

Geology of St. Peter's Dome area, Jemez Mountains, New Mexico

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INTRODUCTION

St. Peter's Dome, one of several ridges and peaks commonly referred to as the San Miguel Mountains, is an uplifted fault block of volcanic and sedimentary rocks lying southeast of Valles Caldera and overlying the western margin of the Rio Grande rift (Fig. 1). Valles Caldera represents the culminating volcanic event in the development of the Miocene to Quaternary Jemez volcanic field and is considered to be one of the world's "type" resurgent calderas (Smith and Bailey, 1968; Smith et al., 1970). In recent years, Valles Caldera has been the focus of intense geothermal exploration and development (Laughlin, 1981; Goff and Griggby, 1982) and has become a prime target for scientific investigation by the Continental Scientific Drilling Program (Goff and Gardner, 1988).

The Rio Grande rift consists of a series of late Tertiary sedimentary basins that stretch from Colorado to northern Mexico and are characterized by active extension and seismicity, high heat flow, and Quaternary basaltic volcanism (Bricker, 1979). Continued growth of Los Alamos National Laboratory and the communities of Los Alamos and White Rock, which lie adjacent to Quaternary fault zones of the Rio Grande rift, has raised concerns about seismic hazards (Gardner and Floss, 1987; House and Cash, 1988). Because St. Peter's Dome area provides one of the best exposures of early Jemez Mountains volcanism and is upfaulted against the Pajarito fault zone, the area was chosen for detailed mapping to provide background information for basic research in the Jemez Mountains and for seismic hazards on the Pajarito Plateau. Much of the petrographic, stratigraphic, and tectonic significance of the St. Peter's Dome area has been previously discussed (Gardner and Goff, 1984; Gardner, 1985; Gardner et al., 1986). Field guides with photos of many geologic points of interest in the area can be found in Self et al. (1987) and Goff et al. (1989). Geologic mapping was performed during 1980 through 1985.

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STRATIGRAPHY

The general stratigraphy of the St. Peter's Dome area was originally defined by Bailey et al. (1969) and later refined by Gardner and Goff (1984) and Gardner et al. (1986). The oldest rocks in the map area are well-sorted sandstones and conglomerates of the Eocene Galisteo Formation. This sequence is bounded on the east and southeast by the Pajarito fault zone and is unconformably overlain by nonindurated to weakly indurated sandstones and siltstones of the Miocene Santa Fe Group. Whereas the Galisteo Formation dips from 35° to 45°W, the Santa Fe Group typically dips from 7° to 15°SW. Many thin flows and yellow subgranitic zones of alkali basalts are scattered throughout upper horizons of the Santa Fe, and a K-Ar age on

one of these basalts is 16.5 Ma (Table 1). Unconformably overlying the Santa Fe Group is the Keres Group, the earliest sequence of Jemez volcanic rocks. Volcaniclastic rocks of the Keres Group generally dip from 2° to 17°W. As defined by Bailey et al. (1969), the Keres Group consists of the following units (oldest to youngest): basalt of Chamisa Mesa, Canovas Canyon Rhyolite, Paliza Canyon Formation, and Bearhead Rhyolite. Each of these units was originally thought to be a discrete isochronous unit, but our mapping at St. Peter's Dome coupled with detailed mapping by Gardner (1985) in Keres Group rocks farther to the west shows that there is substantial time overlap of the units and that the basalt of Chamisa Mesa is an artificial unit designation.

