Zircon-Fission-Track ages of Neogene air-fall ashes from the Gila group and the Camp Rice formation, Grant and Dona Ana counties, New Mexico

W. Leopoldt and C.P. Kortemeier

Isochron/West, Bulletin of Isotopic Geochronology, v. 41, pp. 15-18

ZIRCON-FISSION-TRACK AGES OF NEOGENE AIR-FALL ASHES FROM THE GILA GROUP AND THE CAMP RICE FORMATION, GRANT AND DONA ANA COUNTIES, NEW MEXICO

WINFRIED LEOPOLDT
CURTIS P. KORTEMEIER
Geology Department, University of New Mexico, Albuquerque, NM 87131

Geologic Setting

The three vitric ashes studied in this paper have been collected at two different locations shown in fig. 1. Their geologic setting is described separately as follows.

The northern end of the NW-trending asymmetrical Mangas graben, is filled with up to 700 m (Ratte and others, 1979) of Neogene terrestrial, predominantly clastic sediments, commonly assigned to the Gila Conglomerate or Gila Group (Gilbert, 1875; Page, 1916; Heindl, 1963; Trauger, 1972). Tilted and uplifted Oligocene and early Miocene volcanic rocks on the flanks of the Mangas graben are the principal sources of the locally derived sediments. Basin fill is early Miocene to early Pleistocene in age, as indicated by (1) dated lower Miocene and Pliocene basalt flows (Bikermann, 1972; Elston and others, 1973; Bornhorst and Elston, 1978; Ratte and Finnell, 1978; Weber and Basset, 1963; Finnell, written communication, May, 1980) and (2) faunas of late Clarendonian-earliest Hemphillian, late Hemphillian, and late Blancan ages (Cope, 1884, p. 59; Cunningham, 1974; Ratte and Finnell, 1978, p. 54; Manning and Tedford, written communication, September, 1980). A detailed study of the basin-fill sediments of the central Mangas graben (Leopoldt, 1981) elaborated earlier studies (Trauger, 1972).

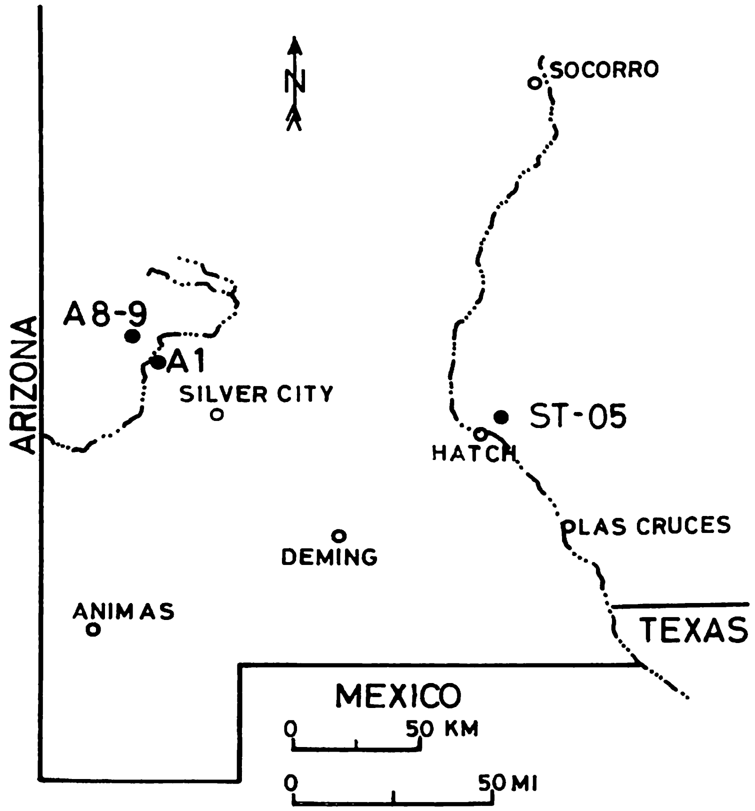

FIGURE 1. Ash sample localities in southern New Mexico.

