A review of the volcanic history and stratigraphy of northeastern New Mexico, the Ocate and Raton-Clayton volcanic fields

Edward M. Calvin

1987, pp. 83-85. https://doi.org/10.56577/FFC-38.83

in:

Northeastern New Mexico, Lucas, S. G.; Hunt, A. P.; [eds.], New Mexico Geological Society 38 th Annual Fall Field Conference Guidebook, 354 p. https://doi.org/10.56577/FFC-38

This page is intentionally left blank to maintain order of facing pages.

A REVIEW OF THE VOLCANIC HISTORY AND STRATIGRAPHY OF NORTHEASTERN NEW MEXICO, THE OCATE AND RATON–CLAYTON VOLCANIC FIELDS

EDWARD M. CALVIN
Department of Geology, University of New Mexico, Albuquerque, New Mexico 87131

Abstract—Volcanic rocks of northeastern New Mexico lie on the eastern flank of the Sangre de Cristo Mountains and can be divided into two major fields, the Ocate and the Raton-Clayton volcanic fields. These two fields are Miocene-Pleistocene in age and constitute the northeastern extension of the Jemez lineament. The Ocate lavas erupted in a series of five pluses over a 7 m.y. period and, based on geochemical and petrographic criteria, are delineated into five rock types: alkali olivine-basalt (AOB), transitional olivine-basalt (TOB), xenocrystic basaltic andesite (XBA), olivine andesite (OA) and dacite (Nielsen and Dungan, 1985). According to Stormer (1972b), the Raton-Clayton volcanic field can also be divided into five rock types: (1) Raton-Clayton alkali olivine basalts, (2) Red Mountain dacites and andesites, (3) Sierra Grande pyroxene andesite, (4) a feldspathoidal group and (5) the Capulin-type basaltic lavas.

INTRODUCTION

This paper is a brief summation of the volcanic history and stratigraphy of northeastern New Mexico. Sources of information include the following: Collins (1949), Stobbe (1949), Muehlberger et al. (1961), Stormer (1972a, b), Kudo (1976), O'Neill and Mehnert (1980) and Nielsen and Dungan (1985).

The volcanic rocks of northeastern New Mexico constitute the eastern limit of late Cenozoic volcanism in the western United States (Kudo, 1976). These rocks lie at the physiographic boundary between the Rio Grande rift/Sangre de Cristo range and the High Plains province to the east. The volcanics of northeastern New Mexico can be divided into two major fields, the Ocate field and the Raton-Clayton field (Fig. 1). These two fields, together with the Taos Plateau and the Jemez volcanic fields, are the Miocene-Pleistocene eruptive complexes defining the Jemez lineament. Baldwin and Muehlberger (1959) suggest that structural control may have played a role in the volcanic centers' emplacement, as they are aligned northwesterly in an en-echelon fashion, paralleling the axes of the Clapham anticline, and in a northeasterly axis paralleling the axis of the Sierra Grande arch. Volcanism in the Ocate, Raton-Clayton and the Taos Plateau volcanic fields was coincident with a major tectonic rejuvenation of the northern Rio Grande rift during the late Cenozoic and was accompanied by regional uplift and activation of major high-angle faults (Nielsen and Dungan, 1985).

Volcanism began in the Ocate and Raton-Clayton fields more than 8 m.y. ago (Stormer, 1972a; Nielsen and Dungan, 1985). More than 100 volcanic centers have now been recognized in Union and Colfax Counties and exhibit a wide compositional range. The Raton-Clayton volcanic field is dominated by basalt, but also contains more silicic rocks such as andesite and dacite.

The Ocate and Raton-Clayton volcanics erupted on the uplifted eastern flank of the Rio Grande rift and subsequent erosion has inverted their topographic expression. Accordingly, mesa tops as much as 600 m above present drainages are capped with resistant lava flows, the oldest of which occupy the highest local elevation (Nielsen and Dungan, 1985).