The lowest unit of the Keres Group that has widespread exposure is a distinctive pink lithic-rich ash-fall tuff of Canovas Canyon Rhyolite. This unit is exposed along several kilometers of cliffs and canyons on the south and east sides of St. Peter's Dome. A thick flow of Canovas Canyon Rhyolite that directly overlies "pink tuff" in Sanchez Canyon has a composite K-Ar age of 12.4 Ma. Locally, the "pink tuff" has been removed by erosion, and younger Keres Group rocks directly overlie Santa Fe Group. A basalt flow in the bottom of Capulin Canyon north of St. Peter's Dome has a K-Ar age of 11.3 Ma. Above the older units is a complicated sequence of Keres Group domes, flows, and tuffs ranging from basalt through rhyolite that are interbedded with lahars and fluvial deposits of the Cochiti Formation. There is no visible compositional progression in this sequence of rocks, which consists primarily of andesite to dacitic units of the Paliza Canyon Formation. Canovas Canyon Rhyolite intrusions and flows as young as 9.2 Ma are found at all levels in the lower two-thirds of the Paliza Canyon Formation. These complex relations are best exposed in Sanchez Canyon. The youngest Paliza Canyon unit is a porphyritic andesite flow capping the summit of St. Peter's Dome at 8.69 Ma, but other andesite and dacite units in the map area range from 9.2 to 8.8 Ma.

The Cochiti Formation is a volcaniclastic unit of lahars, fluvial deposits, and minor tuffaceous cone debris that was shed into topographically low areas between Paliza Canyon volcanic centers. The unit generally thickens to the south and east toward the Rio Grande rift. Although some volcaniclastic deposits can be found at all stratigraphic levels in the map area, very thick Cochiti deposits are exposed in Cochiti Canyon, Sanchez Canyon, and along the eastern ridges of St. Peter's Dome. Radiometric dates on underlying and overlying volcanic units at these locations bracket this major thickness of Cochiti between 9.5 and 8.7 Ma. Although several layers of rhyolite, ash that correlate with the Canovas Canyon Rhyolite are discontinuously exposed in the Cochiti Formation, many thin flows of Paliza Canyon andesite are commonly observed. The unit generally thickens to the south and east toward the Rio Grande rift. The lower St. Peter's Dome sequence and upper Cerro Peñoles sequence of Gardner (1985).

Overlying the Paliza Canyon and Cochiti Formations are intrusions, domes, flows, and tuffs of Bearhead Rhyolite. The first major eruption of this unit formed the widespread white Peralta Tuff composed of ash falls, ash flows, and reworked