Rapid deposition of older basin fill (prior to 10 m.y. ago) is documented by 240 m of marginal coarse-grained fanglomerate. Renewed pre-late Hemphillian deposition of younger basin fill (approximately 6–1.7 m.y. ago) resulted in an asymmetrical westward shift of facies. Three sedimentary subfacies, laterally gradational, can be distinguished: (1) coarse-grained, poorly sorted fanglomerates near the basin margin; (2) interlayered pebble conglomerate and medium to coarse-grained cross-bedded sandstone; and (3) mudcracked mudstone, claystone, diatomite, and chert beds at the basin center. These deposits have been interpreted as products of a dynamic fan and playa-lake environment (Leopoldt, 1981) with the following subenvironments: (1) fan-head; (2) mid-fan to distal fan; and (3) playa and lacustrine. Diatom assemblages (Ratte and Finnell, 1978), authigenic zeolites and fluorite (Sheppard and Gude, 1980, Sheppard and Mumpton, 1981), chert beds (Sheppard and Gude, 1974), and high lithium concentrations (Tourtelot and Meier, 1976 a, b) in the basin-center sediments indicate a hydrologically closed basin with a shallow, ephemeral or seasonally saline lake, fed by hot springs. In late Pliocene and earliest Pleistocene time the lake freshened and expanded slowly, covering most of the mapped area. The integration of the drainage into a regional externally-drained system in mid-Pleistocene time is documented by a series of several well-developed pediment and stream-terrace surfaces, indicating 250 m of downcutting of the Gila River since latest Pliocene or early Pleistocene time (Hawley and others, 1976; Leopoldt, 1981).

The isolated outcrop of the Grama Gully ash in the southern part of the Jornada del Muerto of south-central New Mexico occurs in an arroyo at the Grama siding of the Atchison, Topeka, and Santa Fe railroad approximately 12 km north of Rincon, Dona Ana County, New Mexico. This has been informally identified as Pearlette like by Seager and Hawley (1973, fig. 6). The bed is preserved in fine-grained sediments of the Camp Rice Formation, representing a distinct basin-floor facies of deposition. Strain (1966) dated fossils from the Camp Rice Formation as Pleistocene in age (Blancan and Irvingtonian; Hawley 1978, correlation chart 2). The Camp Rice Formation was deposited by river distributaries which fanned out from the Palomas Basin above Hatch. The locus of active deposition during Camp Rice shifted across the central plain of the southern Jornada del Muerton Basin (Seager and Hawley, 1973). A subfacies of the Camp Rice basin floor preserves the Grama Gully ash. This subfacies consists of 0.3–1 m of reddish-brown clay, overlain by 0.3–0.6 m of light greenish clay, interbedded with and overlain by a white, friable, biotitic volcanic ash bed. The ash ranges in thickness from 0.15 to 0.35 m. The fine-grained subfacies indicates a low-energy environment and rapid aggradation is interpreted as an overbank deposit of the ancestral Rio Grande (Kortemeier, 1980, 1982). Both the upper and lower contacts of the overbank subfacies with the basin-floor facies are conformable or paraconformable.

---

[1] Now Shell U.K. Expro, UETA/12, Aberdeen AB9 2HY, Scotland
[2] Now Geology Department, Arizona State University, Tempe, AZ 85287

Sample Preparation and Methods

Ash samples were prepared for fission-track dating, using standard heavy liquid procedures. Zircons were picked from the 60 to 200 mesh fraction under the petrographic microscope. C. W. Naeser (U.S. Geological Survey, Denver) kindly irradiated and counted the induced tracks in a low-uranium glass standard to determine the thermal neutron flux applied to the sample. The decay constant for spontaneous fission of ^{238}U used in calculating the ages of the ash samples was f = 6.85 × 10^{17}/yr (Naeser, 1976).