VOLCANIC HISTORY

Ocate field

According to O'Neill and Mehnert (1980) and Nielsen and Dungan (1985), the Ocate field (Fig. 2) formed over a 7 m.y. period (8.3–0.8 m.y. ago) in a series of five eruptive pulses. O'Neill and Mehnert (1980) used K/Ar whole rock dates to recognize these five eruptive pulses and also documented a correlation between age of eruption and terrace level. Nielsen and Dungan (1985) agreed with the five-pulse volcanism envisioned by O'Neill and Mehnert (1980), but acknowledge that volcanic activity may have been more continuous than existing dates indicate. Based on geochemical and petrographic data, Nielsen and Dungan (1985) defined five major rock types for the Ocate field: alkali olivine-basalt (AOB), transitional olivine-basalt (TOB), xenocrystic basaltic

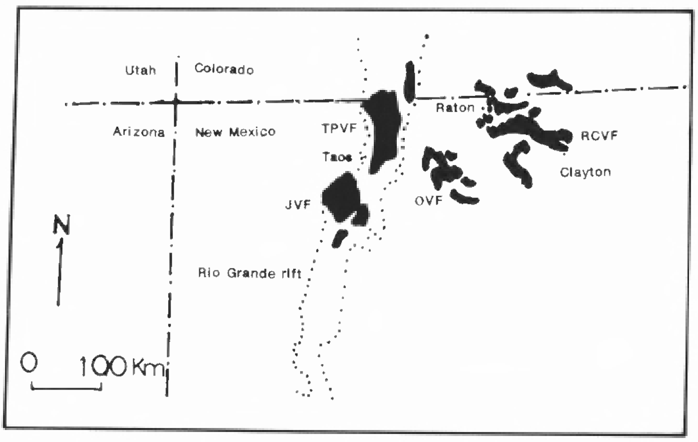

FIGURE 1. Location map for the volcanic fields of northern and northeastern New Mexico. Explanation: TPVF = Taos Plateau volcanic field (4.5 to 1.8 m.y.), JVF = Jemez volcanic field, OVF = Ocate volcanic field (8.1 to 0.8 m.y.) and RCVF = Raton-Clayton volcanic field (7.5 to 0.01 m.y.).

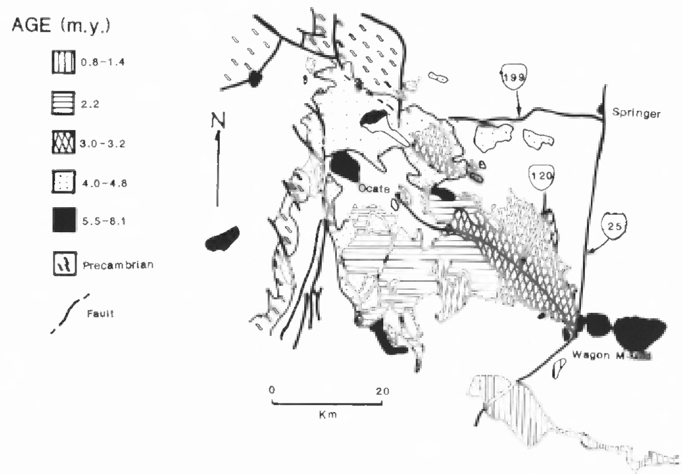

FIGURE 2. Sketch map of the Ocate volcanic field (after Nielsen and Dungan, 1985).

TABLE 1. Approximate ages, rock types and their relative volumes, Ocate volcanic field (after Nielsen and Dungan, 1985).

Episode	I	II	III	IV	V
Total volume (km) of episode	3.9	31	23	28	4.0
Approx. volume of each rock type:					
AOB	40	20	10	10	20
TOB	40	50	80	60	50
XBA	10	20	10	25	30
OA	10	>10	–	>5	>5
Dacite	–	>2	–	>2	–

andesite (XBA), olivine andesite (OA) and dacite. The temporal and volumetric relationship between the eruption of these lavas is a complex one, but there appears to be a close association between the transitional basalts and intermediate rocks during maximum basaltic activity, between 4.5 and 2.9 m.y. (Nielsen and Dungan, 1985). Table 1 summarizes estimates of the total volume of volcanic material during the five pulses as well as the proportions of the five rock types present in each volcanic phase. Between 4.5–2.0 m.y. (episodes II, III, IV), the largest volumetric output of volcanic material took place, with episodes I and V being substantially less voluminous.

Compositionally, the Ocate field shows a volumetric increase in TOB during the interval from 8.1 to 3.2 m.y., followed by a sharp decrease in output of TOB. Maximum output of alkalic volcanics occurred during the first and last episodes, with a minimum during the third episode. Dacites erupted only during the second and fourth episodes.

Raton-Clayton volcanic field

Baldwin and Muehlberger (1959) recognized three distinct basaltic eruptive phases of the Raton-Clayton volcanic field (Fig. 3), the oldest of which is the Raton basalts between 7.2 and 3.2 m.y. (Stormer, 1972a). The Raton basalts are alkali olivine basalts and conformably overlie the Tertiary Ogallala Formation. At 2.5 to 2.2 m.y., the Clayton basalt is the next youngest stratigraphic unit (Stormer, 1972a). Baldwin and Muehlberger (1959) divided the Clayton basalt into two units. An older basalt, compositionally similar to the Raton basalts, forms an extensive flow sheet capping high mesas east of Sierra Grande (Kudo, 1976). The second subdivision of the Clayton basalt is a younger feldspathoidal basalt dated at 1.8 m.y. by Stormer (1972a). This is the Folsom sequence, and its outcrop is limited to the cones and flows near Folsom, New Mexico.

Stormer (1972a, b) interpreted the stratigraphy somewhat differently. He combined the lower Clayton basalts with the Raton basalts, calling this unit the Raton-Clayton basalts. He separated the Folsom sequence of the Clayton basalts of Baldwin and Muehlberger (1959) and named it the feldspathoidal lavas. Kudo (1976) suggested that these "late" Clayton basalts of the Folsom sequence be renamed the Folsom basalts to avoid further confusion and to preserve geographical and non-compositional nomenclature.

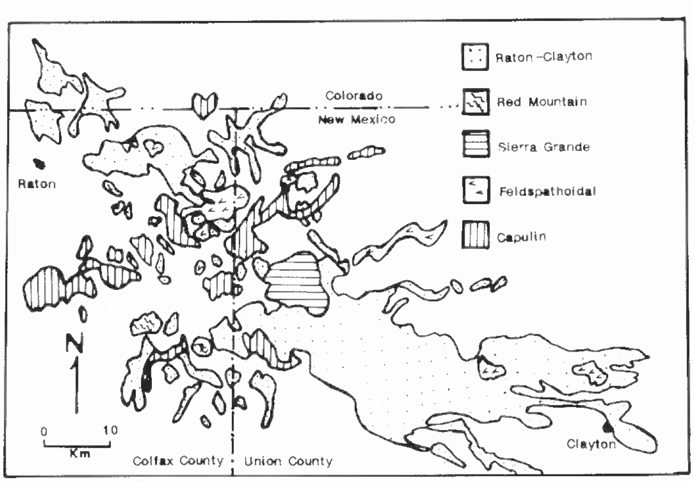

FIGURE 3. Sketch map of the Raton-Clayton volcanic field (after Stormer, 1972b).

Occurring nearly simultaneously with the type Clayton basalts are two silicic pulses during which the Sierra Grande andesite and the Red Mountain dacite erupted. Stratigraphic relationships indicate that the Red Mountain dacite is probably younger than the Raton basalts, conflicting with a K-Ar date of 8.2 m.y. (Stormer, 1972a) from hornblende in the Red Mountain dacite. This date may not be reliable, possibly due to excess Ar in the hornblende (Kudo, 1976). A whole-rock, K-Ar age of 1.9±0.5 m.y. for the Sierra Grande andesite is reported by Stormer (1972a). Table 2 summarizes the age and stratigraphic data for the Raton-Clayton volcanic field given by Baldwin and Muehlberger (1959) and Stormer (1972b).

DESCRIPTION OF UNITS

Ocate volcanic field

Alkali olivine-basalt (AOB)

The predominant phenocryst phase of this rock is a normally zoned olivine, with abundant glomercrysts (An_{77} to An_{60} at core to An_{55-45} at rims); ground-mass plagioclase compositions range from An_{50} to An_{15}. Both high-Al and high-Cr spinels are present in small euhedral inclusions and anhedral grains in the groundmass. Small xenoliths of norite are present in some AOB lavas.

Transitional olivine-basalt (TOB)

The TOB lavas exhibit olivine and plagioclase phenocrysts in a groundmass of plagioclase, augite, titanomagnetite and occasional olivine. The ophitic groundmass texture distinguishes this unit from AOB lavas. TOB groundmass contains clinopyroxenes that are generally more Fe-rich than clinopyroxenes in AOB groundmass. Spinels occur in cores of olivine phenocrysts and as titanomagnetite in anhedral groundmass. Rare plagioclase xenocrysts are present in TOB lavas and exhibit reverse zoning. Rounded quartz-xenocrysts are present, surrounded by pyroxene reaction-rims.

Xenocrystic basaltic andesite (XBA)

Normally-zoned olivine phenocrysts are dominant and, unlike TOB or AOB lavas, these phenocrysts are usually resorbed. Plagioclase phenocrysts are normally zoned, ranging from An_{60-55} (core) to An_{55-40} (rim). Some plagioclase phenocrysts show resorbed and embayed character-

TABLE 2. Volcanic units of the Raton-Clayton volcanic field, their ages and nomenclature (after Kudo, 1976).

Baldwin and Muehlberger (1959)	Stormer (1972a)	Age
Capulin baslats	Capulin basalts	18,000–4,500 *
Folsom sequence of Clayton basalts	Feldspathoidal lavas	1.8 ± 0.1 m.y.**
Sierra Grande andesite	Sierra Grande andesite	1.9 ± .05 m.y.**
Red Mountain dacite	Red Mountain dacite	?
Clayton basalt	Clayton basalt	2.2–2.5 m.y.**
Raton basalt	Raton basalt	3.5–7.2 m.y.**

* Baldwin and Muehlberger (1959).

** Stormer (1972a).

istics, with core compositions in the An_{40-25} range. Embayments are most commonly filled with groundmass material. Quartz is a common xenocrystic mineral. Groundmass texture ranges from subophitic to glassy, and its mineralogy is commonly comprised of brown glass, plagioclase laths, clinopyroxene, clino- and orthopyroxenes and spinel.

Olivine andesites (OA)

These andesites have a wide variety of compositions and textures. Phenocrysts of olivine (Fo_{75-60}) and plagioclase (An_{57-50}) rarely exceed 5% by volume and are set in very fine-grained groundmass. Olivine phenocrysts are normally zoned, and many plagioclase phenocrysts appear resorbed. The groundmass becomes progressively more fine-grained with increasing Si-content and usually contains two pyroxenes. Xenocrysts of quartz and oligoclase are present in a few OA samples.

Dacites

Dacitic lavas erupted from all four major volcanic centers in the Ocate field and have similar major-element chemistry. They contain plagioclase (An_{60} to An_{25}) and amphibole phenocrysts, the latter apparently formed by a reaction between orthophyroxene and the magma in the Agua Fria area, as they are often cored with orthopyroxene ($En_{79}Wo_4Fs_{17}$). The plagioclase phenocrysts are chemically bimodal in several areas, including Cerro Montoso. Virtually all the phenocrysts in these dacites exhibit evidence that they were out of equilibrium with the liquid and with one another at the time of eruption. Nielsen and Dungan (1985) suggest that the disequilibrium assemblage was produced from the mixing of mafic and silicic magmas just prior to eruption, producing complex hybrid dacites.

Raton-Clayton volcanic field

Capulin basalts

The Capulin basalts are characterized by corroded plagioclase crystals which Stormer (1972b) described as "dusty" or "cloudy." Capulin Mountain lavas contain small olivine and large plagioclase phenocrysts set in an aphanitic groundmass, and make up about 10% of the rock.

Folsom sequence of Clayton basalts (feldspathoidal lavas)

The Folsom sequence contains high amounts of the alkalis and is typically undersaturated. Olivine phenocrysts make up approximately 15% of the rock, and augite phenocrysts are commonly associated with the olivine. The groundmass typically contains auguite, plagioclase, magnetite and feldspathoids.

Sierra Grande andesite

This andesite is a relatively homogeneous rock, containing two pyroxenes as phenocrysts (augite and hypersthene). The groundmass is composed of two pyroxenes, feldspars, iron oxides and glass, in a hypocrystalline to microcrystalline texture.

Red Mountain dacites

The Red Mountain dacites range in composition from fine-grained hornblende-bearing andesites to dacites containing plagioclase and amphibole phenocrysts in a hypocrystalline groundmass. These dacites overlie the Raton basalts of Johnson Mesa and typically occur in domes, plugs and flows.

Clayton basalts

These basalts are essentially identical chemically and mineralogically to the Raton basalts. They cap the high mesas in the Clayton area, occurring as continuous sheets from Clayton on the east, to the Canadian River, approximately 17 km south of Raton.

Raton basalts

The Raton basalts erupted as continuous sheets (3 to 30 m thick) and cap the high mesas between Trinidad, Colorado and Raton. They are composed of olivine phenocrysts (about 10% of the rock), with occasional plagioclase and augite phenocrysts, all set in a halocrystalline groundmass containing augite plagioclase, olivine and magnetite.

