DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

**BEDROCK GEOLOGIC MAP OF THE LONE MOUNTAIN
PLUTON AREA, ESMERALDA COUNTY, NEVADA**

By Florian Maldonado

Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY

MISCELLANEOUS INVESTIGATIONS SERIES
Published by the U.S. Geological Survey, 1984

REPRODUCED FROM
BEST AVAILABLE COPY

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

19

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Figure 1.—MODAL ANALYSES OF ROCK SAMPLES FROM LONE MOUNTAIN PLUTON.

117°35'00"

117°32'30"

ssium feldspar

PREPARED IN COOPERATION WITH THE
U.S. DEPARTMENT OF ENERGY

MISCELLANEOUS INVESTIGATIONS SERIES MAP I-1533

CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

ALLUVIUM AND COLLUVIUM (QUATERNARY AND TERTIARY)—Chiefly unconsolidated, unsorted, angular to well-sorted deposits of boulders, cobbles, pebbles, sand, and silt, composed predominantly of quartz monzonite, carbonate rocks, hornfels, and hornfels. Eolian and playa deposits are locally present north of Lone Mountain. Thickness about 0-300 m.

RYHOLITE DIKES AND SILLS (TERTIARY)—Light-gray to dark-greenish-gray, very fine to coarse-grained, containing ubiquitous hornblende crystals as much as 5 mm in diameter, in a very fine grained pilotaxitic matrix composed essentially of plagioclase and augite and containing minor alkali feldspar; accessory minerals include apatite and opaques. Alteration products consist of calcite, epidote, and chlorite. Various types of rhyolite porphyry dikes occur in area; spessartite is more common than vogesite (Bonham and Garside, 1979). Dikes in some parts of area are more dioritic, especially toward the east end of Lone Mountain where hornblende crystals as much as 2.5 m occur. Lamprophyre dikes have prominent north-south trend and intrude Lone Mountain pluton and most of the Precambrian sedimentary rocks, as well as silicified at 22.1 m.y. (Bonham and Garside, 1979). Width about 10 m.

RYHOLITE DIKES, SILLS, AND STOCK(?) (TERTIARY)—Predominantly rhyolite porphyry that appears to be microgranite porphyry, very light gray to light-gray, pinkish-gray, and pinkish-gray, very fine grained, containing alkali feldspar, and sparse biotite phenocrysts (1-4 mm) in a silicified matrix of alkali feldspar and quartz. Dikes and sills are mostly hydrothermally altered, sericite being dominant alteration product. Dikes and sills are concentrated in north-south part of Lone Mountain, where they trend northwest and intrude Lone Mountain pluton, gabbro, and quartz monzodiorite bodies, and, uncommonly, lamprophyre dikes. Dikes that intrude sedimentary rocks, as opposed to those that intrude the pluton, are uncommon.

WYMAN FORMATION (LATE PROTEROZOIC)—Composed of phyllite, schist, hornfels, quartzite, and tactite. At the type locality in Wyman Canyon, Calif., the formation is composed of siltstone, shale, sandstone, and intercalated carbonate beds (McKee and Moiola, 1962). Emplacement of Lone Mountain pluton has resulted in contact metamorphism of argillaceous rock to hornfels and quartzite, carbonate rock to marble, and silty carbonate rock to tactite. Unit is complexly folded near intrusive contact. Wyman Formation is present in northeastern and western parts of Lone Mountain and as roof pendants in central and northeastern part of Lone Mountain pluton. Thickness about 0-915 m (Bonham and Garside, 1979).

INTRODUCTION

This study of the Lone Mountain pluton was undertaken to characterize the homogeneity of the pluton, joint frequency, joint and bedding attitudes, dike trends, and any other major structural features. Work was performed on behalf of the U.S. Department of Energy as part of a reconnaissance of granitoid masses. The joint attitudes were measured in the field and plotted on aerial photos at a scale of 1:24,000. Contacts and some bedding attitudes in the country rock were interpreted from aerial photos or taken from existing maps (Phariss, 1974; Bonham and Garside, 1979), supplemented with reconnaissance of those areas. Descriptions of the country rocks were modified from Albers and Stewart (1972), Phariss (1974), and from Bonham and Garside (1979). Descriptions of the gabbro and the quartz monzodiorite intrusive masses were taken mainly from Bonham and Garside (1979), supplemented with petrographic work.

LONE MOUNTAIN PLUTON

The Lone Mountain pluton is a Cretaceous (approximately 70 m.y.) stock, essentially a homogenous mass of quartz monzonite (fig. 1), as determined from seven modal analyses in this study and from modal analyses by Albers and Stewart (1972) and by Bonham and Garside (1979). It intrudes Proterozoic and Cambrian metasedimentary rocks that include the Wyman Formation, Reed Dolomite, and the Deep Spring, Harkless(?) and Campito Formations. Roof pendants of Wyman Formation rock are preserved in the central and northeastern part of the stock. The country rock has been mineralized in some areas and has

Figure 1.—MODAL ANALYSES OF ROCK SAMPLES FROM LONE MOUNTAIN PLUTON.

