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1974, pp. 291-294. https://doi.org/10.56577/FFC-25.291

in:

Ghost Ranch, Siemers, C. T.; Woodward, L. A.; Callender, J. F.; [eds.], New Mexico Geological Society 25 th Annual Fall Field Conference Guidebook, 404 p. https://doi.org/10.56577/FFC-25

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NEOGENE VOLCANISM IN THE SOUTHERN SAN LUIS BASIN

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INTRODUCTION

The San Luis basin, an intermontane structural depression, is made up of the San Luis Valley in south-central Colorado and the Taos Plateau in north-central New Mexico. On the east it gives way abruptly along a steep fault scarp to the Sangre de Cristo Range, culminated by 14,363-foot Mt. Blanca. On the west the San Juan Mountains in Colorado and the Tusas Mountains (sometimes referred to as the Brazos Mountains or southern San Juan Mountains in New Mexico) gradually rise above the valley floor. Upson (1939) subdivided the basin into five physiographic provinces—the Alamosa Basin, the San Luis Hills, the Taos Plateau, the Costilla Plains, and the Culebra Reentrant—a subdivision generally accepted today.

Prior to development of the San Luis basin a late Eocene erosion surface of low relief existed throughout southern Colorado and northern New Mexico (Epis and Chapin, 1973). This surface truncated early Eocene and older rocks that were deformed during the Laramide orogeny. Beginning about 40 m.y. ago an extensive volcanic field, which has subsequently become fragmented by block faulting and related erosion, developed throughout this area (Steven and Epis, 1968).

The San Luis basin, a complex hinged graben with eastward tilt, is one of a series of echelon grabens with northerly trend, the grabens arranged northeasterly along the course of the Rio Grande (Kelley, 1952). The northern boundary of the basin is at Poncha Pass in Colorado and its southern boundary, as defined by Kelley (1956), is at the Embudo constriction in New Mexico. The San Luis Hills (Fig. 1), an intrarift horst, consist of a series of upthrown blocks in the central part of the basin. They are a physiographic barrier between the San Luis Valley to the north and the Taos Plateau to the south, as well as a structural divide between the northern (Alamosa basin) and southern halves of the San Luis basin (Burroughs, 1972).

The main drainage of the area is that of the Rio Grande, which flows eastward from the San Juan Mountains into the San Luis Valley and crosses the San Luis Hills by way of the La Sauses gorge. Six and one-half miles north of the state line, near the Old State Bridge, begins the development of the Rio Grande canyon as the river flows into New Mexico. The canyon gradually deepens southward for the next 50 miles until its walls become 1,200 feet high at Embudo.

Physiographically the southern San Luis basin is composed of the Costilla Plains east of the Rio Grande and the Taos Plateau west of and including the eastern margin of the Rio Grande canyon. The Plateau is made up of a series of flood basalts, and scattered throughout the area are several volcanoes of Neogene age.

The southern San Luis basin extends over an area of about 1,000 square miles. The Taos Plateau is generally flat and rolling with an elevation ranging between 6,900 feet at its southern end to about 8,100 feet along its northwest margin. The highest volcanoes, Cerro San Antonio, Ute Mountain, and Cerro de la 011a, rise about 2,000 feet above the adjacent valley floor.

The basin has a cool and semiarid climate with the average July temperature at Taos being 68° F and the average January temperature 25° F. The floor of the plateau is covered with grass and sagebrush while the plateau margin and volcanic uplands are covered with Pinyon-Juniper, which eventually give way at higher elevations to Ponderosa Pine, Douglas Fir, Lodgepole Pine, and Aspen.

