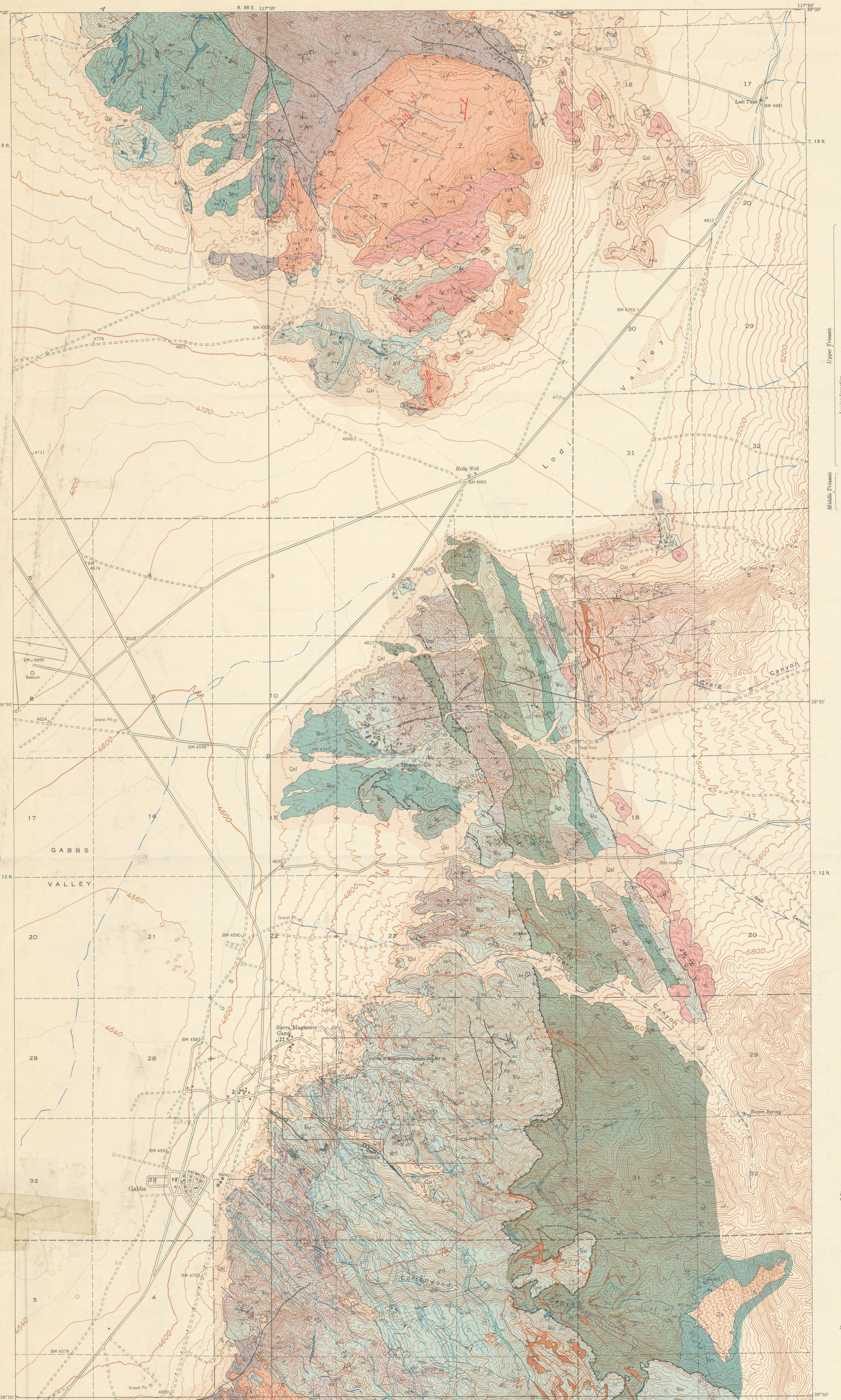
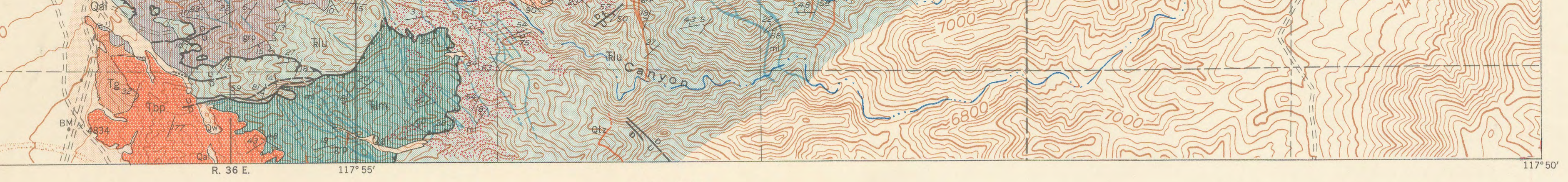


Base map by Topographic Division
U. S. Geological Survey, 1950

Scale 1:24 000

Contour interval 40 feet
Datum is mean sea level

Geology mapped in 1947 by Charles J. Vitaliano, Eugene Callaghan, George E. Ericksen, and J. C. Olson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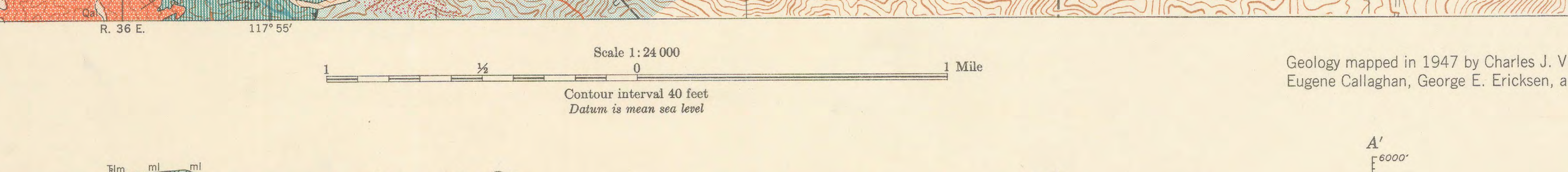
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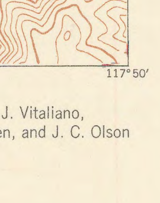


APPROXIMATE MEAN DECLINATION, 1956

EXPLANATION

SEDIMENTARY AND METAMORPHIC ROCKS

QUATERNARY

Qal — **Alluvium**
Fine-grained sand, silt, and gravel, occurring mainly in valley bottoms. Includes sand dune deposits of Gabbs Valley and Lodi Valley.

Qw — **Hill wash or float**
Includes terrace gravel and some older alluvium occurring high up on valley sides.

JURASSIC

Jd — **Dunlap formation**
Red medium-grained arenaceous limestone. Weathers to a conspicuous rusty-appearing surface.

Js — **Sunrise formation(?)**
Dark-gray to black fissile, bituminous limestone, calcareous shale, and siltstone. Contains Weyla cf. W. bodenbenderi.