Figure 2.—ROSE DIAGRAM OF 33 MEASURED FOLIATION DIRECTIONS, LONE MOUNTAIN PLUTON.

Figure 3.—ROSE DIAGRAM—Showing strikes of 255 joints, Lone Mountain pluton; east-west sets included in N. 80°-90° E. sets; north-south sets included in N. 0°-10° W. sets.

38°02'30"

QTac

JEEP

TRAIL

USMM

Klm

Spring

A

QTac

38°00'

117°35'00"

Base from U.S. Geological Survey
Lone Mountain, 1:62,500, 1961;
Silver Peak, 1:62,500, 1963;
Gilbert SE, 1:24,000, 1968;
Paymaster Canyon, 1:24,000, 1970

LAMPORPHYRE DIKES AND SILLS (TERTIARY)—Light-greenish-gray to dark-greenish-gray, very fine to coarse-grained, containing ubiquitous hornblende crystals as much as 5 mm long in very fine grained pilotaxitic matrix composed essentially of plagioclase and augite and containing minor alkali feldspar; accessory minerals include apatite and opaques. Alteration products consist of calcite, epidote, and chlorite. Various types of lamprophyre dikes occur in area; spessartite is more common than vogesite (Bonham and Garside, 1979). Dikes in some parts of area are more dioritic, especially toward southeast end of Lone Mountain where hornblende crystals as long as 0.5 m occur. Lamprophyre dikes have prominent northwest trend and intrude Lone Mountain pluton and most of Paleozoic and Precambrian sedimentary rocks, as well as silicic dikes dated at 22.1 m.y. (Bonham and Garside, 1979). Width 1 cm-20 m

SILICIC PORPHYRY DIKES, SILLS, AND STOCK(?) (TERTIARY)—Predominantly rhyolite porphyry that appears to grade into microgranite porphyry, very light gray to light-gray, yellowish-gray, and pinkish-gray, very fine grained, containing quartz, feldspar, and sparse biotite phenocrysts (1-4 mm) in a spherulitic matrix of alkali feldspar and quartz. Dikes and sills are commonly hydrothermally altered, sericite being dominant alteration product. Dikes and sills are concentrated in northeastern part of Lone Mountain, where they trend northwest and intrude Lone Mountain pluton, gabbro, and quartz monzodiorite intrusive bodies, and, uncommonly, lamprophyre dikes. Dikes and sills that intrude sedimentary rocks, as opposed to those that intrude Lone Mountain pluton, contain more quartz and feldspar phenocrysts and are characterized by presence of resorbed quartz and trace amounts of pyrite; dikes that intrude Lone Mountain pluton contain fewer phenocrysts and lack resorbed quartz phenocrysts. Silicic porphyry rocks are related to silicic intrusive complex exposed mainly north of area that has been mapped by Bonham and Garside (1979). Part of that complex extends into extreme northeastern part of mapped area. A fission-track age of 22.1 m.y. was obtained from zircon by Bonham and Garside (1979). Width 1-15 m

RHYOLITE PORPHYRY DIKES (TERTIARY)—Light-gray and medium- to dark-gray, flow-banded dikes containing mostly plagioclase phenocrysts as large as 1 cm and lesser alkali feldspar in a holocrystalline matrix of quartz and feldspar. Alteration products include mostly sericite, calcite, and sparse epidote after plagioclase. Dikes occur in southern part of Lone Mountain, where they intrude pluton along east-northeast trend, and typically exhibit laminar-flow banding that parallels intrusive contact. Width 1-10 m

LONE MOUNTAIN PLUTON (CRETACEOUS)—Stock of quartz monzonite (fig. 1), light-gray to very light gray; medium-grained (1-5 mm) to coarse-grained (>5 mm) rock containing minor, local fine-grained (<1 mm) phase and porphyritic phase with microcline crystals as long as 2 cm. Quartz monzonite is hypidiomorphic granular, consisting of quartz (16-38 percent), microcline (24-39 percent), plagioclase (myrmekitic) (29-46 percent), biotite (1-2 percent), and trace amounts of apatite, zircon, sphene, magnetite, and hornblende. Alteration products consist of plagioclase altered to sericite, muscovite, and epidote, and biotite altered to chlorite and in places to muscovite. Local protoclastic fabric that is present towards margin of pluton suggests that magma pulsated during crystallization and deformed the more crystallized outer rim of the pluton. Dikes and sills of quartz monzonite in country rock are fine grained; country rock shows migmatization near intrusive contact. Three potassium-argon dates of 67 ± 3 m.y., 71 ± 1.4 m.y., and 69.2 ± 1.4 m.y. (Bonham and Garside, 1979) place the age of emplacement at approximately 70 m.y.