Discussion and Conclusions

Zircon-fission-track data for three ash samples from the younger basin fill of the Mangas graben (A 1, A 8–9) and the Camp Rice Formation (ST-05) are listed below. Sample A 8–9 was determined as 2.01 ± 0.97 m.y., sample A 1 as 2.13 ± 0.47 m.y., and sample ST-05 as .75 ± .20 m.y. These radiometric ages have a great uncertainty because of the low number of fossil tracks counted. Most zircons separated from the ash samples were unfavorable for accurate fission-track dating, due to: (1) deep coloring of some zircons; (2) inclusions and fractures within most of the transparent zircons; and (3) a possible low original uranium content, (A 1, A 8–9) as indicated by the low number of induced tracks only five grains (2.82 × 10^{-5} cm^2 total area) out of 100 were useful for dating sample A 1 and A 8–9.

The whole-rock major and trace element composition of the ashes were determined for comparison with other analyzed Neogene ashes (table 1). The totals indicate that the glass-shards contain considerable water. Sample A 8–9 is highly altered as indicated by low SiO_2, Al_2O_3, high P_2O_5, and very high CaO values and will not be considered further. Sample A 1, with more than 70% SiO_2 (water free), is a rhyolite. Similarity coefficient variations (Borchardt and others, 1971, p. 247) were calculated for both samples as well as for other, well-known neogene ashes (table 2). Differing data sets are indicated for sample A 1 by low similarity coefficient, high coefficient variation, and a mean value greater one. The preliminary petrographic, trace-element, and zircon-fission-track data do not allow a definite correlation of sample A 1 with known Neogene ash deposits. The data suggest that correlation with mid-pleistocene ashes is unlikely. Whether this ash deposit could be correlative with any of the four upper pliocene ashes (2–3 m.y.) of the upper San Pedro Valley and Sulfur Spring Valleys in southeastern Arizona (Scarborough, 1974) remains unknown. Two of these ashes have been dated at 3.1 ± 0.7 m.y. by zircon-fission-track and 2.5 ± 0.4 m.y. by K-Ar on glass shards (Johnson and others, 1975). Petrographic and chemical data of these ashes are not available. Fission-track ages of glass shards from Pliocene ashes in fluvial basin fill of the San Simon Valley, Graham County, Arizona, range from 2.19 ± 0.38 m.y. (sample 78W208) to 2.68 ± 0.96 m.y. (sample 78W209) (Dickson and Izett, 1981). These ages were recalculated for comparison with the decay constant for spontaneous fission (f = 6.85 × 10^{-17}/yr) used in this paper. Fission-track ages of glass shards generally yield minimum ages because of track annealing (Naeser and others, 1980). The zircon-fission track age from sample 78W211 gave 2.41 ± .30 m.y. Its major-element compositions closely resembles sample A 1 (tables 1 and 2) but correlation is at this time unjustified, because petrographic and trace-element data are lacking.

The whole-rock analysis of the Grama Gully ash (sample ST-05) proves it to be an unaltered rhyolite, chemically

TABLE 1. Comparison of chemical analysis of major Neosene ashes with samples A 1, A8–9, and ST-05.

Ash sample	Central Mangas Graben		Grama Ash	Bishop		Pearlette Ash Family			San Simon Valley	
	A 1	A 8–9	ST-05	Tuff	Ash	type O	type S	type B	78 W 211	78 W 212
OXIDES IN WEIGHT PERCENT										
Si O_2	66.1	43.9	77.9	77.4	72.3	72.63	72.1	72.86	69.7	67.5
A1$_2$ O_3	12.1	5.0	13.4	12.3	12.5	11.71	11.7	11.86	11.8	12.6
Fe$_2$ O_3 + Fe$_o$	1.6	0.9	1.0	—	—	1.97	1.3	1.57	2.1	2.7
Mg O	1.9	0.2	0.4	.01	.05	.17	.005	.06	0.14	1.02
Ca O	2.8	39.7	0.6	.45	.45	—	.06	.55	1.0	2.1
Na^2 O	1.7	1.2	3.4	3.9	—	2.0	2.6	3.14	4.0	3.6
K^2 O	3.6	2.5	5.1	4.8	—	5.44	6	5.34	3.1	2.5
Ti O^2	0.19	0.11	0.11	.07	.06	.12	.12	.12	.21	.48
P$_2$ O^5	0.04	0.21	—	.01	—	.012	—	.01	—	—
Total	90.03	93.72	101.8		(85.36)	94.05	93.89	95.51	92.05	92.50
ELEMENTS IN PPM										
Rb	128	43	183	190	150	230	240	—	87	—
Ba	1086	264	109	<10	—	—	—	—	—	—
La	30	16	35	19	—	—	—	—	33.9	—
Zr	186	146	87	—	—	—	—	—	346	—
Sc	4	22	<3	3.0	5	—	—	—	4.8	—
Sr	114	45	57	—	135	—	<10	—	—	—
Y	19	6	22	25	35	—	—	—	—	—
Pb	26	2	56	—	40	—	—	—	—	—
Sn	<2	34	—	—	—	—	—	—	—	—

