

U.S. DEPARTMENT OF THE INTERIOR  
U.S. GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE EAST OF GROTTA HILLS QUADRANGLE, CALIFORNIA

by

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Open-File Report 98-469

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## INTRODUCTION

The East of Grotto Hills 1:24,000-scale quadrangle of California lies west of the Colorado River about 30 km southwest of Searchlight, Nevada (figs. 1, 2), near the boundary between the northern and southern parts of the Basin and Range Province. The quadrangle includes the eastern margin of Lanfair Valley, the southernmost part of the Castle Mountains, and part of the northwest Piute Range. The generally north-trending Piute Range aligns with the Piute and Dead Mountains of California and the Newberry and Eldorado Mountains and McCullough Range of Nevada (fig. 1). The southern part of the Piute Range adjoins Homer Mountain (Spencer and Turner, 1985) near Civil War-era Fort Piute (fig. 2). Adjacent 1:24,000-scale quadrangles include Castle Peaks, Homer Mountain, and Signal Hill, Calif.; also Hart Peak, Tenmile Well, and West of Juniper Mine, Calif. and Nev. (fig. 2).

The mapped area contains Tertiary (Miocene) volcanic and sedimentary rocks, interbedded with and overlain by Tertiary and Quaternary surficial deposits. Miocene intrusions mark conduits that served as feeders for the Miocene volcanic rocks, which also contain late magma pulses that cut the volcanic section. Upper Miocene conglomerate deposits interfinger with the uppermost volcanic flows. Canyons and intermontane valleys contain dissected Quaternary alluvial-fan deposits, mantled by active alluvial-fan deposits and detritus of active drainages. The alluvial materials were derived largely from Early Proterozoic granite and gneiss complexes, intruded by Mesozoic granite, dominate the heads of Lanfair Valley drainages in the New York Mountains and Mid Hills (fig. 1; Jennings, 1961). Similar rocks also underlie Tertiary deposits in the Castle Peaks, Castle Mountains, and eastern Piute Range (figs. 1, 2).

Regional geologic mapping by Hewett (1956) and Bingler and Bonham (1973) included parts of the map area. New geologic mapping in the area was undertaken by U.S. Geological Survey (USGS) between 1983 and 1991; summaries of Castle Mountains and Piute Range stratigraphy have been published from this work by Nielson and others (1987, 1993), and Nielson and Nakata (1993).

## GEOLOGIC SETTING

The volcanic rocks of the Castle Mountains and Piute Range were erupted onto a basement complex of mostly Early Proterozoic age (Wooden and others, 1986), which is not exposed in the East of Grotto Hills quadrangle. Intrusive relations between Early Proterozoic gneiss and less foliated Early Proterozoic granite crop out within the Castle Peaks, Hart Peak,

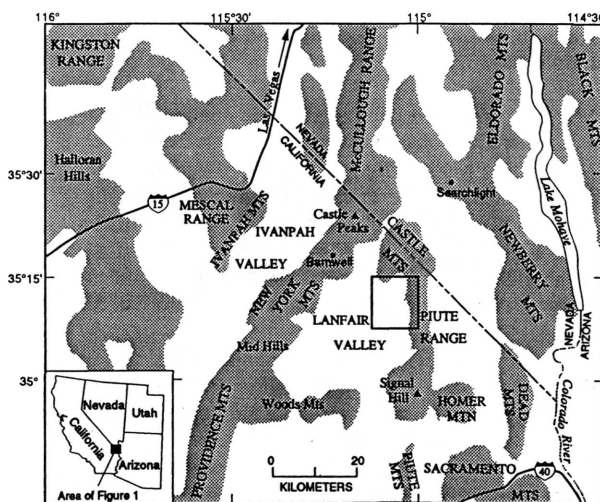


Figure 1. Index map showing location of East of Grotto Hills quadrangle (box) and selected regional features.

Homer Mountain, West of Juniper Mine, and Tenmile Well quadrangles (fig. 2). Deformed to undeformed granite, probably of Mesozoic age, intrudes the Early Proterozoic complex within the Homer Mountain, West of Juniper Mine, and Signal Hill quadrangles (Miller and others, 1986; Spencer and Turner, 1985).