J₸u — **Undifferentiated rocks of Jurassic and Triassic age**
Includes Triassic Gabbs and possibly Luning formation as well as possibly Jurassic Sunrise rocks.

TRIASSIC

₸gl, ₸gs — **Gabbs formation**
Thick-bedded gray limestone with some dolomite containing Halorella cf. H. amphitoma Bronn., ₸gl. This unit underlies the black bituminous limestone of the Jurassic Sunrise formation. The basal unit of this formation is a dark massive siltstone, ₸gs.

Upper Triassic — Luning formation

₸lu, mg — **Upper member**
Dolomite, marble, limestone. Includes areas of magnesitized rock, designated mg. Silicated, mineralized, and recrystallized in the vicinity of intrusive igneous rocks, with intensity of alteration shown by density of stippling.

₸lm — **Middle member**
Sandstone, shale, siltstone, conglomerate, limestone, and pyroclastic rocks and their metamorphosed equivalents.

₸ll — **Lower member**
Dolomite, limestone, and marble. In places contains poorly preserved fossils. Silicated and recrystallized in the vicinity of intrusive igneous rocks.

Middle Triassic

₸e — **Excelsior(?) formation**
Conglomerate, slate greenstone, and metavolcanics. In places contains interbedded layers of dark-brown friable limestone.

PERMIAN(?)

Pcgl — **Conglomerate**
Pebble and boulder conglomerate; black, tough; associated with grit and coarse-grained sandstone.

Pv — **Metavolcanic and volcanic breccias**
Metamorphosed silicic and mafic flow and pyroclastic rocks. Commonly light- to dark-colored tough rocks that are jointed and break with a blocky habit.

IGNEOUS ROCKS

TERTIARY

Tbp — **Volcanics at Brunton Pass**
Flow rocks chiefly rhyolite, trachy-andesite and basalt, locally obsidian, tuff, and breccia.

Tg — **Volcanics at Goldyke**
Andesite flows with interbedded tuffs. Large areas of andesite considerably altered.

JURASSIC(?)

Rhyolite dikes
Light-colored very fine grained dikes. Some show faint flow structure and frequently weather to thin slabs.

ml — **Malchite dikes**
Green, fine-grained porphyritic rock. Makes up largest part of dike rocks in the vicinity of Gabbs. Included are dacitic dikes that are closely related in age to the malchite dikes.

ap — **Aplite dikes**
Light-colored fine-grained sugary-textured rock. Occurs only in association with plutonic intrusive rocks.

fg — **Fine-grained granite**
Light-colored even-grained granitic rock. Intrudes granodiorite.

an — **Andesite dike**
Dark-green to black fine- to medium-grained porphyritic rock. Weathers to a greenish brown and may form prominent, dark resistant ridges.

grd — **Granodiorite**
Gray, medium-grained granitic rock with hornblende and biotite crystals. Intrudes diorite and coarse-grained granite.

di — **Diorite**
Dark-colored medium-grained equigranular igneous rock. Intrudes coarse-grained granite.

grp — **Granophyre dike**
Rusty, red-weathering fine-grained, dense, dike rock. Intrudes coarse-grained granite and Triassic and older sedimentary rocks.

gr — **Coarse-grained granite**
Weathers red and locally is porphyritic, with phenocrysts as much as 10 inches in largest dimension.

Contact
Dashed where approximately located.

Fault, showing dip
Dashed where approximately located.

Fault
Dashed where approximately located; dotted where concealed. U, upthrown side; D, downthrown side.

Fault, showing relative movement

Thrust fault
Dashed where approximately located; dotted where concealed

Brecciated zones

Anticline
Showing trace of axial plane. Dashed where approximately located.

Syncline
Showing trace of axial plane. Dashed where approximately located; queried where doubtful.

Strike and dip of beds

Strike of vertical beds

Strike and dip of foliation

Strike and dip of cleavage

Direction and pitch of lineation in granite

Strike and dip of foliation and direction and plunge of lineation

Strike and dip of joint (mineralized)

Strike and dip of joint (unmineralized)

Strike of vertical joint

Quartz veins

Altered zones

Shaft

Shaft with dump

Adit

Prospect pit

Mine or quarry

GEOLOGY OF GABBS AND VICINITY, NYE COUNTY, NEVADA

By
Charles J. Vitaliano, Eugene Callaghan, and N. L. Silberling

INTRODUCTION

The geologic map of Gabbs and vicinity covers approximately 105 square miles of the northwestern part of the Paradise Peak quadrangle. The major concepts of the pre-Tertiary geology in this area were established by Muller and Ferguson (1939, pl. 1; Ferguson and Muller, 1949, pl. 11) in their regional reconnaissance of the Hawthorne and Tonopah quadrangles. The reports of these authors stressed the stratigraphy and the structural geology. The present report stresses the igneous, metamorphic, and structural geology. The first detailed geologic mapping in this area was done in 1932 by Eugene Callaghan as part of a cooperative program with the Nevada State Bureau of Mines to investigate the magnesium mineral resources on the western slope of the Paradise Range. A reinvestigation of this region by Vitaliano and Callaghan was started in 1942 and resulted in detailed mapping of the magnesite and brucite deposits as well as regional mapping of the Paradise Peak quadrangle. The map published at this time shows, (1) the distribution of igneous rocks in the area, (2) the relationship of these igneous rocks to the areas of magnesium mineralization, and (3) the relationship of the igneous rocks to other areas of mineralization where tungsten and base metal elements are found. The specific details of magnesium mineralization in this area have been discussed earlier (Callaghan, 1933; Vitaliano and Callaghan, 1956).

During the field work many kindnesses were shown the authors by members of the companies mining brucite and magnesite. The authors acknowledge the assistance of Messrs. C. E. Schwab and Charles Connours of Basic Refractories, Inc.; Messrs. Braden Beechel, W. P. Fuller, Jr., and the late T. C. Russell of Basic Magnesium, Inc.; Messrs. Robert O. Jones and Joseph Perry of Sierra Magnesite Co.; the late Mr. Richard Smith of Standard Slags, Inc.; and Mr. A. O. Brown of the Victory Tungsten Mining Co. Dr. C. I. Burk of San Francisco, Calif., permitted the examination of a report on the Illinois mine. George E. Ericksen and Jerry C. Olson, members of the U.S. Geological Survey, assisted in the field mapping. In the summer of 1947 H. G. Ferguson, of the U.S. Geological Survey, spent two days in the field with the senior author. This report has had the benefit of a critical review by Mr. Ferguson.

The geology of the area including the magnesium deposits northeast of Gabbs was generalized from a 1:1,200-scale planetable map.

Gabbs, the principal mining center in the region, is a source of magnesium and tungsten ores. Subordinate mining localities lie to the north and the south of Gabbs. The most important is in the southern tip of the Broken Hills Range, where scheelite disseminated in granite is mined at the Victory tungsten deposit.