NOTE: Chemical analysis of A 1, A 8–9, and ST-05 by T. J. Bornhorst (written communication, 1979); Bishop and Pearlette type S Ash by Izett and others (I-970); Pearlette type O and type B by Izett and others (1972); 78 W 211 and 78 W 212 by Dickson and Izett (1981).

TABLE 2.

Variation analysis of the Grame Gully Ash (ST-05) and ash sample A 1 from lacustrine sediments of the central Mangas Graben with well-established Neogene ashes: Bishop ash (Izett and others, 1970); Pearlette type O, type S and type B (Izett and others, 1972); 78 W 211 and 78 W 212 (Dickson and Izett, 1981); Bishop tuff (w. Hildreth, written communication 1979). Statistical parameters were calculated according to Borchardt and others (1972) and Sarna-Wojciki (1976).

	X-Bar	% Coefficient variation	Number of elements	Coefficient similarity
		VARIATION ANALYSIS SAMPLE ST-05		
Bishop Ash	1.77	31.5	12	.73
Bishop Tuff	1.16	27.9	10	.82
Pearlette "O"	1.26	41.82	8	.74
ST-05	1.00	0.00	13	1.00
		VARIATION ANALYSIS SAMPLE A1		
Bishop Ash	5.98	173.31	13	.50
Pearlette 'S'	5.80	133.34	6	.42
Pearlette 'B'	1.41	86.69	8	.58
78 W 211	1.35	51.05	12	.68
78 W 212	.98	68.98	8	.67
A 1	1.00	0.00	13	1.00

closer to both Bishop volcanics than the Pearlette type O ash. A similarity coefficient near one (.73–.82), low coefficient variation (31.5–27.9) and mean values close to one (1.77–1.16) indicate that the ash from Grama Gully is chemically similar to both the Bishop Ash and the Bishop Tuff of Long Valley, California. It is closer to the Bishop Tuff than to the Bishop Ash, probably because the analysis of the Bishop Tuff was done on whole rock, as was the ash from Grama Gully. The analyses from the Bishop Ash and the Pearlette type O were performed on glass separates. Because of the small volume and simple phenocrystic assemblage, the differences between the whole-rock and glass-only analyses are expected to be small.

The two ashes from post-late Hemphillian lacustrine deposits of the central Mangas graben yielded fission-track ages of 2.01 ± .97 m.y. (sample A 8–9) and 2.13 ± .47 m.y. (sample A 1). These ages are in agreement with field relations and the suspected age for the sediments, as deduced from faunal evidence. Ash sample A 1 can not be correlated with Pearlette type B, type S, type O, or Bishop ash on the basis of petrophysical, chemical composition, trace element, fission-track data, or glass-shard morphology (Barchardt and others, 1972; Izett and others, 1970). Fission track data and major-element composition of sample A 1 bears similarity to those described for ash samples from the San Simon Valley (sample 78W211 and 78212; Dickson and Izett, 1981), but correlation is unjustified.

