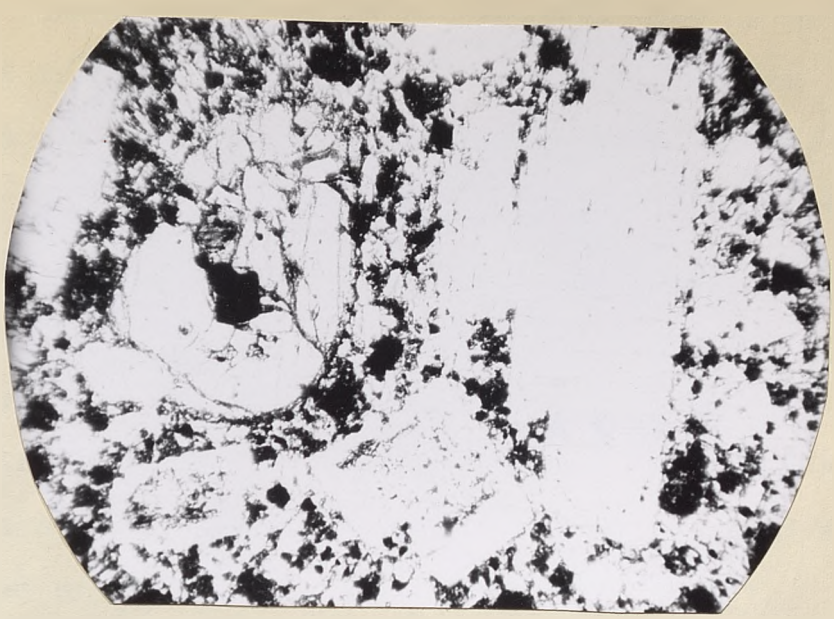


Figure 9. Slide 1639. Alta Andesite. Laboradorite (An 60) and augite phenocrysts in an intergranular matrix composed of augite, andesine, hypersthene and magnetite (25x).

KATE PEAK ANDESITE

General

Overlying the Alta Andesite are similar, yet different, volcanic rocks that have been correlated with the Kate Peak Andesite as described by Gianella (1936, p.69) and Thompson (1956,p.54). They are partly basic pyroxene andesites, but, the most common unit is a coarsely porphyritic hornblende-biotite andesite found in thin local areas on the western side of Peavine Mountain. In the Virginia City region, this type of Kate Peak Andesite is considered by Thompson (1956, p.54) to be an intrusive phase. In the Peavine area, intrusive relationships are lacking. The writer prefers to explain these coarsly crystalline rocks as flows, since the matrix

is very fine-grained and partly glassy. The large phenocrysts probably formed in the magma chamber through slow cooling. When the magma erupted only half of the material was still fluid. The groundmass is much finer-grained than the average basalt found nearby in definite flow relationship. Also, in one locality near the state line, this porphyritic phase of the Kate Peak lies on top of weathered granodiorite. The latter is only slightly affected by heating; it does not show the alteration expected from association with the slow cooling of a dike or sill.

The Kate Peak Andesite rests horizontally on the erroded, tilted and bleached Alta Andesite. The Kate Peak is present on the western side of Peavine Mountain, but appears only as small remnants on the eastern side. Erosion has stripped most of the Kate Peak Andesite from the southern slopes.

Petrography

In the field, the Kate Peak Andesite weathers to large roughly pitted brown boulders. On fresh exposure, it ranges in color from pink to gray. The hand specimen is holocrystalline, porphyritic containing euhedral plagioclase feldspar phenocrysts approximately one-half inch in length, and smaller euhedral phenocrysts of hornblende, biotite and plagioclase in a fine-grained matrix.

In thin section (1607, 1620), the rock is holocrystalline, porphyritic with subhedral to euhedral phenocrysts of: complexly twinned and zoned plagioclase (An 41); zoned augite showing poorly developed hourglass structure; oxyhornblende,

pleochroic from cream to deep rich golden brown and altering to anhedral biotite and magnetite. The biotite shows pleochroism from cream to dark brown (Figure 10). The phenocrysts are randomly oriented or form glomeroporphyritic clots.