All ore mined in the area is shipped by large diesel trucks to Luning, Nev., a station on the Southern Pacific Railroad 33 miles south, on paved State Highway 23A.

The Gabbs area is rugged and is divisible into three major geographic units: the relatively low lying Gabbs and Lodi Valley that trends diagonally through the area from southwest to northeast and ranges from 4,500 to 4,800 feet in altitude; the northwestern foothills of the Paradise Range, where peaks rise to a maximum altitude of 7,687 feet; and the southern part of the Broken Hills Range, which contains deeply dissected pediment valleys flanked by sharp ridges rising to 5,850 feet.

As in most desert regions, water is a critical factor in the Gabbs area. Water for domestic and commercial purposes is obtained from wells in Gabbs Valley. The water taken from the wells has a temperature of about 135° F; it is chlorinated for domestic use.

GEOLOGY

The layered rocks in the vicinity of Gabbs range in age from Permian(?) to Tertiary; they include sandstone, siltstone, shale, limestone, and dolomite of Permian(?), Triassic and Jurassic age, and pyroclastics and lavas of Permian(?), Triassic, and Tertiary age. Unconsolidated deposits of gravel, alluvium, and windblown sand are of Pleistocene and Recent age. Although Tertiary sedimentary rocks do not crop out in the area, they underlie the alluvium-capped low ridge that forms the western boundary of Gabbs Valley. The pre-Tertiary sedimentary and volcanic rocks are metamorphosed and have been intruded by a series of dikes, sills, and stocks that are of probable Jurassic age and range in composition from diorite to granite. Granitic intrusive rocks were partly responsible for metamorphism of the sedimentary rocks.

The pre-Jurassic rocks have been greatly deformed by folding and faulting that took place mostly before the intrusion of the igneous rocks. Both normal and thrust faults cut the rocks, and displacement along some of the normal faults has continued into recent times.

ROCKS OF PERMIAN(?) AGE

Rocks of Permian(?) age, about 250 feet thick, crop out in the northeastern part of the area, southwest of the abandoned site of Lodi Tanks.

The Permian(?) rocks, which include pyroclastics, flows, conglomerate, some interbedded grit, and coarse sandstone, probably are equivalent to the middle part of the Permian(?) sequence as it occurs in the main Paradise Range. The middle part of the Permian(?) sequence of the Paradise Range is normally overlain by siliceous and carbonaceous sedimentary rocks, conglomerate, and metamorphosed rocks of the late Permian(?) age; but in the outcrop near Lodi Tanks these beds are missing and Triassic rocks lie directly on the middle part of the Permian(?).

The pyroclastic rocks are dark-blue to black agglomerates (Wentworth and Williams, 1932, p. 46) with angular to subrounded fragments of porphyritic andesite as much as 1½ feet in diameter embedded in an altered volcanic matrix. Interbedded with the agglomerate are thin layers of porphyritic andesite similar to the agglomerate fragments. Locally lenses of grit are interbedded with layers of greenstone, which are compacted and metamorphosed fine-grained ash deposits. The Permian(?) rocks were sheared by the intrusion of the adjacent igneous complex.

ROCKS OF MESOZOIC AGE

The exposed Mesozoic rocks are limestone, dolomite, shale, and volcanics that cover the major part of the mapped area. All the Mesozoic rocks are metamorphosed, some intensely, others less so. These rocks are divided into the Excelsior(?), Luning, and Gabbs formations of Triassic age, and the Sunrise and Dunlap formations of the Jurassic age.

Excelsior(?) formation.—The oldest Triassic rocks belong to the Excelsior(?) formation, of Middle Triassic age, that everywhere in the vicinity of Gabbs is thrust over younger rocks. The Excelsior(?) formation is composed of limestone layers as much as 20 feet thick interbedded with layers of volcanic breccia and metamorphosed tuff. The breccia is dark green and is andesitic in composition, and the fragments are commonly flattened or distorted by shearing. The metatuff is light-gray sericite schist that in many places contains metacrysts, which give the rock a spotted or knotty appearance.

In the Paradise Range the Excelsior(?) formation is thin, partly owing to removal by erosion, partly to slicing by thrust faults. Everywhere in the area the formation rests on the younger Luning formation. Thus in the vicinity of Downeyville, rocks of Excelsior(?) age are thrust over slate and conglomerate of middle Luning age.

Muller and Ferguson (1936, p. 244-245) first described and named the Excelsior formation in the Excelsior Mountains of Nevada. On the basis of fossils collected from this formation in the Gillis Range, 35 miles to the west, the rocks have been assigned to the Middle Triassic (Muller and Ferguson, 1939, p. 1589). In the Paradise Peak area the identification of Excelsior(?) rocks was by lithologic similarity to known Excelsior rocks as established by Muller and Ferguson.

Luning formation.—The Luning formation of Late Triassic age was named by Muller and Ferguson (1936, p. 245) after the small settlement in Soda Springs Valley. The rocks of the Luning formation crop out in a continuous strip along the western boundary of the area except where they are covered by alluvium in Lodi Valley, north of Downeyville, or where the outcrop is interrupted by igneous rocks, as in the Broken Hills Range; at Gabbs; and in the vicinity of Sheep Canyon.

The Luning formation has been divided by Muller and Ferguson (1939, p. 1596, pl. 3), into lower, middle, and upper members. The lower member, a thin-bedded, dark-blue to black limestone containing some argillaceous and slaty beds near the top, is exposed in the northwestern part of the area on the west and north sides of the igneous rock complex that crops out in the southern part of the Broken Hills Range.

The middle member of the Luning formation is dark grayish green to black and is composed of shale, slate, carbonate rocks, and interbedded conglomerate layers 40 to 50 feet thick and their metamorphic equivalents. The slate and conglomerate are particularly well developed in the northwestern part of the area in the Broken Hills Range. Eastward, beyond the area of the Gabbs and vicinity map, thin-bedded fissile carbonate rocks, schist, shale, conglomerate, and metamorphosed tuff are part of the middle member of the Luning formation. The metatuff is a fine-grained white schistose rock with a knotty texture locally.

The presence of conglomerate in the middle member of the Luning in this area appears to indicate shoreline conditions of deposition in middle Luning time in the southern Broken Hills region. The alternation of conglomerate and shale indicates fluctuation of the shoreline. Muller and Ferguson (1939, p. 1595; Ferguson and Muller, 1949, p. 8) have discussed the possible existence of an embayment in the middle Luning sea. The occurrence of conglomerate in the middle Luning member would indicate, as mentioned above, near-shore depositional environment.

The upper member of the Luning formation is represented by two distinct rock types in the Gabbs area. The first of these is a dense, dark-gray to black dolomite that is somewhat cherty and has a definite tendency to break into rhombohedral blocks. The second type is a thin-bedded black limestone that locally has acquired a slaty cleavage. The eastern boundary of the dolomite of the upper member in the Gabbs area marks the trace of the Paradise thrust fault. East of the thrust fault, the rocks of Luning age are exposed in a narrow elongated strip, trending west of north, which forms the core of an anticline.

