New K-Ar ages for Miocene and Pliocene volcanic rocks in the northwestern Espanola Basin and their relationships to the history of the Rio Grande Rif

K. Manley and H.H. Mehnert

Isochron/West, Bulletin of Isotopic Geochronology, v. 30, pp. 5

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

NEW K-AR AGES FOR MIOCENE AND PLIOCENE VOLCANIC ROCKS IN THE NORTHWESTERN ESPANOLA BASIN AND THEIR RELATIONSHIPS TO THE HISTORY OF THE RIO GRANDE RIFT

KIM MANLEY
H. H. MEHNERT } *U.S. Geological Survey, Denver, CO 80225*

Thirteen basalts from north-central New Mexico were dated by the K-Ar method as part of a regional mapping program of the Aztec 1° x 2° quadrangle. These ages contribute to an understanding of the late Tertiary history of the northwestern Espanola basin, the northern Jemez Mountains, and the western boundary of the Rio Grande rift (fig. 1). K-Ar and fission-track ages previously reported from the southern, north-central, and northeastern parts of the Espanola basin (Manley, 1976, 1979; Manley and Naeser, 1977), in particular those ages that bear on the age ranges of the Tesuque, Chamita, Ancha, and Puye Formations, have also contributed to an understanding of the geologic history in those areas.

Six of the K-Ar ages reported here provide further information concerning the stratigraphic relationships in the northwestern Espanola basin between the basal part of the Chamita Formation of Galusha and Blick (1971), the Chama-El Rito Member of Galusha and Blick (1971) of the Tesuque Formation, the Abiquiu Tuff of Smith (1938), and part of the Los Pinos Formation. The remaining seven age determinations put a limit on the time of movement along the western fault boundary of the Rio Grande rift.

Two basalt flows, separated laterally by an area of erosion and of uncertain stratigraphic relationship, were dated from the Chamita Formation. One flow, cut by U.S. Highway 84 near the town of Chili, is part of a small volcanic center within the lower part of the Chamita Formation; it yielded a K-Ar age of 8.3 ± 2.4 m.y. (Sample 77-9-30-1). A second flow, sampled in Arroyo de la Presa, is cut by the western boundary faults of the Velarde graben and lies close to the base of the Chamita Formation. This sample (78-6-7-4) was dated at 9.9 ± 1.2 m.y. As shown by their K-Ar ages, both flows are of about the same age.

The Chama-El Rito Member of the Tesuque Formation is shown by Galusha (1974) to range from 15.5 to 8.0 m.y. in age. A basalt flow interbedded in the Chama-El Rito and derived from a small volcanic center near El Rito Creek is 13.5 m.y. old (Sample 76-4-15-1).

The Abiquiu Tuff in the westernmost part of the Espanola basin has been difficult to date. Miocene pollen were reported from the Abiquiu by Woodward (in Broomfield, 1974), but no vertebrate fossils have been found. The formation contains neither clean air-fall tephra layers useful for fission-track dating nor any interbedded volcanic rocks. A dike that cuts the Abiquiu was reported as 9.8 m.y. old by Bachman and Mehnert (1978). Another dike that cuts the Abiquiu (Sample 77-9-26-1) and a volcanic rock clast (Sample 77-9-4-2B) from a monolithologic gravel bed within the Abiquiu Tuff give older ages: 15.9 ± 0.9 m.y. and 17.3 ± 0.8 m.y. respectively. The gravel bed is in a fault block but appears to be within approximately 10 m of the top of the formation.

The Abiquiu Tuff is close in age to a part of the Los Pinos Formation to the north, but the stratigraphic relationships of the two formations have never been well defined. Butler (1946) divided the Los Pinos Formation into three members: the Biscara, Esquibel, and Cordito. Barker (1958) was the first to publish a description of these members. Isotopic ages of flows interbedded with the Los Pinos near the Colorado–New Mexico boundary have been reported by Lipman and Mehnert (1975). The ages give a range for the Los Pinos of 25 to 5 m.y. Bingler (1968, p. 36) reported an age of 25.9 ± 1.8 m.y. for a rhyolite welded tuff close to the base of the Cordito Member. Sample 77-9-29-2 is from a basalt flow in the Cordito in Arroyo Seco, 8 km north of El Rito, and has an age of 20.7 ± 3.5.

These isotopic ages support the correlation of the upper part of the Abiquiu Tuff with part of the Cordito Member. It is still uncertain if any of the lower part of the Abiquiu is as old as the lower two members of the Los Pinos. The upper Cordito Member interfingers with the Chama-El Rito Member of the Tesuque Formation (May, 1979).