The matrix is composed of two smaller sizes of plagioclase (An 52) laths, augite, hornblende and magnetite phenocrysts in a cryptocrystalline or glassy matrix.

Many of the hornblende phenocrysts have euhedral outlines but contain matrix material in their centers (Figure 11). Others poikilitically include euhedral apatite crystals, magnetite, and plagioclase laths. Apatite, pleochroic from colorless to pale pink, is present in the groundmass in rounded grains. The matrix also includes cristobolite. The groundmass is transitional between pilotaxitic and hyalopilitic since it is either cryptocrystalline or glass with a slight birefringence.

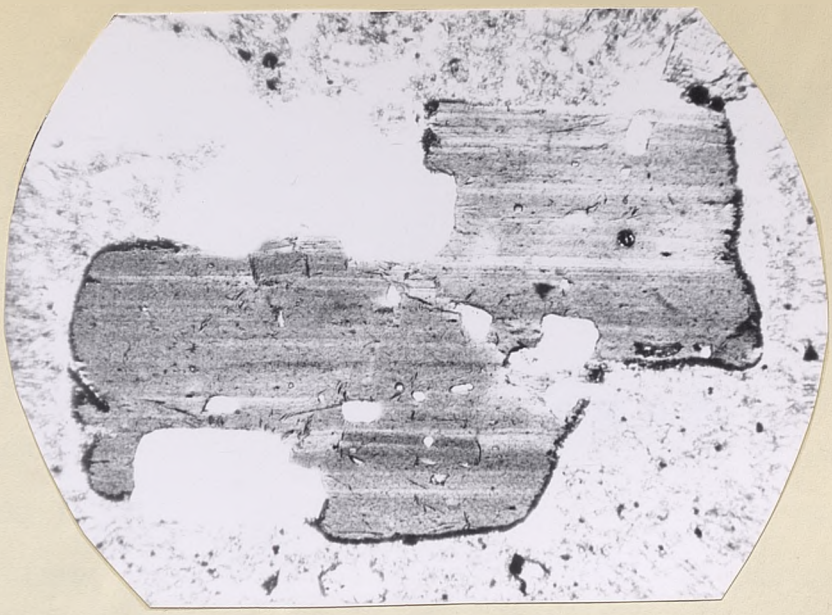


Figure 10. Slide 1620. Kate Peak Andesite. The biotite phenocryst is poikilitically enclosing andesine. The edges of the biotite are altering to magnetite (50x).



Figure 11. Slide 1620. Kate Peak Andesite. The center of the hornblende crystal is filled with matrix material. The matrix is pilotaxitic (25x).

LOUSETOWN BASALT

General

In the Peavine area, olivine basalts form conspicuous outcrops near U. S. Highway 40. They are restricted to the Truckee River area, where they attain a thickness of approximately 400 feet, and the southern slopes of Peavine Mountain where they thin radically to the north. One mile east of Verdi, the nearly horizontal basalts rise abruptly from the Truckee River to form prominent reddish-brown bluffs. On the southern slopes of Peavine Mountain, the basalt caps the ridges, dips to the south, and thins northward. Because the basalt thins to less than ten feet before reaching the present granitic contact and because no basaltic fragments have been found in the granitic area, the writer believes that the basalt never covered the main intrusive body.

Lindgren (1897) considered similar appearing olivine basalts in the Truckee quadrangle to be Lousetown series and to have originated in quiet fissure eruptions from the northern slopes of the Carson Range. Moore (1952, p.34) mapped the area north of North Rose as Lousetown Basalt. He also noted a basaltic cinder cone and an intrusive body of basaltic composition.

There are no visible dikes or cones in the mapped area. Therefore, the writer feels that the olivine basalt flowed down from the Carson Range into the Truckee River Canyon area near the state line and then flowed east to Mogul.

The basalt lies unconformably on steeply tilted Alta Andesite and conformably on the Coal Valley sediments. The basalt probably flowed over an erosion surface of slight relief. Coarse-grained basalt with columnar jointing which may be the same age is encountered in the roadcut one mile east of Verdi. Here U. S. Highway 40 has been carved out of the hill exposing approximately 40 feet of fresh, coarse-grained olivine basalt.