QUARTZ MONZODIORITE (CRETACEOUS)—Medium-grained, containing plagioclase, quartz, microcline, biotite, and lesser amounts of muscovite, sphene, zircon, and apatite. Alteration products are mostly sericite, chlorite, and epidote. Small out-

hom
trend
of th
The
a sc.
were
Bon
Des
Pha
gabl
Bor

ess
sev
(19
Car
Do
per
par
bec
int

co:
tar
intr
tro

m
is
ck
fol
of

21
ar
in
de
to

th
ha
w
of
th
as
ar
M

o
n
st
p
a
l
n
l
f
c

0.5 m occur. Lamprophyre dikes have prominent north-end and intrude Lone Mountain pluton and most of silicic and Precambrian sedimentary rocks, as well as silicic gabbro dated at 22.1 m.y. (Bonham and Garside, 1979). Width 10 m

LAMPROPHYRE DIKES, SILLS, AND STOCK(?) (TERTIARY)—Predominantly rhyolite porphyry that appears to be microgranite porphyry, very light gray to light-gray, pinkish-gray, and pinkish-gray, very fine grained, containing feldspar, and sparse biotite phenocrysts (1–4 mm) in a silicic matrix of alkali feldspar and quartz. Dikes and sills are commonly hydrothermally altered, sericite being dominant alteration product. Dikes and sills are concentrated in northern part of Lone Mountain, where they trend northwest and intrude Lone Mountain pluton, gabbro, and quartz monzodiorite bodies, and, uncommonly, lamprophyre dikes. Dikes that intrude sedimentary rocks, as opposed to those that intrude Lone Mountain pluton, contain more quartz and rhyolite phenocrysts and are characterized by presence of rounded quartz and trace amounts of pyrite; dikes that intrude Lone Mountain pluton contain fewer phenocrysts and lack rounded quartz phenocrysts. Silicic porphyry rocks are related to an intrusive complex exposed mainly north of area that was mapped by Bonham and Garside (1979). Part of that complex extends into extreme northeastern part of mapped area. Fission-track age of 22.1 m.y. was obtained from zircon in Bonham and Garside (1979). Width 1–15 m

LAMPROPHYRE DIKES (TERTIARY)—Light-gray and pinkish-gray to dark-gray, flow-banded dikes containing mostly feldspar phenocrysts as large as 1 cm and lesser alkali feldspar in a microcrystalline matrix of quartz and feldspar. Alteration includes mostly sericite, calcite, and sparse epidote after feldspar. Dikes occur in southern part of Lone Mountain, where they intrude pluton along east-northeast trend, and they exhibit laminar-flow banding that parallels intrusive flow. Width 1–10 m

LONE MOUNTAIN PLUTON (CRETACEOUS)—Stock of quartz monzonite (fig. 1), light-gray to very light gray; medium-grained (1–2 mm) to coarse-grained (>5 mm) rock containing minor, fine-grained (<1 mm) phase and porphyritic phase with plagioclase crystals as long as 2 cm. Quartz monzonite is a morphic granular, consisting of quartz (16–38 percent), plagioclase (24–39 percent), plagioclase (myrmekitic) (29–46 percent), biotite (1–2 percent), and trace amounts of apatite, sphene, magnetite, and hornblende. Alteration products of plagioclase altered to sericite, muscovite, and epidote, biotite altered to chlorite and in places to muscovite. Local foliation fabric that is present towards margin of pluton indicates that magma pulsated during crystallization and defined the more crystallized outer rim of the pluton. Dikes of quartz monzonite in country rock are fine grained; country rock shows migmatization near intrusive contact. Three argon-40/argon-39 dates of 67 ± 3 m.y., 71 ± 1.4 m.y., and 114 ± 1.4 m.y. (Bonham and Garside, 1979) place the age of emplacement at approximately 70 m.y.

QUARTZ MONZODIORITE (CRETACEOUS)—Medium-grained, consisting of plagioclase, quartz, microcline, biotite, and lesser amounts of muscovite, sphene, zircon, and apatite. Alteration products are mostly sericite, chlorite, and epidote. Small outcrops of this body are present in northeastern part of Lone Mountain where it intrudes Harkless(?) Formation (Ch) and (Kgb). Quartz monzodiorite is intruded by silicic porphyry dikes. Crops out north of mapped area (Bonham and Garside, 1979), where it is part of complex intrusive body.