NEOGENE VOLCANISM

The San Luis basin began to subside in early Miocene time (Lipman and Mehnert, 1969) and has continued to do so into the Holocene (Bryan, 1938; Knepper, 1970; Scott, 1970). As subsidence has progressed, the developing trough has gradually accumulated great volumes of terrigenous and volcanic

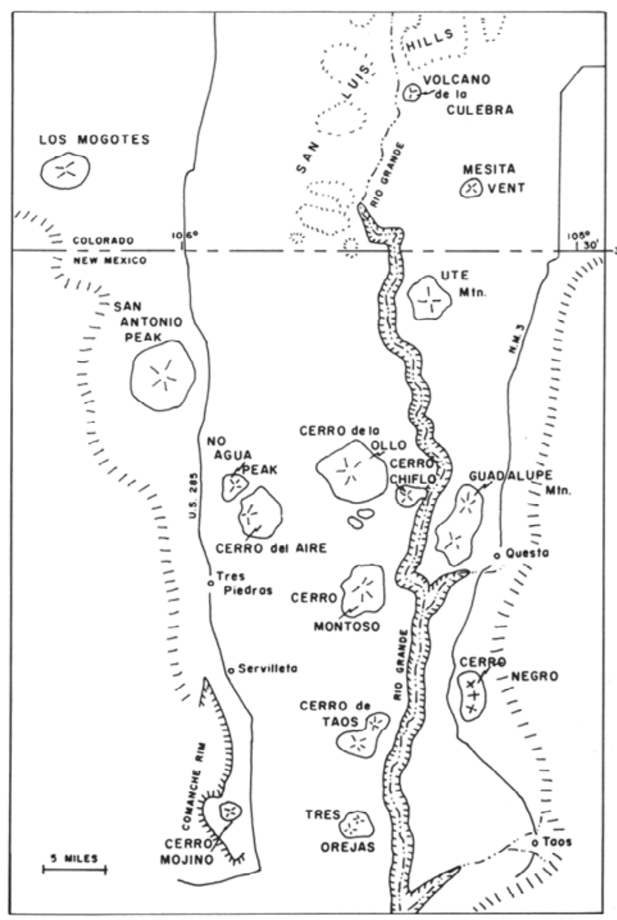

Figure 1. Index map of volcanic features of the Taos Plateau.

material until a maximum of 30,000 feet of fill has accumulated in the deepest part of the basin ten miles northwest of the Great Sand Dunes National Monument in Colorado (Gaca and Karig, 1966).

Servilleta Formation

Neogene volcanism is most apparent in the southern San Luis basin where fissure-type flood basalts make up the Taos Plateau and where several central-type volcanic vents can be seen. Other than the volcanic vents, which rise above the Taos Plateau, the Servilleta Formation, named by Butler (1946), underlies most of the area and is almost the only unit exposed on the plateau. The Servilleta Formation consists of a series of Neogene basalts and interbedded gravels which thicken eastward across the southern San Luis basin. According to Butler (1946), the basalt of the Servilleta Formation is about 100 feet thick in the Canyon of the Rio San Antonio and about 40 feet thick near its western margin south of Servilleta (Fig. 1), a former narrow gauge railroad siding of the famous "Chili Line." The basalts are well exposed along the Comanche Rim. At the Rio Grande gorge 600 to 700 feet of section, primarily basalt, is exposed (Lambert, 1966). Montgomery (1953) suggested that at least 1,500 feet of section is present near Embudo. East of the canyon, in the reentrant of the plateau near Taos, the basalt interfingers with, and is overlain by, a wedge of sand and gravel, which thickens toward the adjacent highlands and basin margin. According to Butler (1946), the Servilleta in this area is about 2,000 feet thick and consists of thick lenses of basalt flows and gravel beds that wedge out laterally to the north and south, but to the east the basalts tend to disappear as the sediments take their place. After the San Luis Hills were eroded to a mature topography, the Servilleta basalts flooded the southern and eastern margins of the hills, the hills becoming islands in a sea of lava (Burroughs, 1971, 1972).

The basalts of the Servilleta Formation are olivine tholeiites that are generally dark gray to black, hypocrystalline to holocrystalline, and subophitic. Most are characterized by a pronounced diktytaxitic texture and are locally intersertal. The rocks are generally non-porphyritic, and although a few phenocrysts may exist, they are not conspicuous because of the coarseness of the groundmass; diktytaxitic texture makes these rocks easily recognized in the field and also helps to distinguish them from the alkalic basalts east and west of the San Luis basin (Lipman, 1969).