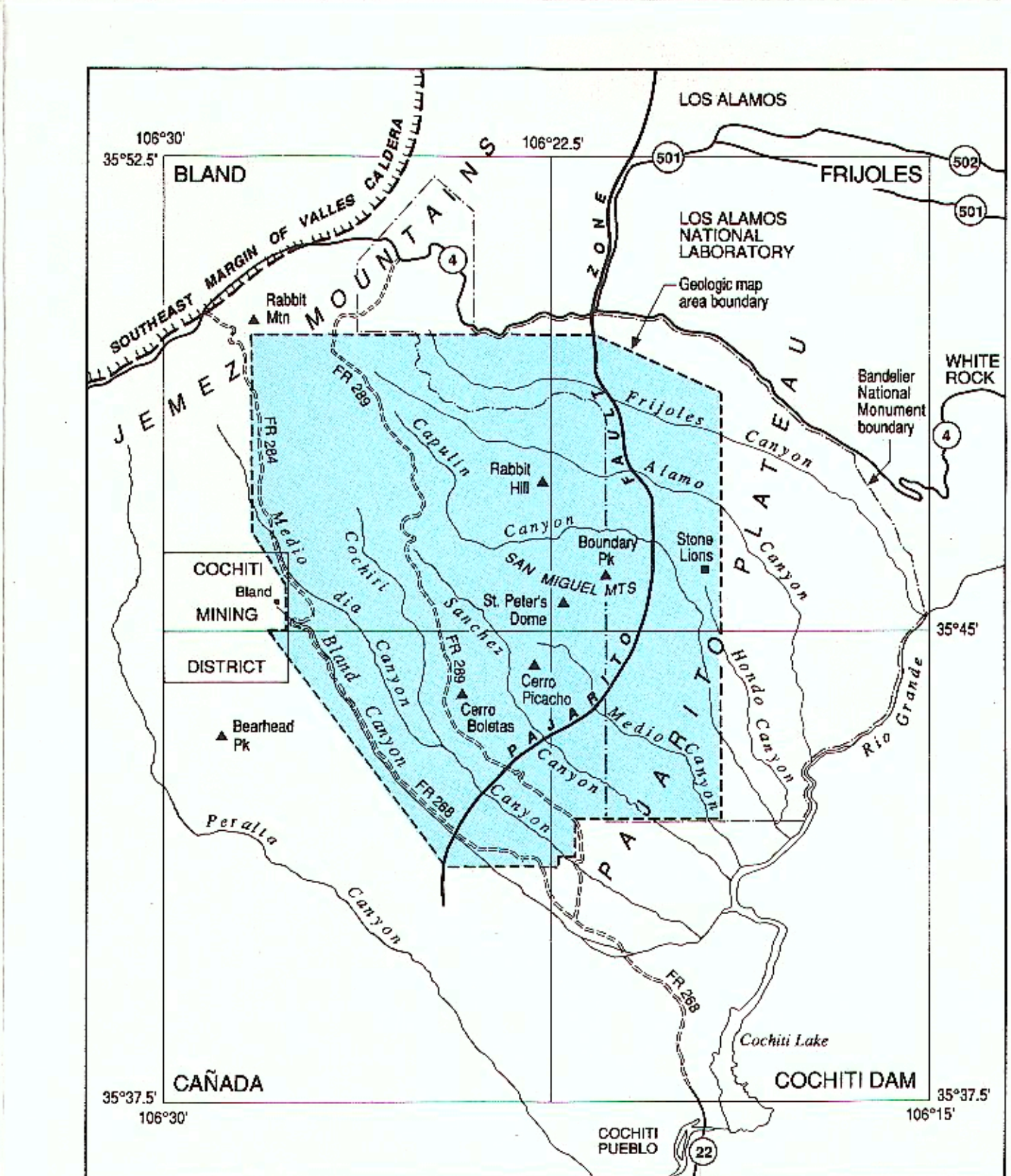


FIGURE 1—Location map of St. Peter's Dome area, New Mexico showing major physiographic features.

fluvial tuffs. Peralta Tuff is very thick in Bland, Medio dia, and lower Cochiti Canyons but thins eastward due to faulting and general thickening of the underlying Paliza Canyon Formation. A K-Ar date on pumice from an ash bed in the Peralta Tuff at Paliza Canyon is 6.81 Ma. Bearhead Rhyolite domes, flows, and intrusions range in age from 7.1 to 6.2 Ma, suggesting a possible overlap in activity between dome eruptions and eruption of Peralta Tuff.

The youngest volcanic unit is ash-fall tuff of El Cajete pumice vented in Valles Caldera, which has accumulated on south- and east-facing slopes and has formed a thin veneer on plateau tops. This unit is dated at approximately 0.15 Ma (Self et al., 1988).

In the south-central Jemez Mountains, Keres Group rocks overlie hydrothermally altered volcanic and hypabyssal rocks of the Cochiti mining district (Bland group of Stein, 1983). Although Smith et al. (1970) show the contact as unconformable, R. A. Bailey (pers. comm., 1980) states that the map contact is placed somewhat arbitrarily because of uncertain relations between the two groups. Smith et al. (1970) show that the Bland group rocks are of probable Eocene or Oligocene age, apparently based on their resemblance to similar rocks in the Cerillos Hills and Ortiz Mountains; however, Ross et al. (1961) presented an "inconclusive lead alpha age determination on zircons" of 19 Ma. Stein (1983) obtained a K-Ar date on feldspar from a monzonite porphyry, one of the younger units in the Bland group, of 11.2 Ma. Reconnaissance in the Bland group indicates that andesitic dikes are numerous, "country rock" in the area is two-pyroxene andesite, and high-silica rhyolite is abundant. All of the rock types, including the monzonite porphyry, are petrographically similar to Keres Group rocks as described in this map. Furthermore, Wronkiewicz et al. (1984) indicate that the gold mineralization in the Cochiti district postdates Bearhead Rhyolite (7-8 Ma). These relations, together with Stein's date, suggest that the Cochiti district rocks are the interior of a dissected Keres Group volcano.