GABBRO (CRETACEOUS)—Dark-gray to grayish-black, medium- to coarse-grained, containing predominantly hornblende (40 percent) and plagioclase (55 percent, Bonham and Garside, 1979). Crystals as large as 6 mm, and minor amounts of augite, apatite, sphene, and alkali feldspar. A small gabbro outcrop is found in northeastern part of Lone Mountain where it intrudes Harkless(?) Formation (Ch) and (Kgb).

were interpreted from aerial photos or taken from existing maps (Phariss, 1974; Bonham and Garside, 1979), supplemented with reconnaissance of those areas. Descriptions of the country rocks were modified from Albers and Stewart (1972), Phariss (1974), and from Bonham and Garside (1979). Descriptions of the gabbro and the quartz monzodiorite intrusive masses were taken mainly from Bonham and Garside (1979), supplemented with petrographic work.

LONE MOUNTAIN PLUTON

The Lone Mountain pluton is a Cretaceous (approximately 70 m.y.) stock, essentially a homogenous mass of quartz monzonite (fig. 1), as determined from seven modal analyses in this study and from modal analyses by Albers and Stewart (1972) and by Bonham and Garside (1979). It intrudes Proterozoic and Cambrian metasedimentary rocks that include the Wyman Formation, Reed Dolomite, and the Deep Spring, Harkless(?) and Campito Formations. Roof pendants of Wyman Formation rock are preserved in the central and northeastern part of the stock. The country rock has been mineralized in some areas and has been described by Phariss (1974) and Sandy (1965). The pluton has been intruded by aplite, pegmatite, silicic porphyry, lamprophyre and dioritic dikes.

Albers and Stewart (1972) have indicated that the pluton has intruded the core of a northwest-trending anticline that was developed in the metasedimentary rocks prior to intrusion of the pluton. An alternative hypothesis is that the intrusion of the pluton domed the metasedimentary rocks to form the northwest-trending anticline.

The pluton is intensely jointed, primarily as a result of cooling and movement of the magma within a northwest-trending stress field. Foliation, in general, is poorly developed, and quality varies from area to area, but it is best developed close to the contacts with the metasedimentary rocks. A prominent northwest foliation direction was observed (fig. 2) that parallels the northwest elongation of the exposed pluton.

STRUCTURE

The three major high-angle joint sets have the following attitudes: (1) N. 20°–50° W. (fig. 3), dip southwest (fig. 4); (2) N. 40°–70° E., dip northwest; and (3) strike approximately east-west, dip predominantly north. The joint sets intersect each other with little apparent displacement. The northwest trend is the dominant joint set. Such joints are commonly filled with lamprophyre dikes and, to a lesser degree, with silicic porphyry dikes.

Faults in the pluton are difficult to identify because of the homogeneity of the rock. Several faults were mapped in the northern part of the area where they have a northeast trend and intersect the northwest-trending lamprophyre dikes with little apparent displacement. A major fault that bounds the northern part of the pluton is downthrown to the north and strikes northeast. This fault offsets the alluvium, the metasedimentary rocks, and the pluton and forms fault scarps as high as 10 m. The fault zone parallels the Warm Springs lineament (Ekren and others, 1976) in the southwestern part of Big Smoky Valley, north of Lone Mountain.

The Lone Mountain area appears to have been exposed to two stress fields of different ages—an older field in which maximum principal stress was oriented northwest-southeast and a younger field oriented northeast-southwest. The older stress field was apparently present during emplacement of the Lone Mountain pluton, as is evidenced by elongation of the pluton in a northwesterly direction and by pronounced northwest-trending joints. This stress field parallels the Walker Lane, a zone of disrupted topography characterized by the presence of a northwest-striking lineament (Gianella and Callaghan, 1934; Locke and others, 1940), and could possibly be related to its early development. The younger stress field is proposed to be at right angles to the older field. The younger stress field orientation is based on the presence of northeast-trending faults that displace alluvium and intersect northwest-trending lamprophyre dikes. These lamprophyre dikes are younger than 22.1 m.y., as shown by intrusion of the silicic porphyry dikes, dated at 22.1 m.y. (Bonham and Garside, 1979), by the lamprophyre dikes. These relationships suggest that the younger of the two stress fields was present after about 22 m.y. ago.

AEROMAGNETIC DATA

Aeromagnetic data (U.S. Geological Survey, 1979) suggest the following: (1) the local magnetic highs in the central part of the Lone Mountain pluton are probably related to topographic highs (peaks) where the flight lines are closer to the pluton; (2) a magnetic low in the northeastern part of Lone Mountain

Figure 2.—ROSE DIAGRAM OF 33 MEASURED FOLIATION DIRECTIONS, LONE MOUNTAIN PLUTON.

Figure 3.—ROSE DIAGRAM—Showing strikes of 255 joints, Lone Mountain pluton; east-west sets included in N. 80°-90° E. sets; north-south sets included in N. 0°-10° W. sets.