Seven of the K-Ar ages reported here are from the Canones area near the western fault boundary of the Rio Grande rift. The ages suggest amounts of vertical offset along the rift boundary and provide control for the time of faulting.

Four samples, from basalt flows south of Canones, are very similar in age and petrology. Their ages are (1) Cerro Pedernal, 78-5-25-3, 7.8 ± 0.7 m.y.; (2) Mesa Escoba, 78-6-2-1, 7.9 ± 0.5 m.y.; (3) Canones Creek 77-9-17-2, 7.6 ± 0.4 m.y.; and (4) Polvadera Mesa, 77-9-2-1, 7.8 ± 0.5 m.y.

If one assumes that the flows were deposited on a broad, nearly level surface, the total offset on the rift faults cutting them is about 670 m down to the east. This amount of throw is comparable with that shown by the Santa Fe Group–Abiquiu Tuff contact and the Abiquiu–El Rito Formation contact. Therefore the western rift boundary (fig. 1) as defined here, shows no evidence of being a growth fault and the boundary fault must have formed later than 7.6 m.y. ago.

Three additional basalts were dated to establish a minimum age for the fault movement in the area. Two basalts from the northwest prong of Canones Mesa have the same age of 2.8 m.y. (Samples 77-9-1-1 and 78-6-3-1). Canones Mesa is a basalt-capped mesa beneath which the rift faults pass without apparently offsetting the basalt. The third sample (77-8-28-4) is from a fault-bounded flow farther