On the basis of fission-track age (.75 ± .20 m.y.), chemical similarity, petrography, and ash-shard morphology, the ash from Grama Gully (ST-05) correlates with the Bishop Ash of Long Valley, California. The ash was deposited and preserved in an overbank depression genetically and spatially related to the ancestral Rio Grande.

ACKNOWLEDGEMENTS

Financial assistance was provided through a research assistantship (N.M. Energy and Minerals Department Grant EMD 78-2123; U.S. Geological Survey Grant 14-08-0001-G0630, W. E. Elston, principal investigator) and a scholarship of the German Academic Exchange Service granted to W. Leopoldt. We thank W. E. Elston, University of New Mexico, and J. W. Hawley, New Mexico Bureau of Mines and Mineral Resources for their assistance during our work, T. J. Bornhorst, Michigan Technological University, provided the geochemical data and E. Manning and R. T. Tedford, American Museum of Natural History, determined several vertebrate-fossil assemblages.

SAMPLE DESCRIPTIONS

At least three laterally extensive beds of silvery gray to grayish white, poorly to well consolidated ash are preserved in the lacustrine deposits of the central Mangas graben (Gila Group), where they preserve depositional structures in great detail. Their basal layers are very pure and contain virtually no admixed sand and silt. These layers are graded and generally well consolidated. The upper parts of the ash beds (samples A 1 and A 8–9) are less consolidated and have a powdery texture. These ashes are mainly composed of hydrated glass shards and fewer than 1% crystal fragments of silt and fine sand size. The refraction index of glass shards is between 1.485 and 1.505 (±.005). Shapes of glass shards are dominated by bubble walls and bubble junctions (Heiken, 1972); pumiceous shards also occur. Crystal fragments consist of quartz, sanidine, pink and transparent zircons, magnetite, biotite, green-brown hornblende, augite and possibly sphene. The chalky-white Grama Ash (ST-01) is preserved in fine-grained sediments of the Camp Rice Formation. This single .15–.35 m thick ash can be traced in outcrop for 2.5 km. The poorly consolidated ash is interbedded with mud overlaying a .3–.6 m thick light green clay belonging to a distinct subfacies paraconformable with the generally silty basin floor facies of the Camp Rice Formation. The ash is virtually unaltered and lacks diagenesis. It consists of hydrates glass shards and vase crystal clasts. The refraction index of glass shards is 1.500 (±.005). Shapes of glass shards are dominated by pumice fragments (65%) and bubble junctions (20–25%) with minor amounts of bubble walls (10%) and complex bubble junction shards (Heiken, 1972). Biotite, magnetic and zircon are the only identified crystal fragments.

1. *A-1* fission-track
   Vitric ash (NW¼ S35,T15S,R17W; 32°55'N, 108°38'W; elevation ca 1500 m; .8 km SSE of Gila; lower part of S slope of mesa adjacent to Bear Creek;

Cliff 15′ quad, Grant Co., NM). *Analytical data:* (zircon) fossil track density Ss = 0.652 [/], 2.5 tracks counted; induced track density Si = 17.258 [/], 569.5 tracks counted; Ss/Si = 0.0378 [/]; Neutron flux = 9.14 × 10^{14} [n/cm^2]; decay constant f = 6.85 × 10^{17} [yr^{-1}].

(zircon)2.13 ± 0.47 m.y.

2. *A 8-9* fission-track

Vitric ash (SE¼ S21,T14S,R17W; 33°05′N, 108°35′W; elevation ca 1720 m; 3.5 km SE of 916 Ranch, 9.5 km N of Cliff; on the E slope of mesa immediately W of Wild Horse Mesa; Canteen Canyon 7½′ quad, Grant Co., NM). *Analytical data:* (zircon) fossil track density Ss = .600 [/], 4.5 tracks counted; induced track density Si = 16.857 [/], 118 tracks counted; Ss/Si = 0.0356 [/]; neutron flux = 9.14 × 10^{14} [n/cm^2]; decay constant f = 6.85 × 10^{17} [yr^{-1}].

(zircon)2.01 ± 0.97 m.y.