Overlying the coarse-grained basalt are approximately ten feet of cream colored unconsolidated water lain tuffaceous sediments deposited on an erosional surface. The tuffs are discontinuous to the northwest, where they are replaced by a purple ash bed of inferior thickness. Overlying these fine-grained, unconsolidated sediments are successive flows of fine-grained olivine basalt that accumulate to a thickness of 400 plus feet.

Approximately one mile to the north in section 4, T. 19 N., R. 18 E., a similar olivine basalt, showing columnar jointing, crops out. It is overlain by about 100 feet of basalt with platy fracture and minute phenocrysts of olivine. The basalts strike N. 60° E., dip 30° S., and are underlain to the north by Alta Andesite.

The basalt overlies and, in part, may be intercalated with the upper portion of the Coal Valley Formation. It is therefore probably late Pliocene in age. The basalt is probably part of the Lousetown series as described by Thayer (1937, p.1648), Thompson (1956, p.57) and Moore (1952, p.37).

Petrography

The coarse-grained olivine basalt, a dark gray porphyritic rock, contains olivine phenocrysts altering to iddingsite and weathers to a red-brown pitted surface. The pits result from the weathering out of the olivine crystals, the most unstable minerals present.

In thin section (1625), the basalt is holocrystalline with phenocrysts of olivine, augite and plagioclase in an intergranular matrix. The olivine phenocrysts have altered along the edges and fractures to iddingsite (Figure 12). Though some olivine crystals have been completely changed

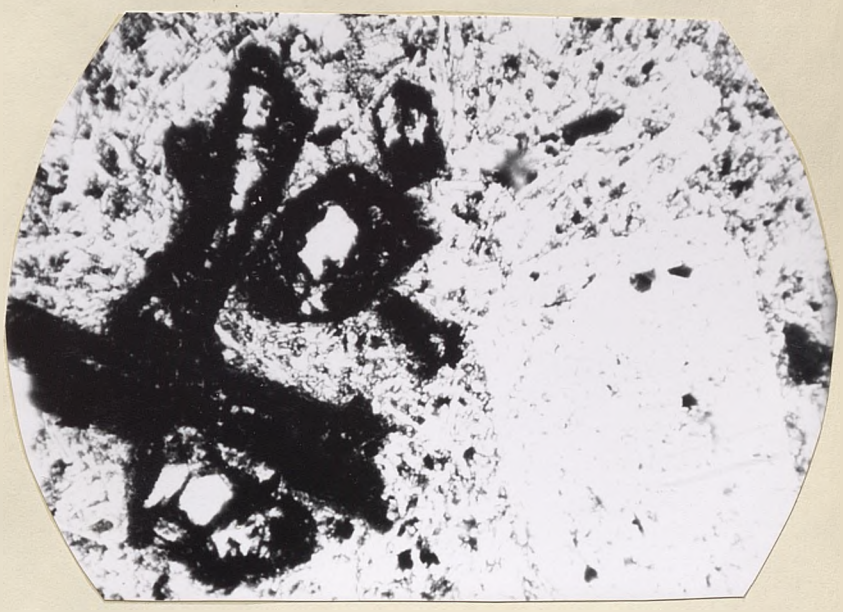


Figure 12. Slide 1625. Basalt. Glomeroporphyritic clot of olivine altering to iddingsite and a spongy laboradorite phenocryst lie in an intergranular matrix (25x).

to iddingsite, the majority are less than one-third altered. The euhedral phenocrysts of augite exhibit an hourglass structure (Figure 13). The plagioclase (An 51) phenocrysts have undulatory extinction, simple to complex twinning, and have been altered along internal cleavage to a yellow substance resembling chlorophaeite. The phenocrysts are randomly oriented with occasional glomeroporphyritic clots. The fine-grained intergranular matrix (Figure 14) is composed of labradorite (An 60) laths with augite, magnetite and olivine filling the intersticies. The groundmass feldspars also show internal alteration.



Figure 13. Slide 1625. Basalt. Hourglass structure in augite. Under crossed nicols (25x).