Extensional faulting of Miocene age produced the main structural elements exposed within the East of Grotto Hills quadrangle. High-angle normal faults with north and northeast strikes, also due to Miocene extension, are the main structures in the area. No low-angle normal (detachment) faults crop out in the Castle Mountains or Piute Range, although detachment faults are exposed to the west in the Kingston Range (Reynolds, 1993) and to the east in the Black Mountains of Arizona (Faulds and others, 1990; Faulds, 1993)(fig. 1). The relation of exposed high-angle faults, either to hypothetical Miocene low-angle normal faults at depth or to regional strike-slip faults, such as the Las Vegas Valley shear zone, remains unclear (Faulds and others, 1990).

## TERTIARY AND QUATERNARY ROCKS

### Lower, Middle, and Upper Miocene Deposits

Tertiary rocks in the East of Grotto Hills quadrangle are middle and upper Miocene, mafic-to-silicic, volcanic flows, tuff, and breccia and interbedded volcanoclastic and epiclastic sedimentary rocks. Basal Miocene rocks have not been observed in the quadrangle. Regionally, the base of the Miocene section is locally-derived arkosic sandstone and conglomerate of Tertiary age (Oligocene? and Miocene), observed in the Castle Peaks, Homer Mountain, West of Juniper Mine, and Tenmile Well quadrangles (fig. 2). The oldest volcanic rock unit of local origin is a basaltic andesite flow in the

southernmost part of the Piute Range (Homer Mountain quadrangle), dated at  $19.8 \pm 0.5$  Ma (Nielson and Nakata, 1993; Nielson and Turner, 1998). The oldest regional Miocene volcanic unit is the sanidine-rich, sphene-bearing Peach Springs Tuff of Young and Brennan (1974), a widespread ash-flow tuff dated at  $18.5 \pm 0.2$  Ma (Nielson and others, 1990; Nielson and Turner, 1998). The closest outcrops of Peach Springs Tuff to the map area are in the West of Juniper Mine and Hart Peak quadrangles (fig. 2).

The East of Grotto Hills quadrangle contain middle Miocene volcanic rocks that were erupted in the Castle Mountains and the Piute Range. Volcanic units in both the Castle Mountains and Piute Range include basaltic, andesitic, and rhyolitic rocks, but the Castle Mountains contain a higher proportion of silicic rocks and also a greater abundance of alkalic compositions compared to rocks of the Piute Range (rock compositions are listed in Nielson and Turner, 1998).

Volcanic rocks of the Castle Mountains are represented by thin outcrops of rhyolitic tuff and breccia (Tr), basalt flows (Tb), and interbedded rhyolite tuff and breccia and basalt flows (Tbts) in the northern and western parts of the map area. The light-colored rhyolite units were erupted from rhyolite domes in the Hart Peak quadrangle to the north of the map area (fig. 2). Rhyolite units in the Castle Mountains have ages between 12.8 and 16.3 Ma (Turner and Glazner, 1990; Capps and Moore, 1991). Outcrops of welded tuff in the southeastern part of the quadrangle, also shown as unit Tr, could have had a source in either the Castle Mountains or the Woods Mountains at the west side of Lanfair Valley (fig. 1; McCurry, 1988).

The far eastern part of the East of Grotto Hills quadrangle is composed largely of Piute Range volcanic rocks, a sequence of dark-colored middle and upper Miocene flows and breccia, which overlap light-colored Castle Mountains units in the northwestern part of the map area, and in the Hart Peak quadrangle (fig. 2). The Piute Range rocks are mostly short, stubby andesite, trachyandesite, basalt, trachybasalt, and basaltic andesite flows and flow breccia (Tb, Ta), interbedded tuff (Tpr) and gravel, representing channel-fill deposits (Tg). Abundant porphyritic or aphyric andesitic and basaltic dikes occur throughout unit Ta in the Piute Range. A unit of thin trachyandesite flows and breccia, lithologically similar intrusions, and interbedded sedimentary rocks (Tats) is

exposed in cliffs in the northeastern part of the quadrangle. Dacitic flows and domes (Td) and domes (Tid) are scattered throughout the more mafic units. Ages that vary from 19.8 to 8 Ma were determined on basaltic and andesitic flows at localities throughout the Piute Range (Nielson and Nakata, 1993). In the East of Grotto Hills quadrangle, samples of basalt and trachyandesite yielded ages of 13.3 to 10.7 Ma.

#### Tertiary and Quaternary Surficial Deposits

Deposits of middle and upper Miocene gravel (Tg) unconformably overlie the volcanic rocks of the Castle Mountains. Clasts in the conglomerate include Early Proterozoic gneiss and granite, Paleozoic limestone and marble, Mesozoic granite, and varying—generally minor—proportions of volcanic rocks. Conglomerate units of Pliocene and Quaternary age conformably overlie the upper Miocene rocks in the Hart Peak quadrangle (Nielson, 1995).