3. *ST-05* fission-track

Vitric ash (NW¼ S14,T18S,R2W; 32°45′N, 107°01′W; elevation ca 1400 m; 12.5 km N of Rincon, 20 km NE of Hatch; in a gully 60 m W of the Grama siding of A.T. & S.F. railway; Rincon 7½′ quad, Dona Ana Co., NM). *Analytical data:* (zircon) fossil track density Ss = .6114 [/], 14 tracks counted; induced track density Si = 46.1572 [/], 1057 tracks counted; Ss/Si = 0.01325 [/]; neutron flux = 9.14 × 10^{14} [n/cm^2]; decay constant f = 6.85 × 10^{17} [yr^{-1}].

(zircon)0.754 ± 0.20 m.y.

REFERENCES

Bikerman, M. (1972) New K-Ar ages on volcanic rocks from Catron and Grant Counties, New Mexico: Isochron/West, v. 3, p. 9–12.

Borchardt, G. A., Aruscave, P. J., and Millard, H. T., Jr. (1972) Correlation of the Bishop ash, a Pleistocene marker bed, using instrumental neutron activation analysis: Journal of Sedimentary Petrology, v. 42, no. 2, p. 301–306.

Bornhorst, T. J., and Elston, W. E. (1978) Reserve to Magdalena via Horse Springs and Datil—supplemental road log no. 8: New Mexico Geological Society Special Publication 7, p. 99–106.

Cope, E. D. (1884) The Loup Fork beds on the Gila River: American Naturalist, v. 18, p. 58–59.

Cunningham, J. E. (1974) Geologic map and section of the Silver City quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 30.

Dickson, J. J., and Izett, G. A. (1981) Fission-track ages of airfall tuffs in Pliocene basin-fill sediments near III Ranch, Graham County, Arizona: Isochron/West, v. 32, p. 13–15.

Elston, W. E., Damon, P. E., Coney, P. J., Smith, E. I., and Bikerman, M. (1973) Tertiary volcanic rocks, Mogollon-Datil province, New Mexico, and surrounding region—K-Ar dates, pattern of erruption, and periods of mineralization: Geological Society America Bulletin, v. 84, p. 2259–2274.

Gilbert, G. K. (1975) Report on the geology of portions of New Mexico and Arizona: United States Geographic and Geologic Survey West of the 100th Meridian (Wheeler), v. 3, p. 501–567.

Hawley, J. W. (1978) Correlation chart 2—middle to upper Cenozoic stratigraphic units in selected areas of the Rio Grande rift in New Mexico: New Mexico Bureau and Mineral Resources Circular, v. 163, p. 239.

Hawley, J. W., Bachman, G. O., and Manley, K. (1976) Quaternary stratigraphy in the Basin and Range and Great Plains provinces, New Mexico and western Texas, *in* Maheny, W. C. (ed.), Quaternary stratigraphy of North America: Stroudsburg, PA, Dowden, Hutchinson and Ross, p. 235–274.

Heiken, G. (1972) Ash shard morphology: Geological Society of America Bulletin, v. 83, p. 1961–1988.

Heindl, L. A. (1963) Cenozoic geology in the Mammoth area, Pinal County, Arizona: U.S. Geological Survey Bulletin 1141-E.

Izett, G. A., Wilcox, R. E., Powers, H. A., and Desborough, G. A. (1970) The Bishop Ash Bed, a Pleistocene marker bed in the western United States: Quaternary Research, v. 1, p. 121–132.

Johnson, N. M., Opdyke, N. D., and Lindsay, E. H. (1975) Magnetic polarity stratigraphy of Pliocene-Pleistocene terrestrial deposits and vertebrate faunas, San Pedro Valley, Arizona: Geological Society of America Bulletin, v. 86, p. 5–12.

Kortemeier, C. P. (1980) An occurrence of Bishop ash in fluvial sediments, near Grama, New Mexico: University of New Mexico, B.S. thesis.

Kortemeier, C. P. (1982) Occurrence of Bishop ash near Grama New Mexico: New Mexico Geology, v. 4, n. 2, p. 22–24.