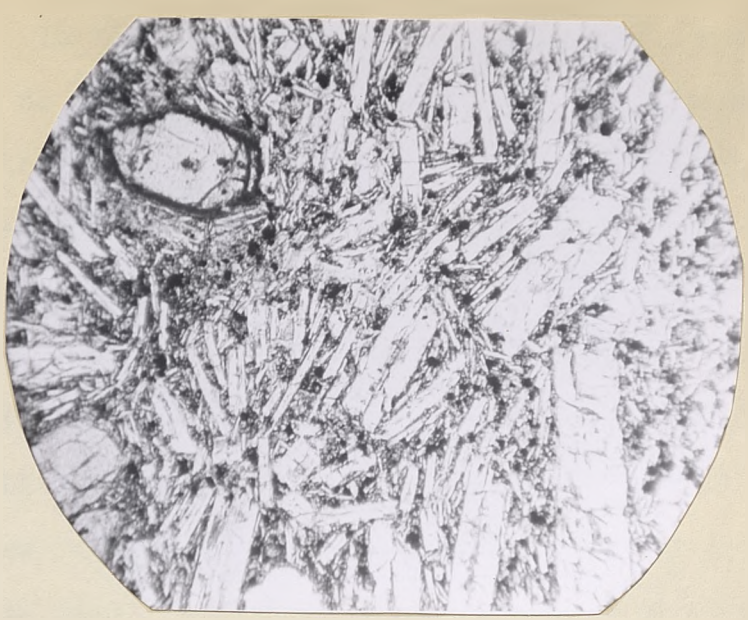


Figure 14. Slide 1625. Basalt. The intergranular matrix is composed of labradorite (An 60) laths, magnetite, augite and olivine (50x).

BLEACHED ROCKS

The bleaching that occurs on the southern slopes of Peavine Mountain is confined, except for small scattered patches, to the eastern edge of the mapped area where all rocks older than Kate Peak Andesite have been bleached along fractures. In an effort to understand the distribution of bleaching in the mapped area, a sketch map of the bleached rocks in the southern portion of the Reno quadrangle has been prepared. The map was prepared from aerial photographs and doubtful areas were checked on the ground (PLATE 2).

The results of the above work indicate that a wide band of altered rocks, predominantly bleached Alta Andesite, extends eastward from the mapped area to the edge of the

quadrangle. In the mapped area, bleaching is less intense to the west so that bleached areas occur only in small patches in the west. Bleached granitic rocks along the Truckee River, approximately 1 mile west of the Nevada State Line, indicate that bleaching extends at least that far.

Thompson (1956, p. 62) attributes bleaching in the rocks of the Virginia City quadrangle to near-surface alteration by acids. Lindgren (1897) notes solfataric alteration of the andesites to rocks high in silica. Most of the bleaching seems to have resulted from weathering of altered rocks containing pyrite. The end products are chiefly secondary quartz, opal and clay in varying proportions, together with residual minerals. The identity of the original rock is revealed in some specimens by relict textures. The alteration and addition of pyrite may have resulted from hydrothermal alteration by hot, mineralized solutions.

Bleached rocks are widespread around Reno. The alteration in the Virginia City area, the bleached zone in the Virginia Range south of Vista, and the bleached rocks that extend from the Wedekind district to Peavine Mountain comprise the remains of what may have been an extensive hot spring complex in the early Tertiary.

S E D I M E N T A R Y R O C K S

COAL VALLEY FORMATION

General

A thick section of sedimentary rocks exposed in the Kawsoh Range east of Wadsworth, Nevada, was named "Truckee Formation" by King (1878, p.415). He also referred to the Tertiary sediments west of Reno as the Truckee Formation and dated them tentatively as Miocene. Calkins (1944, p.23) placed their age between the Miocene and the Pliocene. Later, Axelrod (1955, p.141) correlated the sediments in the Verdi region with the Pliocene Coal Valley Formation. Using fossil leaves, which are plentiful in some horizons, Axelrod dated the Coal Valley Formation as middle Clarendonian and Hemphillian.