The Servilleta basalts are transitional between alkali basalts and the tholeiites. In using the Al_2O_3-total alkali-silica diagram of Kuno (1960), Aoki (1967) found that of 17 analyses of basalt from the Rio Grande gorge, half of them plotted within the high-alumina field and the other half within the tholeiitic and alkalic basalt fields, but near the boundaries of high-alumina basalt. One analysis of the Servilleta basalt from the vicinity of the San Luis Hills plotted within the field of high-alumina basalt (Burroughs, 1972).

Recent crystallization experiments on natural basalts have shown that basalt types are dependent upon pressure (depth) conditions, partial melting, fractionation, rate of advance to the surface, and tectonic conditions (Green and Ringwood, 1967; Green and others, 1967; Kuno, 1960; Kushiro, 1968; O'Hara, 1965; Waters, 1962). Green and Ringwood (1967) and Green and others (1967) have suggested that alkalic basalt may form at depths of 35-70 km; high-alumina basalt with either alkalic or tholeiitic affinities at 15-35 km; and quartz tholeiite at less than 15 km. It thus appears that the Servilleta basalts probably developed at depths of 15-35 km, quickly rising to the surface along deep-seated fissures as uncontaminated basalts during the formation of the Rio Grande rift. The crustal thickness of the southern Rocky Mountains is about 50 km (Jackson and Pakiser, 1965). However, the presence of numerous hot springs and thermal wells along the Rio Grande depression suggest that the area is one of high heat flow. A movement of the mantle into the rift zone would allow the Servilleta basalt to fractionate at higher crustal levels (Lipman, 1969).

The Servilleta basalts of the Rio Grande gorge have been dated by Ozima and others (1967) at 3.6 to 4.5 m.y. (upper Pliocene). Following the basalts, andesitic flows were erupted locally, forming small isolated hills on the basalt plateau. In the area of the San Luis Hills, two vents, the Mesita Volcano and Volcano de la Culebra (Fig. 1), of similar age and composition, have been recognized by Burroughs (1972). These structures are made up of dense basaltic-appearing andesitic flows and scoria. The scoria may be black or deep dull red, depending upon the degree of oxidation. Scoria is concentrated at the center of the Mesita vent with dark flows on its flanks. Very little binding material is present to hold the scoria fragments together, resulting in nearly 100% aggregate. The dense, holocrystalline groundmass of the flows clearly distinguishes these rocks from the diktytaxitic Servilleta basalts. The presence of hypersthene and abundance of spherulitic cristobalite in the vesicular rocks are also characteristic. These andesitic structures appear to be among the youngest of the plateau area and are probably of Pleistocene rather than Pliocene age.

Older Volcanic Rocks

Along the western margin of the Taos Plateau, the Servilleta basalts unconformably overlie older basalts of the Hinsdale Formation. The Servilleta basalts are also generally thought to be younger than many of the central-type vents which rise above the valley floor, although the evidence for this is often tenuous at best. Descriptions of the individual vents have been largely abstracted from Butler (1946, 1971) and Lambert (1966) and have been incorporated in the Alternate Road Log—La Madera Junction to Tres Piedras via U.S. 285, miles 15.2-30.1 (Burroughs, this Guidebook). The present discussion is primarily restricted to the age relationship between the volcanic units.

No Agua Peaks–Los Mogotes Peak

The oldest(?) volcanic rocks exposed on the Taos Plateau are those of No Agua Peaks. The peaks are made up of a rhyolitic mass of spherulitic obsidian and pitchstone (Butler, 1946). The eruption occurred after, or near the end of Los Pinos time, but before the lower basalt (Cisneros) of the Hinsdale Formation was formed (Butler, 1971). A fission track age of 4.8 m.y. has been established for the No Agua event (Lipman and others, 1970). This age is comparable to the m.y. age established for the youngest volcanic activity of the Los Mogotes shield volcano located along the southeastern slope of the San Juan Mountains in Colorado (Fig. 1).