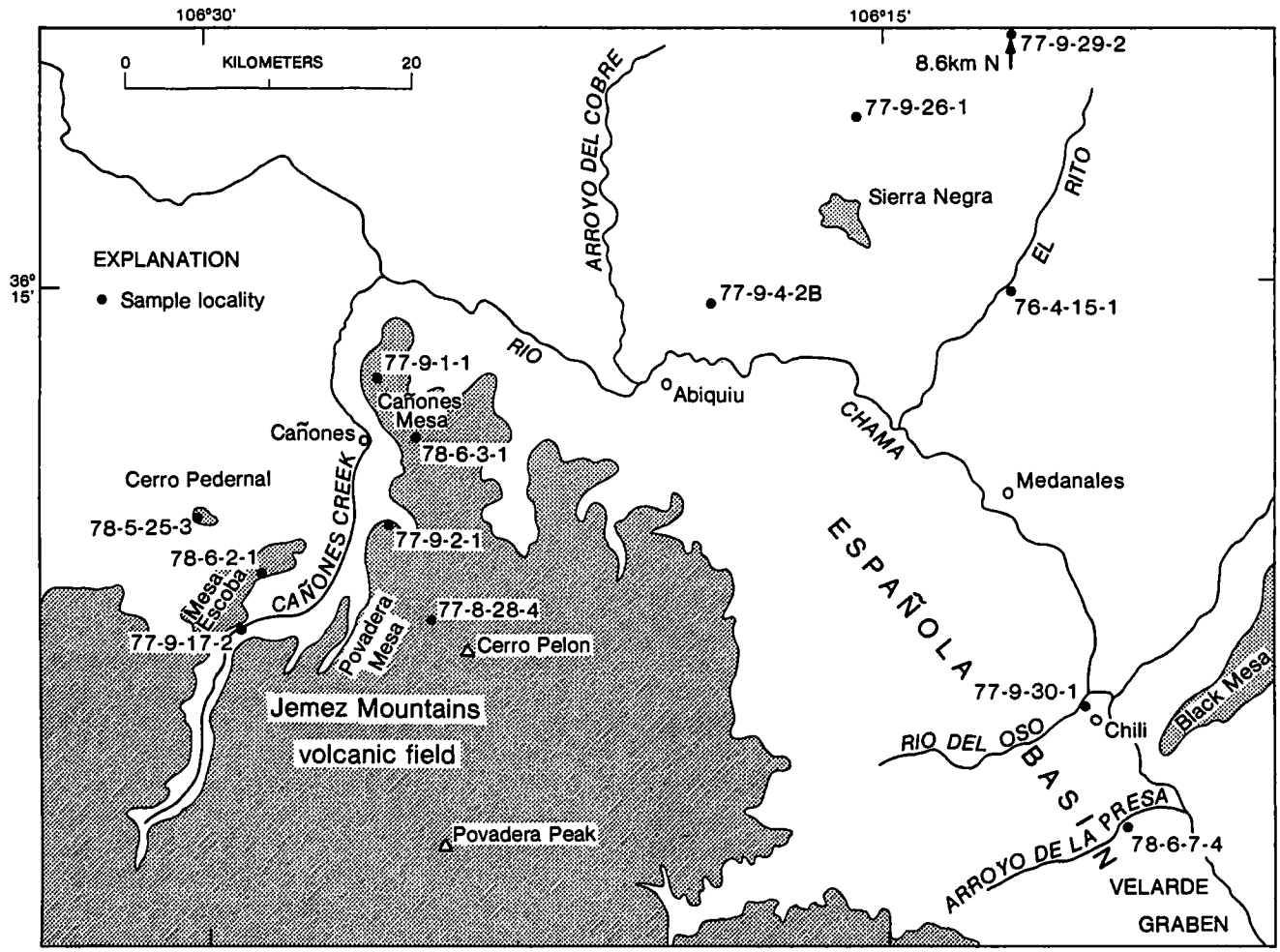

FIGURE 1. Location of samples dated by the K-Ar method, northern New Mexico.

south on Canones Mesa. Its age of 3.1 ± 1.0 m.y. shows that some faulting occurred after that time, although not directly along the major axis of the western rift boundary.

A similar period of fault activity has been noted in the central part of the Espanola basin. There the age restraints are a bit tighter; deformation occurred between 5 and 2.8 m.y. (Manley, 1979).

Conclusions. Several workers in other areas have suggested an early Miocene age for the initiation of Rio Grande rifting (Chapin, 1971; Lipman and Mehnert, 1975). In north-central New Mexico this was a time of formation of a broad downwarp in which volcaniclastic and eventually arkosic sediments were deposited. These deposits extend beyond the margins of the present structural basin.

The broad Miocene basin was not disrupted until the Pliocene when normal faulting occurred in two zones: one in the Canones area that defines the present western boundary of the rift, and one in the central part of the basin.

Analytical data and sample descriptions. Errors reported are for two standard deviations. Constants used: $K^{40}\lambda_e$ = 0.581 x 10^{-10}/yr; $K^{40}\lambda_\beta$ = 4.962 x 10^{-10}/yr; K^{40}/K = 1.167 x 10^{-4}.

1. *Basalt 77-9-30-1* K-Ar
Basalt flow (36°06'56"N, 106°08'22"W; NE¼ S36, T22N,R7E; Chili quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 0.58%, $*Ar^{40}$ = 0.069 x 10^{-10} moles/gm (9.6% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 8.3 ± 2.4 m.y.

2. *Basalt 78-6-7-4* K-Ar
Basalt flow (36°04'08"N, 106°08'13"W; NE¼ S12, T21N,R7E; Chili quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 0.59%, $*Ar^{40}$ = 0.085 x 10^{-10} moles/gm (21.9% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 9.9 ± 1.0 m.y.

3. *Basalt 76-4-15-1* K-Ar
Basalt flow (36°14'23"N, 106°10'58"W; S10,T23N, R7E; Medanales quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 0.71%, $*Ar^{40}$ = 0.143 x 10^{-10} moles/gm (13.1% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 13.5 ± 2.8 m.y.

4. *Basalt 77-9-26-1* K-Ar
Basalt dike (36°17'40"N, 106°14'37"W; T24N,R6E, unsurveyed; El Rito quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 1.11%, $*Ar^{40}$ = 0.256 x 10^{-10} moles/gm (58.9% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 15.9 ± 0.9 m.y.

5. *Dacite 77-9-4-2B* K-Ar
Dacite clast (36°14'02"N, 106°17'58"W; T23N,R6E, unsurveyed; Abiquiu quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 5.19%, $*Ar^{40}$ = 1.300 x 10^{-10} moles/gm (73.7% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 17.3 ± 0.8 m.y.

6. *Basalt 77-9-29-2* K-Ar
Basalt flow (36°24'32"N, 106°11'21"W; SE¼ S9, T25N,R7E; Valle Grande Peak quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 0.18%, $*Ar^{40}$ = 0.054 x 10^{-10} moles/gm (17.0% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 20.7 ± 3.5 m.y.

7. *Basalt 78-5-25-3* K-Ar
Basalt flow (36°09'43"N, 106°30'20"W; S½ S3,T22N, R4E; Canones quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 1.17%, $*Ar^{40}$ = 0.132 x 10^{-10} moles/gm (20.5% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 7.8 ± 0.7 m.y.