Base from U.S. Geological Survey
 Lone Mountain, 1:62,500, 1961;
 Silver Peak, 1:62,500, 1963;
 Gilbert SE, 1:24,000, 1968;
 Paymaster Canyon, 1:24,000, 1970

quartz, feldspar, and sparse biotite phenocrysts a spherulitic matrix of alkali feldspar and quartz are commonly hydrothermally altered, sericite alteration product. Dikes and sills are concentrated eastern part of Lone Mountain, where they trend intrude Lone Mountain pluton, gabbro, and quartz intrusive bodies, and, uncommonly, lamprophyre and sills that intrude sedimentary rocks, as opposed to those that intrude Lone Mountain pluton, contain microcline phenocrysts and are characterized by resorbed quartz and trace amounts of pyrite; dikes of Lone Mountain pluton contain fewer phenocrysts. Silicic porphyry related to silicic intrusive complex exposed mainly north has been mapped by Bonham and Garside (1979) complex extends into extreme northeastern part of area. A fission-track age of 22.1 m.y. was obtained by Bonham and Garside (1979). Width 1-15 m.

RHYOLITE PORPHYRY DIKES (TERTIARY)—Light to medium- to dark-gray, flow-banded dikes containing plagioclase phenocrysts as large as 1 cm and lesser in a holocrystalline matrix of quartz and feldspar products include mostly sericite, calcite, and sparse plagioclase. Dikes occur in southern part of Lone Mountain where they intrude pluton along east-northeast; typically exhibit laminar-flow banding that parallel to contact. Width 1-10 m.

LONE MOUNTAIN PLUTON (CRETACEOUS)—Silicic monzonite (fig. 1), light-gray to very light gray; medium- to coarse-grained (1-5 mm) to coarse-grained (>5 mm) rock containing local fine-grained (<1 mm) phase and porphyritic microcline crystals as long as 2 cm. Quartz hypidiomorphic granular, consisting of quartz (16 percent), microcline (24-39 percent), plagioclase (myrmecitic, 1-2 percent), and trace amounts of zircon, sphene, magnetite, and hornblende. Alterations consist of plagioclase altered to sericite, muscovite, and biotite altered to chlorite and in places to muscovite. Protoclastic fabric that is present towards margins suggests that magma pulsated during crystallization. Deformed the more crystallized outer rim of the pluton and sills of quartz monzonite in country rock are found. Country rock shows migmatization near intrusive complex. Potassium-argon dates of 67 ± 3 m.y., 71 ± 1.4 m.y., and 69.2 ± 1.4 m.y. (Bonham and Garside, 1979) indicate age of emplacement at approximately 70 m.y.

QUARTZ MONZODIORITE (CRETACEOUS)—Medium- to coarse-grained, containing plagioclase, quartz, microcline, biotite, and trace amounts of muscovite, sphene, zircon, and apatite. Products are mostly sericite, chlorite, and epidote. Crops of this body are present in northeastern part of Lone Mountain where it intrudes Harkless(?) Formation gabbro (Kgb). Quartz monzodiorite is intruded by rhyolite porphyry dikes. Crops out north of mapped area (Bonham and Garside, 1979), where it is part of complex intrusive complex.

GABBRO (CRETACEOUS)—Dark-gray to grayish-black to coarse-grained, containing predominantly hornblende (55 percent) and plagioclase (55 percent, Bonham and Garside, 1979) crystals as large as 6 mm, and minor amounts of biotite, apatite, sphene, and alkali feldspar. A small crop was found in northeastern part of Lone Mountain where gabbro intrudes Harkless(?) Formation and is intruded by rhyolite porphyry dikes and quartz monzodiorite. North of mapped area gabbro occurs as roof pendants in silicic intrusion (Bonham and Garside, 1979) related to silicic porphyry dikes. A potassium-argon age of 110 m.y. was obtained by Bonham and Garside (1979) from hornblende. They considered this to be a minimum age due to heating of gabbro during emplacement of quartz monzodiorite intrusive bodies.

HARKLESS(?) FORMATION (LOWER CRETACEOUS)

owish-gray, and pinkish-gray, very fine grained, containing rtz, feldspar, and sparse biotite phenocrysts (1-4 mm) in herulitic matrix of alkali feldspar and quartz. Dikes and sills commonly hydrothermally altered, sericite being dominant alteration product. Dikes and sills are concentrated in northern part of Lone Mountain, where they trend northwest and intrude Lone Mountain pluton, gabbro, and quartz monzodiorite intrusive bodies, and, uncommonly, lamprophyre dikes. Dikes and sills that intrude sedimentary rocks, as opposed to those that intrude Lone Mountain pluton, contain more quartz and feldspar phenocrysts and are characterized by presence of redbed quartz and trace amounts of pyrite; dikes that intrude Lone Mountain pluton contain fewer phenocrysts and lack redbed quartz phenocrysts. Silicic porphyry rocks are related to the silicic intrusive complex exposed mainly north of area that has been mapped by Bonham and Garside (1979). Part of that complex extends into extreme northeastern part of mapped area. A fission-track age of 22.1 m.y. was obtained from zircon in Bonham and Garside (1979). Width 1-15 m.