Lacustrine deposits (QTp) in the East of Grotto Hills quadrangle extend south into the Signal Hill quadrangle, where they conformably overlie Miocene volcanic rocks, but also crop out in buttress unconformity against fault scarps composed of Miocene lava. The unit of lacustrine deposits is deeply dissected into badlands

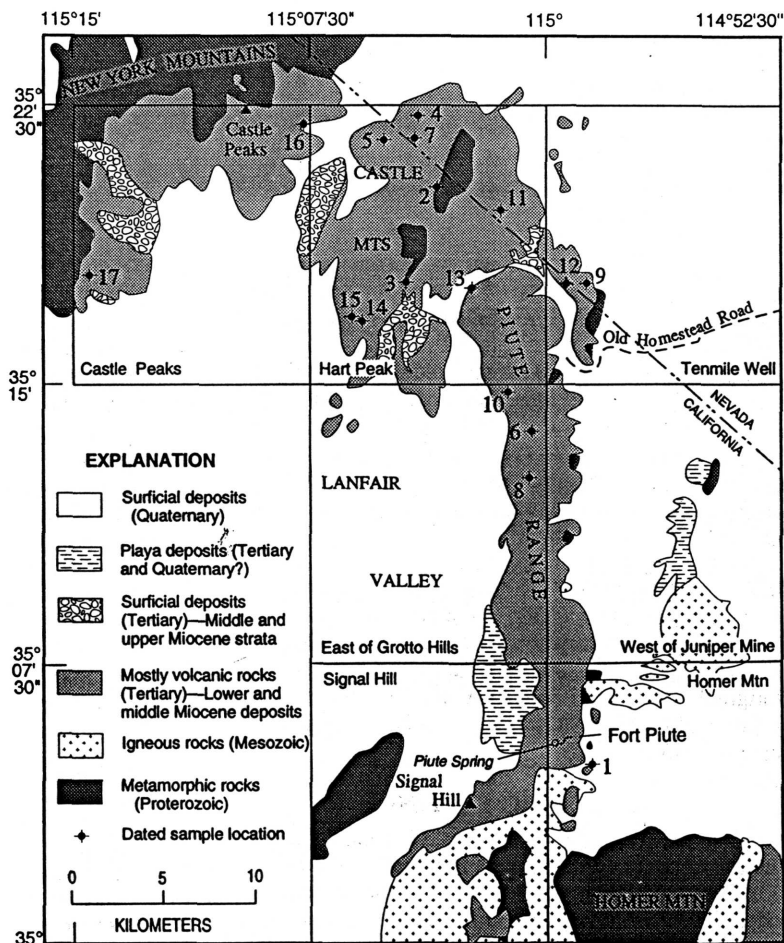


Figure 2. Map showing generalized geology and 7.5-minute quadrangles in the Castle Peaks, Castle Mountains, and Piute Range area, California and Nevada. Numbers indicate locations of dated samples (Nielson and Turner, 1998).

topography by the locally-developed drainage of Piute Gorge (fig. 2), and is capped by alluvium that bears a soil horizon with a thick petrocalcic layer. The thickness of the petrocalcic layer suggests that the soil developed between early and late Pleistocene (Katzenstein and others, 1995). Other playa deposits overlie Piute Range volcanic rocks within the West of Juniper Mine quadrangle; these playa units contain zones of siliceous tufa deposited by hot springs. Some of the tufa outcrops contain fossil bison, yielding a Rancholabrean (late Pleistocene) land mammal age (R.E. Reynolds, oral commun., 1987).

Several generations of unsorted alluvial-fan and stream-channel deposits are found in the quadrangle, mantling mountain slopes and washes and blanketing the intervening valleys. Older fan deposits (Qoa) are highly dissected; the surfaces are stripped of soil and expose calcified zones. Fan and stream deposits of intermediate age (Qia<sub>1a</sub>, Qia<sub>1b</sub>) have thick, poorly defined soil profiles. Stream deposits of intermediate age (Qia<sub>2a</sub>, Qia<sub>2b</sub>) have bar-and-swale surfaces.