North of Gabbs the upper member of the Luning formation disappears beneath Quaternary alluvium south of Holly well, but it reappears on the northwest wall of Douglas Canyon in the Broken Hills Range, where it is thrust southward over slate and conglomerate of the middle member of the Luning. The rock in the upper plate is dolomitized as a result of regional metamorphism. This metamorphism, presumably resulting from folding and thrusting of the sedimentary rocks, may in part have been accompanied by metasomatic alteration, which dolomitized the limestone. The degree of metasomatism is not clear, but near Downeyville are lenticular masses and lenses of unaltered dark-blue to black limestone 150 feet long and 8 to 15 feet wide that are surrounded by white recrystallized dolomitic rock with a rusty weathered surface.

Gabbs, Sunrise(?), and Dunlap formations:—Muller and Ferguson (1939, pl. 1; Ferguson and Muller, 1949, pl. 11) in their reconnaissance study of the geology of the Paradise Range area have indicated the occurrence of the Gabbs formation of Late Triassic age and the Dunlap and Sunrise formations of Early Jurassic age northeast of Downeyville and in the southeastern part of the map area. East of the Paradise thrust the rocks of the Luning formation rest unconformably on top of rocks ranging in age from Late Triassic Luning to Jurassic Sunrise(?). Near the thrust fault these rocks are tightly folded and an anticline exposes Luning, Gabbs, and Sunrise(?) rocks.

Conformably overlying the dolomite in the Luning, which forms the core of an anticline exposed in the northwestern part of Green Spring Flat, is a dark siltstone containing some argillite that is probably the lower part of the Gabbs formation. This member is overlain by a thick-bedded gray limestone with some dolomite. The limestone, the base of which has yielded a small collection of poorly preserved brachiopods containing *Halorella* cf. *H. amphitoma* Bronn of Norian age, forms the upper part of the Gabbs formation as exposed in this area. The two units described are not lithologically similar to the Gabbs formation at its type locality. In more typical outcrop areas the Gabbs formation may, however, be divided into a basal shaly member and an upper predominantly carbonaceous member that is roughly analogous to the sequence east of Gabbs.

Stratigraphically overlying the carbonate member of the Gabbs formation is a series of dark-gray to black fissile bituminous limestone beds. The Jurassic age of these rocks was established by the presence of *Weyla* cf. *W. bodenbenderi* and by a fragment of an "Arietite"-like ammonite. These rocks are limited to a rather narrow outcrop northeast of Downeyville and trend southeastward in an ever-widening belt until at the heads of Tungsten and Granite Canyons they occupy the entire area between the Paradise thrust fault on the west side and the main crest of the range on the east. The central-western portion of this formation, where it abuts against the Paradise fault, has been metasomatically altered, no doubt as a result of the intrusion of the large granodiorite stock just to the west.

On the basis of the presence of the fossils mentioned above, and in view of the resemblance to clastic horizons in the Jurassic Sunrise formation elsewhere, the rocks in this unit are tentatively classified as Sunrise(?).

At the eastern edge of the low-lying ridge that borders the southeastern side of Lodi Valley is an outcrop of clastic sedimentary rocks not unlike those occurring in the Dunlap formation of Jurassic age in the Shoshone Mountains. Despite the classification of these rocks as Dunlap, the possibility that they may belong to the silty member of the Gabbs formation must not be overlooked. The presence of thrust faulting in this ridge makes correlation difficult.

Coarse-grained granite.—The oldest intrusive rock is a coarse-grained granite that crops out in several apparently unconnected bodies. On most fresh surfaces the granite is light colored and commonly stained red or black by iron and manganese oxides. In general, the rock is porphyritic, with feldspar phenocrysts 20 to 25 cm in diameter in a groundmass composed of quartz and potash feldspar grains as much as 1 cm in diameter and biotite flakes as much as 0.5 cm in diameter. Where biotite is absent, hornblende is found in small amounts.

Two bodies of coarse-grained granite crop out within the map area. The largest is a small stock that underlies a broad valley in the southern part of the Broken Hills Range. The ridges of this valley are in part sedimentary rocks that have been metamorphosed by the granite. On the west and north the granite is in contact with the lower member of the Luning formation, on the east with rocks of Permian(?) age, and on the south and southwest with younger plutonic intrusive rocks.

A laccolithic body of coarse-grained granite crops out in Sheep Canyon in the southwestern part of the map area. In many places the granite contains mafic xenoliths that may be inclusions of an earlier mafic rock or silicated masses of dolomite. Concentrations of biotite occur as schlieren. Quartz veins and aplite dikes cut through the rock. The granite is broken by closely spaced fractures; and near the Victory tungsten mines and prospects, mineralizing solutions that soaked through the granite along these fractures deposited scheelite near the contact with the limestone.

Granophyre dikes.—A widespread group of dikes of aplitic composition are classed as granophyre because of their texture. These dikes are resistant to erosion and in many places stand out as ridges that can be traced for long distances. The rock is fine grained and ranges in color on fresh surfaces from white through reddish white to purple. The main constituents are quartz, plagioclase, and orthoclase, with biotite and some hornblende. Pyrite cubes commonly occur in the fresh rock and account for stains on weathered surfaces. In places the rock is slightly porphyritic, and quartz and plagioclase phenocrysts can be distinguished with the unaided eye.

In Sheep Canyon south of Gabbs these granophyre dikes transect granite that is equivalent in age to the coarse-grained granite, but they do not cut the later diorite or granodiorite intrusive masses. In turn the granophyre dikes are intruded by the granodiorite and are therefore regarded as being closely related in age to the granite.

Hydrothermal emanations, probably associated with the granophyre intrusion, have formed contact calcium magnesium silicate minerals in limestone at places along the walls of the dikes. Locally the carbonate rocks have been recrystallized, and in at least one place fluorite has been introduced. In the central reaches of Tungsten Canyon, where granophyre and sedimentary rocks of the Luning formation are in contact, brown tourmaline (dravite) has been formed.

A complex group of minerals including quartz, pyrite, brown tourmaline, talc, scheelite, and leuchtenbergite occur in a vein that is associated with a granophyre dike. The vein may, however, be later and related in age to granodiorite that crops out nearby. (Kerr and Callaghan, 1935, p. 1972.)

Diorite.—The next youngest igneous rocks are dioritic in composition. They are best exposed in the southern part of the Broken Hills Range, where diorite crops out in an area 2 miles long and a quarter of a mile wide. It is also exposed in the ridge that forms the south flank of Green Spring Flat.

The weathered surface of the diorite is black and strongly exfoliated. On fresh surfaces the diorite is dark gray to black and medium to coarse grained. The diorite is uniform in grain size and appearance throughout its entire mass. Jointing is well developed, and locally along the joints there are later dikes composed of malchite.

In the Broken Hills Range the diorite is part of an intrusive complex in that it has intruded early coarse granite and has itself been intruded by apophyses of granodiorite. At the contact between the diorite and the granodiorite is a selvage of hybrid granular rock resembling granodiorite and composed of quartz, orthoclase, oligoclase, some andesine, hornblende, and biotite.