SILICIC PORPHYRY DIKES (TERTIARY)—Light-gray to medium- to dark-gray, flow-banded dikes containing mostly plagioclase phenocrysts as large as 1 cm and lesser alkali feldspar in a holocrystalline matrix of quartz and feldspar. Alteration products include mostly sericite, calcite, and sparse epidote after plagioclase. Dikes occur in southern part of Lone Mountain, where they intrude pluton along east-northeast trend, and locally exhibit laminar-flow banding that parallels intrusive contact. Width 1-10 m.

LONE MOUNTAIN PLUTON (CRETACEOUS)—Stock of quartz monzonite (fig. 1), light-gray to very light gray; medium-grained (1-5 mm) to coarse-grained (>5 mm) rock containing minor, fine-grained (<1 mm) plagioclase and porphyritic phase with microcline crystals as long as 2 cm. Quartz monzonite is homomorphic granular, consisting of quartz (16-38 percent), microcline (24-39 percent), plagioclase (myrmekitic) (29-46 percent), biotite (1-2 percent), and trace amounts of apatite, sphene, magnetite, and hornblende. Alteration products consist of plagioclase altered to sericite, muscovite, and epidote; biotite altered to chlorite and in places to muscovite. Local foliation fabric that is present towards margin of pluton suggests that magma pulsated during crystallization and defined the more crystallized outer rim of the pluton. Dikes of quartz monzonite in country rock are fine grained; country rock shows migmatization near intrusive contact. Three potassium-argon dates of 67 ± 3 m.y., 71 ± 1.4 m.y., and 71 ± 1.4 m.y. (Bonham and Garside, 1979) place the age of emplacement at approximately 70 m.y.

QUARTZ MONZODIORITE (CRETACEOUS)—Medium-grained, containing plagioclase, quartz, microcline, biotite, and lesser amounts of muscovite, sphene, zircon, and apatite. Alteration products are mostly sericite, chlorite, and epidote. Small outcrops of this body are present in northeastern part of Lone Mountain where it intrudes Harkless(?) Formation (Ch) and (Kgb). Quartz monzodiorite is intruded by silicic porphyry dikes. Crops out north of mapped area (Bonham and Garside, 1979), where it is part of complex intrusive body.

GABBRO (CRETACEOUS)—Dark-gray to grayish-black, medium- to coarse-grained, containing predominantly hornblende (40 percent) and plagioclase (55 percent, Bonham and Garside, 1979). Crystals as large as 6 mm, and minor amounts of augite, apatite, sphene, and alkali feldspar. A small gabbro outcrop is found in northeastern part of Lone Mountain where it intrudes Harkless(?) Formation and is intruded by silicic porphyry dikes and quartz monzodiorite. North of mapped area, gabbro occurs as roof pendants in silicic intrusion (Bonham and Garside, 1979) related to silicic porphyry dikes. A potassium-argon date of 110 m.y. was obtained by Bonham and Garside (1979) from hornblende. They considered this to be a minimum age due to heating of gabbro during emplacement of silicic or quartz monzodiorite intrusive bodies.

LONE MOUNTAIN PLUTON

The Lone Mountain pluton is a Cretaceous (approximately 70 m.y.) stock, essentially a homogeneous mass of quartz monzonite (fig. 1), as determined from seven modal analyses in this study and from modal analyses by Albers and Stewart (1972) and by Bonham and Garside (1979). It intrudes Proterozoic and Cambrian metasedimentary rocks that include the Wyman Formation, Reed Dolomite, and the Deep Spring, Harkless(?) and Campito Formations. Roof pendants of Wyman Formation rock are preserved in the central and northeastern part of the stock. The country rock has been mineralized in some areas and has been described by Phariss (1974) and Sandy (1965). The pluton has been intruded by aplite, pegmatite, silicic porphyry, lamprophyre and dioritic dikes.

Albers and Stewart (1972) have indicated that the pluton has intruded the core of a northwest-trending anticline that was developed in the metasedimentary rocks prior to intrusion of the pluton. An alternative hypothesis is that the intrusion of the pluton domed the metasedimentary rocks to form the northwest-trending anticline.

The pluton is intensely jointed, primarily as a result of cooling and movement of the magma within a northwest-trending stress field. Foliation, in general, is poorly developed, and quality varies from area to area, but it is best developed close to the contacts with the metasedimentary rocks. A prominent northwest foliation direction was observed (fig. 2) that parallels the northwest elongation of the exposed pluton.