In the type section in the Hawthorne quadrangle, the Coal Valley Formation (Axelrod, 1956, p.29) is 3325 feet of fluvo-lacustrine beds consisting of soft lake silts, sandstones, conglomerates and sedimentary breccias intercalated with Kate Peak Andesites. The Coal Valley Formation in the mapped area consists primarily of lake deposits that filled a structural basin south of Peavine Peak. The lowermost beds lie on an erosion surface of the Alta Formation and contain large cobbles of andesite and granite. The sediments grade upward to fine sands and tuffs. North of Verdi, the Coal Valley beds are less than fifty feet thick and are conformably overlain by Kate Peak breccias.

To the east, the sediments increase in thickness and become finer-grained. Across the river from the Verdi powerhouse Coal Valley beds are cut by low angle faults. The lowest beds are cobble conglomerates lying on eroded Alta Andesite. The sediments grade upward to fine tuffs. The uppermost bed is a red ash deposit approximately 15 feet thick which is conformably overlain by the olivine basalt.

In the Mogul area, the sediments attain a thickness of at least 500 feet and consist of: white, fine-grained tuffs, diatomites (1638) and finely laminated shales. The sediments are poorly consolidated and easily eroded.

Fused Coal Valley

East of Verdi on Rakota Hill (PLATE 2), the Pliocene sediments have been altered to a brick red color and locally fused. One half mile to the east, two other small localities have also been altered. The alteration is independent of type of sediment; the sandstones have been changed as thoroughly as the tuffs and diatomites. Oxidation of authigenic or deuteric iron ore to hematite causes the red color.

Locally, along small fractures and bedding planes, fusion appears to have taken place. The center of the fused material is black glass, and on both sides red glass can generally be found. The red glass grades into the unfused sedimentary rock. In a sandstone sample (1640), the glass surrounds the unfused sand grains (Figure 15).

The natural glasses and a glass which was fused in a



Figure 15. Fused sandstone from the Coal Valley Formation (25x).

carbon arc from the finely ground powder of a sample of the reddened sediment were investigated under a petrographic microscope. The index of refraction of the black glass is 1.525 and the index of the red glass and the artifically fused sediment is 1.505. Silica content of the glasses was determined by using curves for silica content in volcanic glasses (Williams, Turner and Gilbert, 1955, p.28). The black glass contains 62-65 percent silica and the red glass and artifically fused sediment contain 70-73 percent silica. The above percentages of silica are only approximate. Chemical analyses should be preformed to check their validity.

The above data suggests that the black glass has a noticable difference in silica content. The smaller amount of silica in the black glass may be the result of

mixing of a basic magma with the highly acid sediments.

The altered sediments are possibly the result of the emplacement of a shallow dike or sill, in recent times. Small fissures broke through the surface and allowed gases and a small amount of the molten material to escape. As the molten lava and gases stoped their way up to the surface, they assimilated the highly siliceous surrounding rock. The mixed melt squirted out onto a small surface that extended a few acres at maximum. The liquid froze rapidly at the surface producing a vesicular ropy texture. Delicate glass is in place on top of Rakota Hill, which is part of a surface planed by the Truckee River in Pleistocene time. Therefore, the fused material must be late Pleistocene or younger.

PLEISTOCENE GLACIAL GRAVELS

Resting on the tilted and eroded Coal Valley Formation are poorly sorted granitic and volcanic boulders that were derived from the Sierra Nevada to the west. The gravels are common just west of Reno, but in the mapped area are limited to two localities: west of Mogul and northeast of Crystal Peak Cemetery. Granite boulders greater than ten feet in diameter are noted. Any mode of transportation other than flotation by ice seems improbable.

The boulder gravels are poorly sorted as though deposited by a flood. Perhaps the Truckee River was impounded by an ice dam to the west, near Truckee, California. When the water was released, the force was great enough to carry large rock masses, partly supported by ice, and dump them in a haphazard fashion over the surfaces that were being cut by the Truckee River.