The body of diorite in Green Spring Flat appears to follow the trend of the structure of the sedimentary rocks. This body of diorite may be in contact with a granodiorite intrusive that occurs in the high country of the range just east of Green Spring. It appears to be limited on the west by a fault.

Andesite dikes.—Andesite dikes of two ages, earlier and later than the granodiorite, occur in the area. The older dikes are aphanitic and dark colored. They are cut by granodiorite, but they cut all earlier igneous rocks. The younger andesite dikes intrude all sedimentary rocks in the area and transect the coarse-grained granite, granodiorite, and diorite. The outstanding feature of the younger andesite is its color, which ranges from dark green to black and is a deep brownish black on weathered surfaces. Some of these dikes are dense and fine grained; others are porphyritic with phenocrysts of feldspar and ferromagnesian minerals as much as 1.5 mm in diameter in a fine-grained dark groundmass. In many places the andesite dikes contain glomeroporphyritic aggregates of feldspar grains. Where crosscutting relations are not shown, it is difficult to distinguish between the andesite dikes and a group of later malchite dikes, especially where the latter have a dark weathered surface. The andesite dikes are as much as 20 feet wide and may be 3,000 to 4,000 feet long.

The relation between the andesite dikes and the granodiorite plutonic intrusives in this region has long been a puzzle (Callaghan, 1935). Where andesite dikes in the granodiorite mass reach the boundary of the granodiorite some of them become dismembered into a series of aligned fragments 10 to 15 feet long. In other parts of the granodiorite, contacts with the andesite dikes are mutually interpenetrating and gradational. The dikes probably were intruded later than the granodiorite, but at a time when the granodiorite probably was in a hot, plastic, or semifluid state; and slight movement may have generated enough force to dismember the dike. This relationship is clearly shown on the 1:2,400-scale map of the Gabbs magnesite deposit (Vitaliano and Callaghan, 1956).

Granodiorite.—Several stocks of granodiorite with closely associated apophyses, dikes, and outliers occur in the area.

The granodiorite stock east of Gabbs has deposits of older magnesite and contemporaneous brucite along its contacts. This granodiorite is gray, medium grained, and equigranular (2.0 mm) and contains plagioclase, some orthoclase, quartz, biotite, and hornblende. Very strong, somewhat irregular jointing is prominent throughout the stock. Where apophyses of granodiorite invaded brucite the contact minerals were formed in the brucite and the narrow tongues of granodiorite were endometamorphosed. The endometamorphosed granodiorite, which was classified as monzonite by Callaghan (1933, p. 14), has a green, silky or soapy appearance and contains perthite, quartz, augite, apatite, and titanite.

In the southern part of the Broken Hills Range an irregular-shaped body of granodiorite 1½ miles long and a mile wide cuts coarse-grained granite and diorite. The contact between the granodiorite and the coarse-grained granite is sharp and sinuous, with many apophyses. The contact between the diorite and the granodiorite, on the other hand, is gradational and marked by a hybrid rock.

Fine-grained granite.—A white to light-gray fine-grained even-textured granite was emplaced in the Broken Hills complex shortly after the intrusion of the granodiorite. This granite is exposed near the southern boundary of the complex in a body about a mile long and a quarter of a mile wide.

Aplite dikes.—White sugary aplite dikes were intruded with the granite and granodiorite in plutonic rocks. Quartz and feldspar are the main minerals; they are associated with minor amounts of pyrite which imparts a rusty weathering surface to the aplite. The aplite is uniformly equigranular, and the grain size nowhere exceeds 1.0 mm. The aplite dikes are very local in their occurrence and never exceed 2 feet in width and 500 feet in length.

Later dike rocks.—The emplacement of the granodiorite and fine-grained granite was followed by the intrusion of a swarm of dikes that cut the granite, granodiorite, and all earlier rocks. These dikes are classified as malchite, dacite, and rhyolite. The malchite and dacite dikes are similar in outcrop pattern and trend and are shown on the map as a unit under the classification malchite.

Malchite is a porphyritic feldspathic lamprophyre of dioritic composition carrying some quartz in the groundmass. The malchite dikes are dark green on fresh surfaces and yellow green to black on weathered surfaces. The texture is porphyritic, with small phenocrysts of feldspar and hornblende in an aphanitic groundmass. The borders of the dikes are fine grained to dense. Locally, concentrations of feldspar phenocrysts give the rock a glomeroporphyritic texture. Flow banding is shown by alignment of phenocrysts. The hornblende is unaltered in some dikes and totally chloritized in others. The malchite dikes are as much as 20 feet wide and 2 miles long.

The dacite dikes are porphyritic with white zoned phenocrysts as much as 0.5 cm in diameter in a green fine-grained to dense groundmass. These dikes are as much as 50 feet wide, and one dike, which crops out just southeast of Gabbs townsite, may be traced for more than 3 miles in a southeasterly direction. Some of the dikes grade along the strike into a granular dike rock that resembles granodiorite and that alters to a brownish color. They are correlated with several large dikes in the southeastern part of the map area that are believed to represent the last magmatic stages of the granodiorite intrusion.

The rhyolite dikes are light gray and dense to slightly porphyritic, with quartz and feldspar phenocrysts. Some dikes have spherulitic structures. The sides of the dikes are striated and locally on weathering yield plates that resemble barrel staves. The striations and weathering phenomena are probably due to the extreme viscosity of the magma when it was intruded. The dikes may be as much as 20 feet wide and one of them has been traced for more than 3 miles. These rhyolite dikes are older than the Tertiary volcanic and intrusive rocks in the region; and, since they transect the granodiorite and the malchite dikes, they probably are the youngest of the pre-Tertiary igneous rocks.

ROCKS OF TERTIARY AGE

In the Paradise Peak quadrangle great masses of volcanic extrusive and some intrusive igneous rocks of Tertiary age crop out. Some Tertiary sedimentary rocks are associated with the igneous rocks. Only one small area of Tertiary extrusive rocks crops out in the southwestern part of the present map area. Two of the rock types represented are the Tertiary andesite at Goldyke and the Tertiary rhyolite at Brunton Pass. These have been described in detail by Callaghan and Vitaliano (1947).

SEDIMENTS OF QUATERNARY AGE

Unconsolidated gravel and valley alluvium and sand deposits of eolian origin have all been classified as Quaternary in this area. Deposits of perched alluvium are found in some of the canyons, especially in the upper reaches of Granite Gulch and Cottonwood Canyon, where they are as much as 150 feet above the canyon floor. These deposits are much older than the present valley alluvium, but no evidence of precise age was found.