### STRUCTURE

Miocene rocks in the East of Grotto Hills quadrangle mostly dip 15° or less, either to the west or east. Low radial dips occur locally where lava flows overlapped older domical silicic flows, which formed topographic mounds. Miocene faults are difficult to identify within sequences of monotonously similar-appearing lava and breccia that make up the southwestern part of the Piute Range in the map area. Near Fort Piute, in the Homer Mountain and Signal Hill quadrangles to the south, flows and breccia of the Miocene section dip gently eastward and these units are repeated by well-exposed northwest-striking and west-dipping normal faults. Thus, faults in the quadrangle that have north and northeast strikes also probably dip steeply; the dip directions could be either to the west or east, however, and the displacements are unknown.

Elsewhere in the Castle Mountains and Piute Range, faults with northern strikes have observable displacements of tens of meters at most. In the eastern part of the Piute Range (Homer Mountain, West of Juniper Mine, and Tenmile Well quadrangles), however, the contact of basal units—arkosic sedimentary deposits or the Peach Springs Tuff (Nielson and Turner, 1998)—on Early Proterozoic augen gneiss is as much as 300 m lower than the basal contact in the central part of the Castle Mountains (Hart Peak quadrangle). The difference in elevation of the basal nonconformity indicates at least a 300 m fault offset of the basal Tertiary rocks in less than a 4 km horizontal distance, therefore. Gravity measurements (Mariano and others, 1986) show a steep gravity gradient that strikes parallel to the west side of the Piute Range in the eastern part of the East of Grotto Hills quadrangle, suggesting the presence of buried or cryptic range-parallel faults with substantial offset.

### INTERPRETATION

The volcanic rocks of the Castle Mountains and Piute Range were erupted in adjacent fault-bounded volcano-tectonic depressions (Nielson and Turner, 1998). The basin-bounding faults are not well expressed, but one of the mapped north-northeast-

striking Piute Range faults in the East of Grotto Hills quadrangle could belong to the group of faults that offset the basal contact of Tertiary deposits on Early Proterozoic rocks by 300 m. Such faults probably represent the western boundary of a volcano-tectonic half-graben in which Piute Range lavas accumulated at the same time that rhyolite ejecta were erupted and intrusive domes emplaced in the Castle Mountains volcano-tectonic depression to the west (Nielson and Turner, 1998).

Volcanism continued in the Piute Range until about 8 Ma, more than 4 m.y. after the rhyolitic eruptions in the Castle Mountains had ended (at about 12.8 Ma), and this activity apparently filled the eastern volcano-tectonic depression. To the north and west in the Castle Mountains, Miocene gravel (Tg) and younger fanglomerate deposits conformably overlie the rhyolite units, and these deposits apparently filled the western depression. The predominant pre-Tertiary sources of all the surficial units, including channel-gravel deposits within and above the Miocene volcanic sequences, show that the map area has continuously received detritus eroded from uplands composed of Early Proterozoic gneiss and granite, and Mesozoic granite, similar to the dominant sources for both Holocene and active channel fills in Lanfair Valley.

Depositional and structural relations in the East of Grotto Hills quadrangle and adjacent quadrangles support a history of continued faulting episodes in the late Tertiary and early Quaternary. The linear boundary of the range is most likely controlled by faults parallel to basin-bounding faults that defined the volcano-tectonic depression of the Piute Range in early and middle Miocene time. Thick playa deposits at the western boundary of the Piute Range indicate formation of a buttress that ponded drainages at the east side of Lanfair Valley after volcanism ended in the late Tertiary, probably due to continued movement on faults. Other evidence of continued faulting in the region include: 1) Superimposed drainages that cross the Piute Range to the north and south of the East of Grotto Hills quadrangle (Piute Gorge on the Signal Hill quadrangle; unnamed canyon west of Old Homestead Road on the Tenmile Well and Hart Peak quadrangles, fig. 2). The Piute Gorge drainage cuts a soil horizon that probably developed no earlier than early Pleistocene (Katzenstein and others, 1995), which suggests faulting and relative offset of valleys and mountain ranges after late Tertiary time.

2) Miocene gravel deposits in the Castle Mountains and Piute Range commonly contain clasts of Paleozoic limestone, and Mesozoic granite of the Teutonia batholith, which were derived from sources in and near the Mescal Range to the northwest and the southeastern New York Mountains to the southwest. Drainages from those sources presently are either obstructed by topographic barriers or flow in an inappropriate direction for transportation of such clast types to the present site of deposits. The earliest time that the topographic barriers could have formed is the late Miocene (Nielson, 1995; Miller, 1995; Nielson and Turner, 1998). Formation of the topographic barriers provided wide exposure of basement rocks, from which detritus continues to be shed into the drainage systems of Lanfair Valley.

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