PLEISTOCENE ALLUVIAL FANS

Alluvial fans formed contemporaneously with the Pleistocene gravels. Near Copperfield, a large alluvial fan, composed of metamorphic fragments, was formed. Neither granitic nor unmetamorphosed volcanic rocks have been found in this fan. Intermittent streams have eroded canyons in the fan up to 100 feet deep.

In the northwestern portion of the map, metamorphic fan material covers Kate Peak Andesite. This fan has been so deeply dissected that only patches remain. An alluvial fan composed chiefly of metamorphic debris extends westward from Peavine Peak. Between these two fans there are scattered patches of fan material on the tops of the granitic hills, indicating that the fan at one time was very extensive.

In the south, fan material extends from the foot of the mountain southward. This fanglomerate is composed of volcanic, metamorphic and granitic material derived from the north. It unconformably overlies the Coal Valley, andesites and basalts. A half mile east of Rakota Hill the fan material has a dip of 25° W. Therefore, the fan material is older than the latest deformation.

The poorly sorted, sub-rounded gravels are interbedded with fine sands and silts. The majority of the fan material is small, generally less than 2 inches in diameter. However, boulders three to five feet in diameter have been noted. They probably mark stream courses.

S T R U C T U R E

FAULTS

General

Normal faults are the characteristic features of Peavine Mountain. The mountain is a tilted fault block with a N. 45° W. fault-line scarp on the northeastern side (PLATE 1), which has a topographic displacement of at least 2000 feet. The fault had at least three stages of uplift. From U. S. Highway 395, three sets of faceted spurs and altered drainage patterns can be seen along the scarp.

In the northeastern corner of the mapped area, a cross fault that strikes N. 45° E. offsets the above mentioned fault and extends across U. S. Highway 395 to form the eastern escarpment of Granite Peak. The scarp in the unconsolidated Pleistocene fan materials is not deeply eroded; consequently, the fault is young.

At Peavine Peak another cross fault, striking generally east-west, offsets the major fault. A north-south fault one mile west of the Peak has formed a bold fault-line scarp 1000 feet high. These two faults have resulted from the tilting of the southern portion of Peavine Mountain to the southeast..

Near the base of the southern slopes, a major fault not shown by topography is marked by the change in dip and strike between the Tertiary andesites and the Coal Valley Formation. In one locale, horizontal Coal Valley beds

appear to butt against andesites which strike N. 70 E. and dip 40° S. Unfortunately, Pleistocene and Recent alluvium cover the fault so that it is nowhere visible.

A minor reverse fault is displayed in the railroad cut at Copperfield. Flat-lying Coal Valley sediments are faulted against younger fanglomerates that are also horizontal. The Coal Valley beds form the hanging wall of the fault that strikes north and dips 70° W. The gouge zone of the fault is approximately one foot thick.

A group of low angle faults can be seen across the river from the Verdi powerhouse. These normal faults which strike approximately north and dip 30° W. cut the Coal Valley beds into a series of steps. The lake sediments at this point lie on eroded Kate Peak Andesite. The uppermost Coal Valley, a red ash deposit approximately 15 feet thick, is conformably overlain by the olivine basalt.

Springs

On the northern slope of Peavine Mountain an east-west alignment of springs marks the fault contact of the metamorphic rocks and the fan material. On the southern flank an east-west trending series of springs marks the erosional contact of the granodiorite and the overlying andesite. The water permeates the deeply weathered granitic rock, flows in joints and cracks under ground and issues forth as springs at the contact with the dense volcanic rock. The springs found in the metamorphic terrane probably represent faults, since the permeability of the metamorphosed rock is very low.

FOLDS

The folding in the mapped area is confined to the pre-Tertiary metamorphic rocks. The Coal Valley Formation is extensively faulted, but no evidence for folding was noted. In the metamorphic rocks, the strikes and dips of the beds are difficult to obtain. And even when they are determined they do not present a simple problem. The strike of the beds varies from north-south to east-west while the dip ranges from horizontal to vertical. The almost completely random variety of dips and strikes lends a chaotic aspect to the structure of the metamorphic rocks. However, in Sections 3, 4, and 9, T. 20 N., R. 18 E., a fossiliferous bed is traceable from the mine in section 9 to the road in section 3. The dip varies from horizontal at the mine to 30° E at the road. Repetition of beds was not noted. However the outcrops are so poor that repetition of beds could be missed completely.