The fan gravel is composed of boulders of many rock types mixed with gravel and finer material deposited at the mouths of canyons on the west side of the Paradise Range and the east, south, and west sides of the Broken Hills Range. The steep gradient on many of the fan surfaces indicates that the gravel was deposited from streams loaded with coarse debris whose velocity was checked suddenly at the mouths of the canyons. In many places dried mud flows are found, and deposits of coarse gravel and boulders continue well up into the canyons above their junctions with the range front. Renewed erosional activity or recent uplift of the range has caused downcutting on some of the fans, and in some of the canyons rock-defended terraces have been formed. This process may have been responsible for the formation of the perched alluvium deposits.

The youngest sediments are the valley alluvium, composed of coarse to fine sand. A prominent deposit of wind-blown sand as much as 3,000 feet wide forms a belt in Lodi Valley and in Gabbs Valley west of Paradise Range. Although these deposits are largely eolian, they follow the main drainage route of the Gabbs-Lodi Valley region into the Alkali Flat, 15 miles to the southwest.

STRUCTURE

The rocks are complexly folded and are dislocated in many places by normal and thrust faults. Movement along normal faults preceded the start of thrust faulting and has continued to the present (Gianella and Callaghan, 1933, p. 258). Thrust faulting began later than normal faulting and prior to intrusion of at least the granophyre dikes. Thrusting appears to have occurred during two distinct periods.

The Triassic sedimentary rocks along the west front of the Paradise Range were complexly folded during the earlier orogeny. The rocks of the Luning formation are severely folded and faulted. In the southern part of the Broken Hills Range the rocks of the lower member of the Luning are broken by many high-angle normal faults; in the east-west ridges just south of Holly well, at least the upper member of the Luning along with other Mesozoic rocks has been tightly folded into a series of isoclinal folds whose axes are vertical. To the south the folding occurs in members that are stratigraphically higher, and in Sheep Canyon the folds are preserved in tactites formed by metamorphism of the dolomitic rocks in the upper member. In Cottonwood and Sheep Canyons the folds of the Luning formation are recumbent and overthrust to the east.

The extent of prethrust normal faulting is unknown. It can be definitely demonstrated in at least one locality near the east boundary of the area. There, in the lower member of the Luning formation, a normal fault of at least 1,100 feet displacement passes southward beneath the Paradise Peak klippe, which is part of the Paradise thrust fault.

Early thrust faulting began in the later stages of the first orogeny. The Paradise thrust fault was formed at this time, and movement along the fault was completed before the intrusion of the younger Mesozoic igneous rocks.

The Paradise thrust fault begins just north of Downeyville and extends southward along the range to a point south of Sheep Canyon, where it turns westward and can be traced nearly to the front of the range. At its westernmost exposure the trace of the fault is obscured by the trace of another thrust fault of much later age—the South thrust (Ferguson and Muller, 1949, p. 40). The granodiorite stock in the vicinity of Gabbs cuts the upper member of the Luning in the upper plate of the Paradise thrust fault. Many igneous dikes in the area cross the fault, and some even follow the fault plane.

The trace of the main part of the Paradise thrust is limited to the Mesozoic formations. At Gabbs and to the south the dolomitic facies of the upper member has been thrust over the thin-bedded black limestone facies. In some places bedding on both sides of the fault contact is markedly unconformable. Elsewhere the difference in dip on both sides of the fault is almost negligible. Locally rocks along the sole of the thrust are brecciated. Elsewhere, as near Paradise Peak, fragments of younger Mesozoic rocks are caught beneath the thrust and adjoining rocks are silicified along the thrust plane. Frequently the rock in the upper plate and adjacent to the thrust has a slaty cleavage.

The upper member of the Luning has been thrust over rocks as young as Jurassic. This relation is best shown in the vicinity of Paradise Peak, where a large klippe is exposed. Here rocks of the upper member lie on rocks ranging from the lower member of the Luning to the Gabbs and Sunrise formations, which are Triassic to Jurassic transition rocks. Ferguson and Muller (1949, p. 40) have estimated that movement on the Paradise thrust fault probably far exceeded the 6-mile east-to-west breadth of outcrop.

The South thrust, which represents the later period of thrusting, crops out across the entire southern part of the Paradise Range but only its western trace appears in the southwestern part of the area, where it cuts the Paradise thrust. Imbricate thrusting has occurred locally.

In the northwestern part of the area on the north wall of Douglas Canyon, thrusting believed to be of the same age as the South thrust has brought rocks of the upper member of the Luning over shale, slate, and conglomerate of the middle member. Near Downeyville a thrust fault probably of the same age as the South thrust has brought rocks of Excelsior(?) (Middle Triassic) age over rocks of the middle member of the Luning. In marked contrast to the earlier period of thrusting, thrust faults of the later period postdated all the intrusive igneous rocks of presumed Mesozoic age.

Movement along normal faults earlier than the South thrust would be difficult to verify. Renewed movement may have occurred along normal faults that predate the Paradise thrust. Movement along normal faults that postdate the South thrust occurred in the southwestern part of the map area where a branch of the range front fault cuts the laccolithic body in Sheep Canyon, displacing the western part of the intrusive downward.

The general region of the Paradise Range has undergone warping and continued uplift since late Tertiary time. The area was formerly covered by Tertiary volcanic rocks, which have been warped and eroded to expose a core of pre-Tertiary rocks surrounded by flows, tuff, breccia, and agglomerate of Tertiary age.

METAMORPHISM

The rocks have been affected by regional, contact, and hydrothermal metamorphism. The results of regional metamorphism are clearly shown in the sedimentary rocks of Triassic age. The dolomite is black and jointed in rhombohedral fashion. The jointing is probably the result of the stresses set up during the regional metamorphism. Talc occurs as a stress mineral in the sheared limestone of the lower member of the Luning. In the area south of Granite Canyon and in the limestone of the Sunrise formation on the west slopes of McGery Canyon, where it is associated with large cubes of clear unaltered pyrite.

Contact metamorphism, widespread in the area, is related to the plutonic intrusives and to some of the dikes. Adjacent to the intrusive bodies dolomite and limestone were recrystallized, and new silicate minerals formed locally wherever silica was introduced. In the southern part of the Broken Hills Range is a prominent black zone within the regionally metamorphosed sedimentary rocks altered by contact metamorphism. Here tungsten mineralization apparently accompanied the alteration, as small amounts of scheelite are found in the silicated carbonate rocks. West of Granite Canyon, in the vicinity of Gabbs, contact metamorphic silicate minerals have been formed in the carbonate rocks. Also in Granite Canyon, west and south of the brucite deposits contact silicate minerals characteristic of magnesium-rich rocks (i.e., chondrodite, forsterite, grossularite) and apatite were formed. In addition muscovite and serpentine were formed where the granodiorite is in contact with the brucite. Dolomite and magnesite were also formed.

Thus contact metamorphism related to igneous intrusions was responsible for the formation of several large bodies of minerals of economic importance in the area. In the upper plate of the Paradise thrust, near Gabbs, black fine-grained regionally metamorphosed material recrystallized to brownish and white dolomite. Where metamorphism continued to concentrate MgO, large bodies of magnesite were formed. Brucite and hydrous magnesium silicate were formed in turn by a later stage of mineralization of the magnesite and dolomite.