Leake, B. E., et.al. (1969) The chemical analysis of rock powders by automatic X-ray fluorescence: Chemical Geology, v. 5, p. 7–86.

Leopoldt, W. (1981) Neogene geology of the central Mangas graben, Cliff-Gila area, Grant County, New Mexico: University of New Mexico, M.S. thesis.

Naeser, C. W. (1976) Fission-track dating: U.S. Geological Survey open-file report 76-190.

Naeser, C. W., Izett, G. A., and Wilcox, R. E. (1973) Zircon fission-track ages of Pearlette family ash beds in Meade County, Kansas: Geology, v. 1, p. 187–189.

Naeser, C. W., Izett, G. A., and Obradovich, J. D. (1980) Fission-track and K-Ar ages of natural glasses: U.S. Geological Survey Bulletin 1489.

Paige, S. (1916) Descriptions of the Silver City quadrangle, New Mexico: U.S. Geological Survey Atlas Folio, v. 199.

Ratte, J. C., and Finnell, T. L. (1978) Road log from Silver City to Reserve via Glenwood and the Mogollon Mining District: New Mexico Geological Society Special Publication 7, p. 49–63.

Ratte, J. C., et.al. (1979) Mineral resources of the Gila primitive area and Gila Wilderness, Catron and Grant Counties, New Mexico: U.S. Geological Survey Bulletin, v. 1451.

Sarna-Wojcicki, A. M. (1976) Correlation of late Cenozoic tuffs in the central coast ranges of California by means of trace- and minor-element chemistry: U.S. Geological Survey Professional Paper 972.

Scarborough, R. B. (1974) Geochronology of Pliocene vitric ash falls in southern Arizona: Geological Society of America Abstracts with Programs, v. 6, p. 249–250.

Seager, W. R., and Hawley, J. W. (1973) Geology of the Rincon quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin, v. 101.

Sheppard, R. A., and Gude, A. J., III (1974) Chert derived from magadaiite in a lacustrine deposit near Rome, Malheur County, Oregon: U.S. Geological Survey Journal of Research, v. 2, p. 625–630.

Sheppard, R. A., and Gude, A. J., III (1980) Diagenetic fluorite in the Eastgate zeolite deposit, Churchill County, Nevada: U.S. Geological Survey, open-file report 80-506.

Sheppard, R. A., Gude, A. J., III, and Hay, R. L. (1970) Makatite, a new hydrous sodium silicate mineral from Lake Magadi, Kenya: American Mineralogist, v. 55, p. 358–366.

Sheppard, R. A., and Mumpton, F. A. (1981) Pelletal and oolitic fluorite in lacustrine zeolitic tuff near Buckhorn, Grant County, New Mexico: Geological Society of America Abstracts with Progams, v. 17, p. 226.

Strain, W. S. (1966) Blancan mammalian fauna and Pleistocene formations, Hudspeth County, Texas: Austin Texas Memorial Museum Bulletin, v. 10.

Tourtelot, E. B., and Meier, A. L. (1976a) Preliminary report on samples collected during lithium reconnaissance studies of the Rocky Mountains and adjacent states: U.S. Geological Survey open-file report 76-856.

Tourtelot, E. B., and Meier, A. L. (1976b) Lithium in the Gila Conglomerate, southwestern New Mexico: U.S. Geological Survey Professional Paper 1005, p. 123–127.

Trauger, F. D. (1972) Water resources and general geology of Grant County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Hydrologic Report 2.

Weber, R. H., and Basset, W. A. (1963) K-Ar ages of Tertiary volcanic and intrusive rocks in Socorro, Catron and Grant Counties, New Mexico: New Mexico Geological Society Guidebook of Socorro Region, 14th Field Conference, p. 220–223.

NEW MEXICO TECH PRINT PLANT
Camera-ready copy provided by the Nevada
Bureau of Mines and Geology
Presswork: Text and cover printed on Davidson 600
Paper: Body on 60-lb white offset; cover on 65-lb
Russett
Ink: Van Son rubber base plus all-purpose black