The metamorphic beds appear to have been folded into broad gentle folds by the dynamic forces that caused the regional metamorphism. However, to understand the structure of the metamorphic rocks much more detailed work must be done in that area.

STRUCTURAL CONCLUSIONS

Before the emplacement of the intrusion, the Jurassic sediments and volcanic rocks were regionally metamorphosed and thrown into broad folds. During early Cretaceous time the granodiorite pluton intruded the metamorphosed rocks causing contact metamorphism and faulting. The region was uplifted and the rocks stripped away by erosion until the granite was exposed. Then in early Tertiary times the orogenic forces began again with the extrusion of volcanic material. At the end of the Tertiary, igneous extrusive forces has exhausted themselves and orogenic forces had begun. Peavine Mountain, a low lying mass in the Middle Tertiary, was elevated slightly in Pliocene times. The Coal Valley Formation was deposited in structural basins both to the north and south of Peavine Mountain.

Extensive normal faulting began in the late Tertiary along the northeastern side of the mountain. The movement was spasmodic, as shown by the drainage patterns. A fault to the south caused the andesites to tip and the Coal Valley Formation to remain essentially horizontal. As the tilting became more intense, compensation was necessary in the region containing the flat-lying Coal Valley Formation. The area broke into small blocks and readjustment was accomplished by tilting as the forces raised the mountain almost to its present height.

Later, the Truckee River beveled the Coal Valley sediments and cut stream terraces as it eroded toward base level. Recent seismic activity in the Verdi area proves that regional equilibrium has not yet been established.

RELIABILITY OF STRUCTURAL FIELD DATA

In a volcanic terrane, the measurement of deformation is complicated by the lack of extensive stratigraphic markers and by initial dips that may have been very steep (Thompson, 1956, p.65). Metamorphism adds further complications by the introduction of schistocity, foliation, and recrystallization which may destroy the bedding.

In the mapped area, the only measurement of structural deformation which can be determined accurately are dips and strikes taken in the finely laminated Coal Valley Formation. Next in degree of reliability are strikes and dips taken in the metamorphosed sediments where bedding has been preserved. Of doubtful reliability are strikes and dips of flows and fragmental volcanic rocks where the initial dip is uncertain. Least reliable as indicators of tectonic deformation are the strikes and dips of the platy parting in the basalt and basic andesites and the apparent bedding found in the metamorphosed volcanic breccias.

E C O N O M I C P O S S I B I L I T I E S

Mineralization on Peavine Mountain was first reported by Browne (1868, p.316):

> "Among the more promising cupriferous localities in the state is the Peavine District. ---A town also named Peavine, was laid out in 1863, at the group of springs. It contains several houses, and being adjacent to the mines, should the latter turn out according to expectation, its growth will no doubt keep pace with their future development."

Copper is found in the metamorphic rocks as copper sulfides, carbonates and silicates. Hill (1915, p.194) wrote of the Red Metals mine:

> "---2 miles northwest of the summit of Peavine Mountain, 15 miles by road northwest of Reno and 7½ miles east southeast of Purdy, California, its shipping point. The ores so far developed lie in rather small lenses parallel to the structure of feldspathic schists, probably derived from andesitic material. The main body consists of overlapping lenses, which occur through a vertical height of 50 feet and run from the surface for about 200 feet along the dip of 20° southeast. The ore makes in crushed streaked schist, the crushing having resulted from movement nearly parallel to the schistosity. ---The ore is all more or less oxidized though kernels of bornite, the chief sulphide seen, are being altered to chalcocite and copper pitch ore. Malachite and copper-iron sulphate were found in some ore, and in one specimen a thin film of light-blue copper phosphate was noted."

The Red Metals mine closed soon afterwards. Julius Redelius, present owner of the property, has been re-exploring the claims for profitable ore.

Gold-silver mineralization in hydrothermal quartz veins, rich in fine-grained tourmaline, occurred in conjunction with the intrusion of the granitic stock. The veins have been prospected intensively in the past and are rumored to

contain up to $70.00 a ton in gold and silver; however, at present no quartz veins are being mined.

Near the summit of Peavine Peak, a claim has been staked on magnetite ore. In the summer of 1957, cuts were made with a bulldozer to delineate the ore body.

Diatomaceous earth, locally of high quality, is mined from the Truckee Formation at Clark Station, approximately 20 miles east of Reno. Large exposures of diatomite also occur in the southeastern portion of the mapped area in the Coal Valley Formation. The white fine-grained rock (1638) contains approximately 90 percent diatoms. The waste material is tuffaceous and contains glass shards and small fragmental crystalline material.

S U M M A R Y

Igneous, sedimentary and metamorphic rock types are represented on the west side of Peavine Mountain. The oldest beds exposed are Jurassic sedimentary and volcanic rocks which have been regionally metamorphosed to the biotite zone of the greenschist facies. The metamorphic rocks consist of: graywackes, impure limestone lenses recrystallized to garnet-epidote skarns, pyroclastic rocks, flows, breccias and poorly rounded and sorted volcanic sediments.

The sedimentary and volcanic rocks have been thermally metamorphosed by the pluton which invaded the older rocks in early Cretaceous time. The intrusive body is essentially a nonfoliated biotite-hornblende granodiorite stock that is exposed over seven square miles near the center of the map area. Granodiorite also outcrops north of Mogul as a low ridge. The two outcrops are of similar mineralogy and probably extend beneath the Tertiary sediments and volcanic rocks.

After the intrusion of the granodiorite stock, erosion ensued. The metamorphic rocks were stripped away and the granitic rock exposed. Basic andesites flowed over an old deeply weathered erosion surface of low relief in the early Tertiary. These early volcanic rocks are low in silica. They contain clinopyroxenes, orthopyroxenes, olivine and plagioclase phenocrysts in a groundmass that varies from intergranular to pilotaxitic or hyalopilitic. Propylitization

has altered many of the andesites, giving them a green color. These early Tertiary volcanic rocks have tentatively been correlated with the Alta Andesites of the Virginia City quadrangle.

Above the Alta Andesite are similar volcanic rocks which have been correlated with the Kate Peak Andesite. These rocks are, in part, basic andesites; however, the most common unit for correlation is a coarsely porphyritic hornblende-biotite andesite. In the Virginia City area this facies of Kate Peak is commonly an intrusive phase, but in the Peavine area, intrusive relationships are lacking.

Fossiliferous Pliocene sediments, named the Coal Valley Formation by Axelrod, were deposited on an eroded surface of the Alta Andesite. The lake sediments grade upward from very coarse cobble conglomerates to fine sands and shales. Locally the shales grade into very fine-grained tuffaceous sediments and diatomaceous earth.

On Rakota Hill, the Coal Valley beds have been burned brick red by heat from a shallow basic dike or sill. The major effect was the oxidation of the authigenic iron in the sediments to hematite which colors the hill red. The mixing of a small amount of the basic magma with the siliceous sediments probably caused a dacitic melt which rose to the surface and cooled to black glass along fractures.

After the Coal Valley Formation was deposited, some tilting and block faulting occurred. Erosion began before the olivine basalt was extruded. The latter flowed over

the surface, filling the deeper ravines and capping the low ridges. After the basalt has ceased to flow, the Truckee lowlands were extensively block faulted.

Peavine Mountain was elevated to nearly its present elevation at the end of the Pliocene and extensive fans were formed to the north and south. The major portion of the Coal Valley Formation was covered by fan material. Upward movement on the major fault on the northeastern face of Peavine Mountain and downcutting of the Truckee River has caused the gradient of the tributary streams to be increased and the Pleistocene alluvial fans to be deeply dissected.

During Pleistocene times, a glacial outwash flood carried debris from the Sierra Nevada down the Truckee River. The flood deposited the unsorted debris in heaps at the head of the floodplain in the Truckee Meadows. The boulders which are up to 10 feet in diameter may have been transported by floating on chunks of ice. When the deluge had ended, the lower terraces of the Truckee River were covered with the poorly sorted debris.

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