Hydrothermal mineralization formed scheelite in the vicinity of the Sheep Canyon intrusive. Scheelite is also found in the ridge on the Betty O'Neal claims, the low ridge in the southeastern part of Lodi Valley just west of the Big Chief mine, and in the southern part of the Broken Hills Range at the Victory mine and vicinity. Hydrothermal mineralization also accompanied the base- and precious-metal ore deposition of the Downeyville and Illinois mines.

MINERAL DEPOSITS

Parts of the Mammoth and Lodi mining districts are included within the Gabbs map area. The Mammoth district, the oldest, was organized in 1863 after the discovery of the deposits at Ellsworth, Nev. Within this district are magnesite and brucite deposits and some of the tungsten deposits now being operated. The Lodi district, in the northwestern part of the area, was organized in 1875 and has produced a larger amount of precious metals. Currently it is the scene of development work on the tungsten deposits.

LODI DISTRICT

Illinois mine and other base-metal and precious-metal deposits.—The earliest production from the Lodi district came from the Illinois mine, discovered in 1874. The mine is on the southeast flank of the Broken Hills Range approximately 2 miles northwest of Lodi Tank and 12 miles north of Gabbs. The principal metals extracted were silver and lead and small quantities of gold. Cerussite, cerargyrite, and argentiferous galena were the principal ore minerals in the Illinois vein system, a mineralized zone about 100 to 150 feet wide with a northwest trend. The Illinois system consists of three veins—the Illinois, Welch, and East—which cut limestone of the lower member of the Luning near the contact with the older coarse-grained granite. Andesite and malchite dikes crop out at the surface near the veins and strike parallel to the contact of the Luning formation with the granite. To the east are pre-Triassic metavolcanic rocks and Recent alluvium. The veins have been slightly displaced along small cross faults.

Several shafts—the Illinois, 1,000 feet deep, the Silver Link, 65 feet deep, and the Sand Mound—have been sunk on the vein system, and drifts have been run on several levels. The Illinois mine was productive from its discovery to 1880, was dormant from 1880 to 1905, and in 1905 it was reopened and small annual shipments of ore were made until 1914. Various methods to improve the concentrates were tried but proved unsuccessful. Production from this mine virtually ceased in 1914; its total production was about $300,000.

Several groups of claims have been located along the contact of the limestone of the lower member of the Luning and the coarse-grained granite in the area between the Illinois mine and the vicinity of the Victory tungsten mine. These include the Smuggler, the Silver King, and the Resolution claims. The rocks along the contact are mineralized and form a prominent ridge that bounds the igneous complex on the northeast, north, and west. In the ore zone small quartz veins contain sparse galena and cerussite.

The Kramer-Osgood property, E. P. Osgood of Reno, Nev., owner, and the Ray Ricketts group of mines owned by William Gregory of Weimar, Calif., are small properties in the southern part of the Broken Hills Range. Small shipments of ore have been made from both properties; the Kramer-Osgood production came from a narrow quartz vein in granodiorite near the contact with granite, and the Ray Ricketts production was from small ore pockets in granodiorite. The ore from the Kramer-Osgood mine carried 0.25 oz gold and 60 oz silver per ton and 7.1 percent copper and 3 percent lead. The ore from the Ray Ricketts group carried gold in narrow stringers.

Silver Leaf-Black Reef group.—The Silver Leaf-Black Reef group of claims are in the old camp of Granite, in the southwestern part of the Broken Hills Range. The claims are in the center of unsurveyed T. 13 N., R. 36 E., about 2 miles southwest of the Illinois workings, along part of the contact between the limestone of the lower member of the Luning and older coarse-grained granite. The contact dips steeply west and the limestone has been changed to tactite by contact metamorphism. The sedimentary rocks have been faulted both to the north of the workings and to the south at the extreme southwestern tip of the Broken Hills Range.

Two main shafts and several smaller ones explored the veins that contained gold. The discovery of ore there in 1921 resulted in appreciable production of gold from seams and pockets (Kral, 1951, p. 93).

Tungsten deposits.—In the vicinity of the old town of Granite, 10.5 miles north of Gabbs in the southern part of the Broken Hills Range, the claims of the Victory tungsten mine and Nevada-Pacific Mining Co. cover deposits of scheelite in granite. Sporadic occurrences of scheelite are found for a distance of 2 to 3 miles along the contact of granite with silicated sedimentary rocks of the lower member of the Luning. Twelve tons of ore from one of these occurrences reportedly assayed 19.0 percent WO_3 (Kral, 1951, p. 98). The scheelite is of hydrothermal origin and was deposited in both the granite and the metamorphosed sedimentary rocks.

The Victory tungsten claims were located in 1945 by Albert O. Brown of Gabbs and W. C. Sovy and J. Southerland of Fallon. In 1945 J. S. Dougan and associates, organized as Gabbs Exploration Co., took over the property. Silicated and unaltered calcareous rocks and granite are cut by several lamprophyre dikes and small quartz stringers and lenses. Exploratory work exposed a zone of mill-grade ore about 100 feet long and 36 feet wide. A mill was constructed at Gabbs to concentrate the ore, and about 80 tons per day was being treated in May and June 1951.

The Kay Cooper group of claims, which adjoin the Victory group, were taken up by Carl H. Cooper and R. C. Peterson of Gabbs but were later absorbed by Dougan and associates. Title to part of the claims is under litigation with the Nevada-Pacific Mining Co. No work is being done on the Kay Cooper claims by the Dougan interests, but in the summer of 1951 representatives of the Nevada-Pacific Co. were on this ground and were driving an adit and crosscut. Ore of mill grade was intercepted in the crosscut. Original exploratory work was by trenching, but in 1949 scheelite ore was discovered by diamond drilling.

MAMMOTH DISTRICT

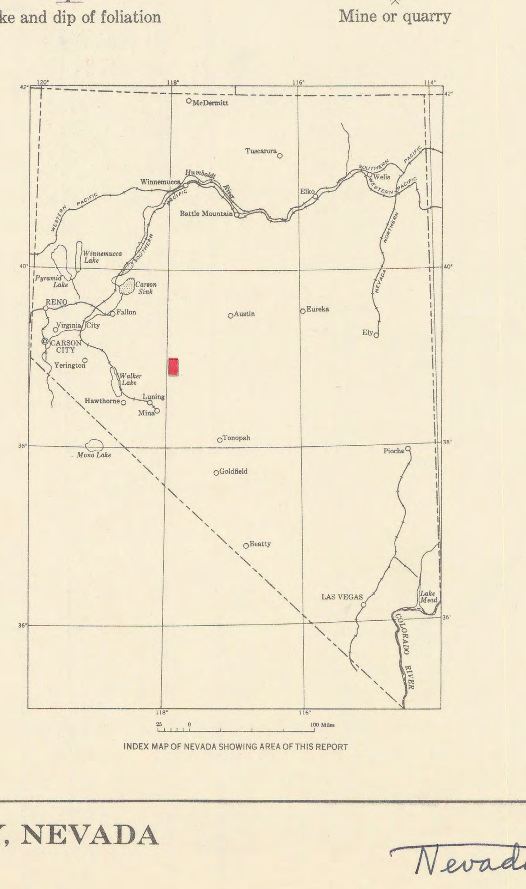
The Mammoth district is in the eastern and southern part of the map area. Magnesite, brucite, tungsten, and minor lead and zinc deposits have been or are being worked from the part of this district that is within the mapped area. Tremolite has been reported at one prospect, but it is not of commercial grade. The part of the district not covered by this report has produced minor quantities of lead, silver, gold, mercury, tungsten, and copper.