STRUCTURE

The southern segment of the Pajarito fault zone as defined here stretches from NM-4 near the southwestern corner of Los Alamos County south across the east side of St. Peter's Dome. At this point the fault zone splays with one group of faults continuing due south to south-southeast towards La Bajada fault east of the Rio Grande and the other group of faults trending southwest for another 5-6 km. Our detailed geologic map in the St. Peter's Dome area does not show the southern termination of either group of faults comprising the Pajarito fault zone. Smith et al. (1970) show the south-trending splay

joining La Bajada fault and show the southwest-trending splay bending south and dying out in Tertiary sediments in the northern Santa Domingo Basin. Along its entire length the southern segment of the Pajarito fault zone is a major fault, showing significant offset of stratigraphic units and zones of gouge and breccia.

The northern half of the southern segment of the Pajarito fault zone is a well exposed 1 km wide marked by two parallel faults with visible down-to-the-east displacement in the Tshireg Member of the Banderlier Tuff. The maximum displacement of the west fault is about 200 m judging from physiographic evidence on the mesa south of Frijoles Canyon. Maximum displacement of the east fault is about 90 m in the vicinity of the Stone Lions in Banderlier National Monument. At least three cross faults connect the major north-south faults along this part of the Pajarito fault zone. Although physiographic evidence is the easiest way to locate the fault traces, exposures of fault gouge and breccia can be observed in the walls of Frijoles, Alamo, Capulin, and Hondo Canyons.

In the vicinity of St. Peter's Dome, the displacement of the west fault decreases. The fault vanishes beneath a very large landslide on the northeast side of the dome. South of the landslide the west fault juxtaposes both Santa Fe Group and Galisteo Formation against the Tshireg Member of the Banderlier Tuff. Maximum displacement in Banderlier Tuff is 40 m, down to the east, in the vicinity of Red Canyon.

South of Red Canyon, the west fault of the Pajarito fault zone bends sharply southwest. Close to Red Canyon, west-dipping red beds of Galisteo Formation are sheared and drag folded to the southeast into the fault. The fault plane dips 70°SE, and the Banderlier Tuff is relatively undeformed save for fracturing and brecciation. Farther to the southwest the fault generally juxtaposes flat-lying Banderlier Tuff (southeast) against Santa Fe Group. Keres Group andesite and rhyolite, Cochiti Formation gravels, Peralta Tuff, and, in one place, Quaternary alluvium, are faulted against the Banderlier Tuff. Maximum displacement in the older rocks is unknown but could easily exceed 300 m.

South of the Stone Lions, the east fault of the Pajarito fault zone continues south to south-southeast, but displacements diminish abruptly, and physiographic demarcation of the fault is much less obvious. The best place to observe the fault is in an unnamed side canyon west of Capulin Canyon where brecciated Banderlier Tuff can be seen in the canyon wall and Peralta Tuff (west) is faulted against Keres Group andesite and older alluvium in the canyon bottom. Maximum displacement in the Banderlier Tuff is no more than 20 m although displacement in the older rocks may easily exceed 100 m. Farther south the east splay of the Pajarito fault zone is not easily located by surface mapping but appears to trend across the Rio Grande toward the obvious scarp of La Bajada fault.

Because of the unconformable nature of contacts between Galisteo Formation (dip 45°W), Santa Fe Group (dip 10°SW), Cochiti Formation (dip 25°SW), and Banderlier Tuff (dip 3°-5°SE) in the vicinity of the Pajarito fault zone and because of the observable brecciation in older rock units cut by the Pajarito fault zone, it is clear that the Pajarito fault zone has been active for several million years. In fact, the large unconformity between Galisteo and Santa Fe, and a basalt flow dated