STRUCTURE

The three major high-angle joint sets have the following attitudes: (1) N. 20°-50° W. (fig. 3), dip southwest (fig. 4); (2) N. 40°-70° E., dip northwest; and (3) strike approximately east-west, dip predominantly north. The joint sets intersect each other with little apparent displacement. The northwest trend is the dominant joint set. Such joints are commonly filled with lamprophyre dikes and, to a lesser degree, with silicic porphyry dikes.

Faults in the pluton are difficult to identify because of the homogeneity of the rock. Several faults were mapped in the northern part of the area where they have a northeast trend and intersect the northwest-trending lamprophyre dikes with little apparent displacement. A major fault that bounds the northern part of the pluton is downthrown to the north and strikes northeast. This fault offsets the alluvium, the metasedimentary rocks, and the pluton and forms fault scarps as high as 10 m. The fault zone parallels the Warm Springs lineament (Ekren and others, 1976) in the southwestern part of Big Smoky Valley, north of Lone Mountain.

The Lone Mountain area appears to have been exposed to two stress fields of different ages—an older field in which maximum principal stress was oriented northwest-southeast and a younger field oriented northeast-southwest. The older stress field was apparently present during emplacement of the Lone Mountain pluton, as is evidenced by elongation of the pluton in a northwesterly direction and by pronounced northwest-trending joints. This stress field parallels the Walker Lane, a zone of disrupted topography characterized by the presence of a northwest-striking lineament (Gianella and Callaghan, 1934; Locke and others, 1940), and could possibly be related to its early development. The younger stress field is proposed to be at right angles to the older field. The younger stress field orientation is based on the presence of northeast-trending faults that displace alluvium and intersect northwest-trending lamprophyre dikes. These lamprophyre dikes are younger than 22.1 m.y., as shown by intrusion of the silicic porphyry dikes, dated at 22.1 m.y. (Bonham and Garside, 1979), by the lamprophyre dikes. These relationships suggest that the younger of the two stress fields was present after about 22 m.y. ago.

AEROMAGNETIC DATA

Aeromagnetic data (U.S. Geological Survey, 1979) suggest the following: (1) the local magnetic highs in the central part of the Lone Mountain pluton are probably related to topographic highs (peaks) where the flight lines are closer to the pluton; (2) a magnetic low in the northeastern part of Lone Mountain coincides with the pluton-country rock contact, which may be very steep; (3) the contours for the southwestern part of the mapped area indicate that the pluton-country rock contact is not as steep as that in the northeastern part and that the pluton probably coalesces at depth with the Weepah pluton, a pluton exposed south of the mapped area; and (4) the contours for the area of the Lone Mountain pluton express a northwest-trending gradient that parallels the northwest elongation of the Lone Mountain pluton and the northwest-trending stress field.

Figure 4.—DIPS OF 255 JOINTS, LONE MOUNTAIN PLUTON.

INDEX MAP SHOWING STUDY AREA

AREA OF INDEX MAP

BEDROCK GEOLOGIC MA

SCALE 1:24 000

1 1/2 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVALS 20 AND 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THE LONE MOUNTAIN PLUTON AREA, ESMERALDA COUNTY

By
Florian Maldonado
1984

Geology mapped in 1979

INTERIOR-GEOLOGICAL SURVEY, RESTON, VA.-1984-G83242

DA COUNTY, NEVADA

- Ch** HARKLESS(?) FO
Predominantly der
sists of green and t
ite, recrystallized li
by Stewart (1970)
of Wood Canyon
formation may ac
and Stewart, 197
about 0-300 m
- EpEc** CAMPITO FORMAT
PROTEROZOIC)
Andrews Mountain l
greenish-gray, ol
grayish-red, very
siltstone (Albers
southeastern enc
Mountain pluton
- Zds** DEEP SPRING FO
Composed pred
and minor schist.
have been altere
Mountain pluton
of Wood Canyon
0-450 m
- Zr** REED DOLOMITE
massive recrystal
light tan; contain
ite. Dolomites h
intrusion of Lor
upper part of Str
0-900 m (Bont

This report was prepared as an
Government. Neither the Unit
employees, makes any warranty
bility for the accuracy, comple
process disclosed, or represents
ence herein to any specific con
manufacturer, or otherwise do
mendation, or favoring by the
and opinions of authors expr
United States Government or a

occurs as roof pendants in silicic intrusion (Bonham and Stewart, 1979) related to silicic porphyry dikes. A potassium-argon age of 110 m.y. was obtained by Bonham and Garside from hornblende. They considered this to be a minimum age to heating of gabbro during emplacement of silicic or monzodiorite intrusive bodies.