REGIONAL RELATIONSHIPS

Lipman (1969), Lipman and Mehnert (1979) and Dungan et al. (1983) pointed out a temporal relationship between the Raton-Clayton, Ocate and Taos Plateau volcanic fields. The most voluminous volcanic episodes for all three fields occurred between 4.5 and 2.0 m.y. This period is characterized by eruptions of tholeiitic and/or transitional basalts, which comprise the highest volumetric output, together with eruptions of andesites and dacites. The final period of volcanism exhibits smaller volumetric output in which more alkaline primitive and xenocrystic intermediate lavas are dominant.

Moving from west to east, there is a progressive increase in the alkaline nature of the lavas. This is also seen in incompatible minor- and trace-elements; their concentrations increase within a given rock type from west to east. According to Nielsen and Dungan (1985), the association of alkaline and tholeiitic basalts in the Raton-Clayton and Ocate volcanic fields suggests two possibilities: (1) the source regions were separated by a large depth interval; or (2) significantly different degrees of partial melting occurred at the same depth.

REFERENCES

Baldwin, B. and Muehlberger, W. R., 1959, Geologic studies of Union County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 63, 171 pp.

Collins, R. F., 1949, Volcanic rocks of northeastern New Mexico: Geological Society of America Bulletin, v. 60, pp. 1017–1040.

Dungan, M. A., Thompson, R. A., McMillian, N. J. and Nielsen, R. L., 1983, Time-dependent basalt crust interactions in the RGR and the role of assimilation/fractional crystallization (AFC) in the origin of calc-alkalic magmas in a rift setting: Geological Society of America, Abstracts with Programs, v. 14, p. 379.

Kudo, A. M., 1976, A review of the volcanic history and stratigraphy of northeastern New Mexico: New Mexico Geological Society, Guidebook 27, pp. 109–110.

Lipman, P. W., 1969, Alkalic and basaltic volcanism related to the Rio Grande depression, southern Colorado and northern New Mexico: Geological Society of America Bulletin, v. 80, pp. 1343–1353.

Lipman, P. W. and Mehnert, H. H., 1979, The Taos Plateau volcanic field, northern Rio Grande rift, New Mexico; *in* Reicker, R. E., ed., Rio Grande rift: tectonics and magmatism: Washington, D.C., American Geophysical Union, pp. 289–311.

Muehlberger, W. R., Baldwin, B. and Foster, R. W., 1961, High plains, northeastern New Mexico: New Mexico Bureau of Mines and Mineral Resources, Scenic Trips to the Geologic Past, no. 7, 107 pp.

Nielsen, R. L. and Dungan, M. A., 1985, The petrology and geochemistry of the Ocate volcanic field, north-central New Mexico: Geological Society of America Bulletin, v. 96, pp. 296–312.

O'Neill, J. M. and Mehnert, H. H., 1980, Late Cenozoic physiographic evolution of the Ocate volcanic field, north-central New Mexico: United States Geological Survey, Open-File Report 80-298, 44 pp.

Stobbe, H. R., 1949, Petrology of volcanic rocks of northeastern New Mexico: Geological Society of America Bulletin, v. 60, pp. 1041–1093.

Stormer, J. C., Jr., 1972a, Ages and nature of volcanic activity on the southern High Plains, New Mexico and Colorado: Geological Society of America Bulletin, v. 83, pp. 2443–2448.

Stormer, J. C., Jr., 1972b, Mineralogy and petrology of the Raton-Clayton volcanic field, northeastern New Mexico: Geological Society of America Bulletin, v. 83, pp. 3299–3322.

Arroyos along tributary to Ute Creek about 27 km east-northeast of Mosquero. View is N70°W upstream. The road is NM Highway 65 where it passes through a group of basalt-capped hills that border the west side of Ute Creek. The arroyos are about 1.5 km above the mouth of the tributary and are cut into alluvium that has partially filled the narrow valley between the hills. Triassic sandstone underlies the alluvium and is exposed in the floor of the main stream near the middle of the view. The scarp in the distance (18 km) is the Canadian Escarpment. Camera station is in NE¼ sec. 32, T19N, R31E. Altitude about 1,417 m. W. Lambert photograph No. 86L98. 28 December 1986, 2:37 p.m., MST.