Hinsdale Basalts

Along the western margin of the Taos Plateau the Hinsdale

Formation is subdivided into two basalt members, the Cisneros Basalt and the overlying Dorado Basalt (Butler, 1946, 1971). The Cisneros Basalt unconformably overlies the Los Pinos Formation. It crops out in the area between San Antonio Peak and No Agua Peaks as well as forming some isolated outcrops southwest of Tres Piedras where it occupies areas of low topographic relief. The Dorado Basalt underlies the mesas southwest of Tres Piedras and east of Petaca and Las Tablas (see road log, Coyote Junction to Tres Piedras, mile 49-55, by Burroughs and Woodward, this Guidebook) where it unconformably overlies the Los Pinos Formation. It is present along the southwest side of San Antonio Peak and on the north side of No Agua Peaks where it appears to fill irregular depressions developed on the Cisneros. It is also present along the west side of Cerro• del Aire (Butler, 1946). Vents of Dorado age, including many cinder cones, are numerous along the western margin of the plateau. Although the Dorado Basalt is often topographically higher than that of the Servilleta, it is unconformably overlain by the Servilleta.

Other Volcanic Vents

The original work by Butler (1946) on the "Tertiary and Quaternary geology of the Tusas-Tres Piedras area, New Mexico" is certainly impressive. For a more detailed discussion of the age relationships between volcanic events of the Taos Plateau the reader is referred to Butler's paper.

Many of the volcanic centers, including San Antonio Peak, are composed of hypersthene-bearing rocks of similar appearance, which are chemically quartz latites. This could imply a similarity in age among several of these vents.

Alluvial fans cover the slopes of San Antonio Peak concealing its relationship with the adjacent Hinsdale basalts. However, if the hypersthene-bearing rocks are of similar age, there is some evidence near the base of the mountain that flows of this composition are probably younger than the Cisneros Basalt. The relationship of the Servilleta basalt to San Antonio Peak and some of the other volcanic vents is not clear, but it extends around the vents and appears to be younger.

The rock type of Cerro de la 0lla, Cerro del Aire, and a small butte 6 miles southeast of Tres Piedras, is similar to the rock of San Antonio Peak and may be of similar age. A low cliff of Servilleta basalt is present facing Cerro de la 011a at the outer edge of the alluvial fans along the northeast side of the mountain. The arrangement of the basalt to the fans suggests that the basalt is younger than the mountain. Near Cerro Montoso the Servilleta basalt wraps around a low hill of hypersthene-bearing rock similar to that found at San Antonio Peak.

Although the contacts are not exposed, Upson (1938) inferred that Ute Peak is older than the plateau basalt. Bryan (1928) noted that there was a similar relationship between the basalts and Cerro Chiflo. McKinlay (1957) described Cerro Chiflo as composed of porphyritic andesite and suggested that the andesite may have intruded the lower basalt flows of the Rio Grande gorge, spreading out on the surface as a domal mass, and then being partially buried by later flows. He suggested that Cerro Chiflo was of Quaternary age.

On the basis of the high erosional dissection of Guadalupe Mountain and Cerro Negro, Lambert (1966) suggested that these basaltic buildups may be among the oldest of the volcanic vents along the east side of the plateau. He also pointed out that about four miles up the Rio Grande from the junction with the Red River a cinder cone was completely buried by the plateau basalts.

CONCLUSIONS

The volcanic rocks of the Taos Plateau are directly related in time to the development of the Rio Grande rift. The Servilleta Formation contains uncontaminated basalts which rose quickly along deep-seated fissures in the rift, and they are generally younger than many of the central-type vents of the plateau.

The Hinsdale basalts of the San Juan Mountains of Colorado have ages ranging from 23.4 m.y. to 4.7 m.y. (Lipman and others, 1970). Although there have been no age determinations made for the Cisneros and Dorado basalt members of the Hinsdale Formation, these units are at the younger.limit of the age range for the formation. They are certainly younger than the rhyolite of No Agua Peaks which is dated at 4.8 m.y. From field relationships it would seem that many of the volcanic vents of the plateau are younger than the No Agua Peaks eruption, but older than the 3.6 m.y. of the uppermost flows of the Servilleta Formation at the Rio Grande gorge. A few andesitic structures, such as the Mesita Vent and Volcano de la Culebra, are probably of Pleistocene age.

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