8. *Basalt 78-6-2-1* K-Ar
Basalt flow (36°08'43"N, 106°28'40"W; NE¼ S14, T22N,R4E; Canones quadrangle. Rio Arriba County, NM). *Analytical data:* K_2O = 0.9%, Ar^{40} = 0.103 x 10^{-10} moles/gm (53.6% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 7.9 ± 0.5 m.y.

9. *Basalt 77-9-17-2* K-Ar
Basalt flow (36°07'42"N, 106°28'55"W; S23,T22N, R4E; Canones quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 1.80%, $*Ar^{40}$ = 0.197 x 10^{-10} moles/gm (66.7% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 7.6 ± 0.4 m.y.

10. *Basalt 77-9-2-1* K-Ar
Basalt flow (36°09'43"N, 106°25'41"W; T22N,R5E, unsurveyed; Canones quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 1.07%, $*Ar^{40}$ = 0.120 x 10^{-10} moles/gm (45.5% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 7.8 ± 0.5 m.y.

11. *Basalt 77-9-1-1* K-Ar
Basalt flow (36°12'34"N, 106°26'11"W; SE¼ S19, T23N,R5E; Canones quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 2.05%, $*Ar^{40}$ = 0.084 x 10^{-10} moles/gm (10.3% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 2.8 ± 0.7 m.y.

12. *Basalt 78-6-3-1* K-Ar
Basalt flow (36°11'13"N, 106°25'10"W; T23N,R5E, unsurveyed; Canones quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 2.2%, $*Ar^{40}$ = 0.089 x 10^{-10} moles/gm (14.2% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 2.8 ± 0.5 m.y.

13. *Basalt 77-8-28-4* K-Ar
Basalt flow (36°07'58"N, 106°24'40"W; T22N,R5E, unsurveyed; Canones quadrangle, Rio Arriba County, NM). *Analytical data:* K_2O = 1.3%, $*Ar^{40}$ = 0.058 x 10^{-10} moles/gm (7.8% ΣAr^{40}). *Collected by:* Kim Manley; *dated by:* H. H. Mehnert, USGS.
(whole rock) 3.1 ± 1.0 m.y.

REFERENCES

Bachman, G. O., and Mehnert, H. H. (1978) New K-Ar dates and the late Pliocene to Holocene geomorphic history of the central Rio Grande region, New Mexico: Geological Society of America Bulletin, v. 89, p. 283–292.

Barker, Fred (1958) Precambrian and Tertiary geology of Las Tablas quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 45.

Bingler, E. C. (1968) Geology and mineral resources of Rio Arriba County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 91.

Broomfield, R. E. (1974) Structural geology and igneous petrology of the Canones area, Rio Arriba County, New Mexico: University of New Mexico M.S. thesis.

Butler, A. P., Jr. (1946) Tertiary and Quaternary geology of the Tusas–Tres Piedras area, New Mexico: Harvard University, Ph.D. dissertation.

Chapin, C. E. (1971) The Rio Grande rift, part 1—Modifications and additions: New Mexico Geological Society Guidebook 22, p. 191–201.

Galusha, Ted (1974) Dating rocks of the Santa Fe Group—Programs and problems: New Mexico Geological Society Guidebook 25, p. 282–286.

Galusha, Ted, and Blick, J. C. (1971) Stratigraphy of the Santa Fe Group, New Mexico: American Museum of National History Bulletin, v. 144, no. 1.

Lipman, P. W., and Mehnert, H. H. (1975) Late Cenozoic basaltic volcanism and development of the Rio Grande depression in the southern Rocky Mountains: Geological Society of America Memoir 144, p. 119–154.

Manley, Kim (1976) K-Ar age determinations on Pliocene basalts from the Espanola basin, New Mexico: Isochron/West, no. 16, p. 29–30.

_____ (1979) Stratigraphy and structure of the Espanola basin, Rio Grande rift, New Mexico: Rio Grande Rift—Tectonics and Magnetism: American Geophysical Union, Washington, D. C., p. 71–86.

Manley, Kim, and Naeser, C. W. (1977) Fission-track ages for tephra layers in upper Cenozoic rocks, Espanola basin, New Mexico: Isochron/West, no. 18, p. 13–14.

May, S. J. (1980) Geology of the Ojo Caliente–Rio Chama area, Rio Arriba and Taos Counties, New Mexico: University of New Mexico, Ph.D. dissertation.

Smith, H. T. U. (1938) Tertiary geology of the Abiquiu quadrangle, New Mexico: Journal of Geology, v. 46, no. 7, p. 933–965.