Brucite and Magnesite.—Brucite and magnesite are mined from the rugged west slope of the Paradise Range, in the vicinity of Gabbs (Vitaliano and Callaghan, 1956). The ore-bearing area is in secs. 25, 26, 27, 34, 35, and 36, T. 12 N., R. 36 E. The brucite and magnesite deposits are in the upper plate of the Paradise thrust fault in the dolomite of the upper member of the Triassic Luning formation. The deposits of magnesite are on the northeast and north sides of a granodiorite plug. They were formed by hydrothermal emanations that recrystallized and mineralized pre-existing Triassic dolomite. The ore solutions probably were related to the intrusion of the older granite. Formation of the magnesite deposits preceded the intrusion of the granodiorite. Hydrothermal emanations related to intrusion of the granodiorite brucitized the magnesite and associated dolomite. Thus brucite deposits are always found at the granodiorite-carbonate contact. Silication accompanied this stage of mineralization also, forming additional forsterite and serpentine. Subsequently meteoric alteration of brucite formed hydromagnesite and artinite. Many andesite, granophyre, malchite, and rhyolite dikes cut the magnesium-bearing rocks. Small dikes of granodiorite in brucite were endogenetically metamorphosed to a rock of monzonite composition. Large dikes were similarly affected only along the borders.

Further details on the geology and mineralogy of the brucite and magnesite deposits are given by Callaghan (1933) and Vitaliano and Callaghan (1956).

Lead.—The Downeyville lead mine now abandoned is about 3 miles north of Gabbs in sec. 9, T. 12 N., R. 36 E. It is one of the oldest mines in the district and probably came into production shortly after work began at the Illinois mine. The property is owned by J. G. Phelps Stokes of New York. The mine is in steeply west dipping brown mineralized dolomitic limestone near the outcrop of the Paradise thrust fault where the fault turns westward and disappears beneath the alluvium and gravel of Gabbs Valley. Nearby, on the ridge south of the workings, slate, tuff, shale, and some limestone of the middle member of the Luning are tightly folded and are overlain by a thrust slice of the metatuff and interbedded limestone of the Triassic Excelsior(?) formation. Lenticular and irregular-shaped remnants of blue thin-bedded limestone surrounded by white recrystallized carbonate occur in the brownish to gray dolomitic limestone. The sedimentary rocks are badly fractured. According to Kral (1951, p. 109) the ore was in shoots or chimneys 2 to 4 feet wide, many of which extended to a depth of at least 180 feet. A porous gossan that contains cerussite and wulfenite, probably formed by secondary enrichment, was mined down from the surface in an area roughly one-eighth of a mile square. Sulfide ores, including pyrrhotite, sphalerite (marmatite), and galena, were reached at depth. The main productive period of the mine was 1875-1881, during which 2,357 tons of ore worth $80,622 were produced. Since that time production has been sporadic, and recently the slag and oxide ore dumps have been shipped to smelters.

Tungsten.—The Gabbs Valley tungsten prospect is 1½ miles southeast of Gabbs on the west flank of the Paradise Range. The claims were prospected in 1944. Scheelite in narrow quartz stringers occurs in a hornfelsed part of the upper Luning formation, in the upper plate of the Paradise thrust fault. The veins are just below the base of the laccolith of older granite. Dikes of lamprophyre and granophyric composition are common. The western edge of the laccolith has been sliced off and dropped down by a branch of the range front fault. The displacement is small, about 100 feet, but it has exposed the lower contact of the laccolith as well as tungsten mineralization. The workings consist of two short drifts and a crosscut approximately 250 feet long. The work was abandoned because of the spotty nature of the ore, but in 1951 work was resumed, and it is reported that a better ore body has been opened up. Small shipments are being made to a mill at Sodaville, Nev.



INDEX MAP OF NEVADA SHOWING AREA OF THIS REPORT

LITERATURE CITED

Callaghan, Eugene, 1933, Brucite deposit, Paradise Range, Nev. A preliminary report: Nevada Univ. Bull., v. 27, no. 1, p. 1-34.
Callaghan, Eugene, 1935, Pre-granodiorite dikes in granodiorite, Paradise Range, Nev.: Am. Geophys. Union Trans. 17th Ann. Meeting, p. 302-307.
Callaghan, Eugene, and Vitaliano, Charles J., 1947, Type sequence of Tertiary volcanic rocks in the western part of the Great Basin, [Nev.] [abst.]: Geol. Soc. America Bull., v. 58, no. 12, pt. 2, p. 1171.
Ferguson, H. G., and Muller, S. W., 1949, Structural geology of the Hawthorne and Tonopah quadrangles, Nevada: U. S. Geol. Survey Prof. Paper 216, 55 p.
Gianella, V. P., and Callaghan, Eugene, 1933, The Cedar Mountain, Nevada, earthquake of December 20, 1932: Am. Geophys. Union, Trans. 14th Ann. Meeting, p. 257-260.
Kerr, P. F., and Callaghan, E., 1935, Scheelite-Leuchtenbergite deposit in the Paradise Range, Nev: Geol. Soc. America Bull., v. 46, p. 1957-1974.
Kral, Victor E., 1951, Mineral resources of Nye County, Nev.: Nevada Univ. Bull. v. XLV, no. 3, Geol. Min. Ser. 50, 223 p.
Muller, S. W., and Ferguson, H. G., 1936, Triassic and Lower Jurassic formations of west-central Nevada: Geol. Soc. America Bull., v. 47, p. 241-252.
Muller, S. W., and Ferguson, H. G., 1939, Mesozoic stratigraphy of the Hawthorne and Tonopah quadrangles, Nev.: Geol. Soc. America Bull., v. 50, p. 1573-1624.
Vitaliano, Charles J., and Callaghan, Eugene, 1956, Magnesite and brucite deposit at Gabbs, Nye County, Nev.: U. S. Geol. Survey Min. Inv. Map MF 35.
Wentworth, C. K., and Williams, Howell, 1932, The classification and terminology of the pyroclastic rocks: Report of Committee on Sedimentation: Nat. Research Council Bull. 89, p. 19-53.

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GEOLOGY OF GABBS AND VICINITY, NYE COUNTY, NEVADA

By
Charles J. Vitaliano, Eugene Callaghan, and N. L. Silberling

1957

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