S(?) FORMATION (LOWER CAMBRIAN)—A dominantly detrital unit that has been metamorphosed; con-
green and brown to black hornfels and minor thin quartz-
crystallized limestone, phyllite, and schist. It is considered
Stewart (1970) to be lateral equivalent of uppermost part
of Canyon Formation. Some of strata included in this
unit may actually belong to Campito Formation (Albers
and Stewart, 1972; Bonham and Garside, 1979). Thickness
0-300 m.

FORMATION (LOWER CAMBRIAN AND LATE PROTEROZOIC)

Lone Mountain Member—Composed predominantly of dark-
gray, olive-gray, pale-brown, yellowish-gray, and
red, very fine grained quartzite and minor coarse
grained schist (Albers and Stewart, 1972). Present only at
eastern end of Lone Mountain and intruded by Lone
Mountain pluton. Thickness about 0-80 m.

STIRLING FORMATION (LATE PROTEROZOIC)—
Composed predominantly of alternating gray, thin marble beds
and hornfels and quartzite. Locally, impure carbonate rocks
have been altered to hornfels and talcites by intrusion of Lone
Mountain pluton. Unit is westward equivalent of lower member
of Canyon Formation (Stewart, 1970). Thickness about
0-100 m.

DOLOMITE (LATE PROTEROZOIC)—Predominantly
recrystallized dolomite; weathers white to light gray and
contains minor local interbedded hornfels and quartz-
ite. Dolomites have been partly or totally altered to marble by
intrusion of Lone Mountain pluton. Unit is correlative with
part of Stirling Quartzite (Stewart, 1970). Thickness about
0-100 m (Bonham and Garside, 1979).

country rock contact is not as steep as that in the northeastern part and that the
pluton probably coalesces at depth with the Weepah pluton, a pluton exposed
south of the mapped area; and (4) the contours for the area of the Lone
Mountain pluton express a northwest-trending gradient that parallels the north-
west elongation of the Lone Mountain pluton and the northwest-trending stress
field.

REFERENCES CITED

- Albers, J. P., and Stewart, J. H., 1972, Geology and mineral resources of
Esmeralda County, Nevada: Nevada Bureau of Mines and Geology Bulletin
78, 80 p.
- Bonham, H. F., Jr., and Garside, L. J., 1979, Geology of the Tonopah, Lone
Mountain, Klondike, and northern Mud Lake quadrangles, Nevada: Nevada
Bureau of Mines and Geology Bulletin 92, 142 p.
- Ekren, E. B., Bucknam, R. C., Carr, W. J., Dixon, G. L., and Quinlivan, W.
D., 1976, East-trending structural lineaments in central Nevada: U.S.
Geological Survey Professional Paper 986, 16 p.
- Gianella, V. P., and Callaghan, Eugene, 1934, The earthquake of December
20, 1932, at Cedar Mountain, Nevada, and its bearing on the genesis of
Basin-Range structure: Journal of Geology, v. 42, p. 1-22.
- Locke, Augustus, Billingsley, P. R., and Mays, E. B., 1940, Sierra Nevada
tectonic patterns: Geological Society of America Bulletin, v. 51, p. 513-540.
- McKee, E. H., and Moiola, R. J., 1962, Precambrian and Cambrian rocks in
south-central Esmeralda County, Nevada: American Journal of Science,
v. 260, no. 7, p. 530-538.
- Phariss, E. I., 1974, Geology and ore deposits of the Alpine mining district,
Esmeralda County, Nevada: Reno, Nev., University of Nevada, unpublished
M.S. thesis, 114 p.
- Sandy, John Jr., 1965, Geology of the Lone Mountain intrusive, Esmeralda
County, Nevada: New Orleans, La., Tulane University, unpublished M.S.,
thesis, 49 p.
- Stewart, J. H., 1970, Upper Precambrian and Lower Cambrian strata in the
southern Great Basin, California and Nevada: U.S. Geological Survey
Professional Paper 620, 206 p.
- U.S. Geological Survey, 1979, Aeromagnetic map of the Lone Mountain area,
Nevada: U.S. Geological Survey Open-File Report 79-1456, scale
1:62,500.

AI08-78ET 44802

DISCLAIMER

This document is an account of work sponsored by an agency of the United States
Government. The United States Government nor any agency thereof, nor any of their
employees, makes any warranty, express or implied, or assumes any legal liability or responsi-
bility for the accuracy, completeness, or usefulness of any information, apparatus, product, or
process disclosed, or represents that its use would not infringe privately owned rights. Refer-
ence to any specific commercial product, process, or service by trade name, trademark,
or otherwise does not necessarily constitute or imply its endorsement, recom-
mendation, or approval by the United States Government or any agency thereof. The views
expressed herein do not necessarily state or reflect those of the
Government or any agency thereof.

MASTER

For sale by Branch of Distribution, U.S. Geological Survey,
Box 25286, Federal Center, Denver, CO 80225

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED