Late Cenozoic basalts of southwestern New Mexico

Jerry M. Hoffer

1988, pp. 119-122. https://doi.org/10.56577/FFC-39.119

in:

Cretaceous and Laramide Tectonic Evolution of Southwestern New Mexico, Mack, G. H.; Lawton, T. F.; Lucas, S. G.; [eds.], New Mexico Geological Society 39th Annual Fall Field Conference Guidebook, 216 p. https://doi.org/10.56577/FFC-39

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

LATE CENOZOIC BASALTS OF SOUTHWESTERN NEW MEXICO

JERRY M. HOFFER
Department of Geological Sciences, University of Texas at El Paso, El Paso, Texas 79968

Abstract—Chemical analyses of 208 basaltic rocks from 13 occurrences in southern New Mexico show the existence of two differing basalt types. The group I basalt occurrences contain both alkalic and tholeiitic varieties with low SiO_2 and high MgO and TiO_2 concentrations. Group II basalts are 100% tholeiitic and contain high SiO_2 and low MgO and TiO_2 concentrations. Differences in Y, Zr, Rb, Sr and Ba concentrations also exist between the two groups. Spatially, the group I basalts occur in the center of the area and are flanked on the west and east by the group II basalts; this distribution is roughly parallel to the proposed boundaries of the Rio Grande rift.

INTRODUCTION

Basalts of late Cenozoic age crop out in at least 17 locations within approximately 45,800 km^2 of southwestern New Mexico; total outcrop area covers about 2500 km^2 or just over five percent of the region. The volcanic features associated with a number of the larger occurrences have been previously described (Hoffer, 1975, 1976; Frantes and Hoffer, 1982). However, to date, very little information has been published on the geochemistry of the basalts.

The basalt outcrops range from 380 km^2 (Palomas volcanic field) to less than one km^2 (Carrizalillo Hills). They range in age from a few thousand years (Carrizozo flows: Weber, 1963) to 11.8 ± 0.3 my (Hachita: Seager et al., 1984). These basalts represent the youngest stage of volcanism associated with extension in the Rio Grande rift. The basaltic volcanism accelerated during the culmination of rifting, peaking within the past five my (Seager et al., 1984). The purpose of this note is to summarize the chemical data currently available on the basalts of southwestern New Mexico (Fig. 1).

BASALT TYPES

The terminology of Yoder and Tilley (1962) was used to classify the basalts as alkalic or tholeiitic. The alkalic basalts consist of alkali olivine basalt (normative olivine and nepheline) and basanite (normative nepheline exceeds 5%) and the tholeiitic basalts consist of olivine basalt (normative olivine and hypersthene) and tholeiite (normative hypersthene greater than 3%). The distribution and abundance of the basalt types are summarized in Table 1. These data indicate that both alkalic and tholeiitic basalts occur in southwestern New Mexico. Based upon analyses of 208 samples, the most abundant are the alkalic variety (80%).

There appears to be a spatial distribution of the two basalt types across southwestern New Mexico. To the west, basalts from the Animas, Deming and Hachita localities are of the tholeiitic type. Moving eastward, the basalts at Carrizalillo Hills, Palomas and the West Potrillo Mountains are predominantly alkalic (92%). Further east, at Aden and Afton, the basalts are alkalic in nature. At Black Mountain and vicinity, tholeiitic basalts reappear and make up approximately 25% of the total. The percentage of tholeiitic basalts increases to over 90% at the four locations east of the Rio Grande (Orogrande, Jornada del Muerto, Broken Back Crater and Carrizozo). This trend, which is diagrammed in Figure 2, shows a central zone, just west of the Rio Grande, where

TABLE 1. Distribution and ages of alkalic and tholeiitic basalts in southwestern New Mexico (ages from 1—Lynch, 1978; 2—Seager et al., 1984; 3—Bachman and Mehnert, 1978; 4—Weber, 1963).

	Alkalic		Tholeiitic		
	Basanite	Alkaline Olivine Basalt	Olivine Basalt	Tholeiite	Age
Animas	0	0	0	1	0.544 ± 0.05 my[1]
Palomas	11	16	1	6	3.0 ± 0.07 to 5.2 ± 0.10 my[2]
West Potrillo	57	15	0	2	n.d.
Hachita	0	0	0	6	11.B $\pm$ 0.3 my[2]
Deming	0	0	0	2	n.d.
Aden	30	16	0	0	0.53 ± 0.04 my[2]
Afton	2	3	0	0	0.53 ± 0.03 my[2]
Black Mtn.	4	9	3	1	0.55 ± 0.03 my[2]
Orogrande	2	0	0	0	n.d.
Jornada del Muerto	0	0	0	1	0.76 ± 0.1 my[3]
Broken Back	0	0	0	1	n.d.
Carrizozo	0	0	0	18	< 0.0015 my[4]
Carrizalillo	1	0	0	0	n.d.
Total Samples	107	59	4	38	

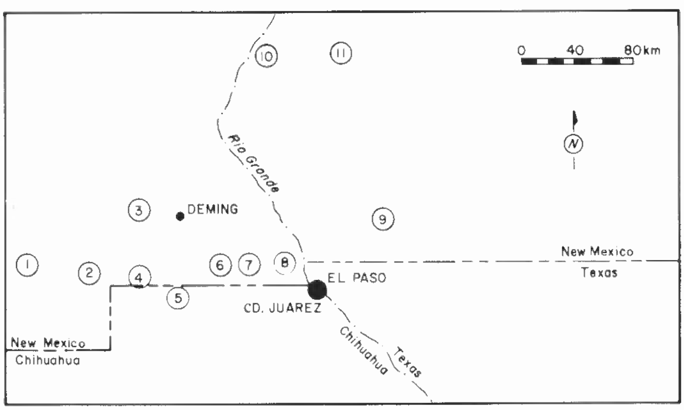

FIGURE 1. Index map of basalt locations, southwestern New Mexico: (1) Animas, (2) Hachita, (3) Deming, (4) Carrizalillo, (5) Palomas, (6) West Potrillo, (7) Aden-Afton, (8) Black Mountain, (9) Orogrande, (10) Jornada del Muerto, (11) Carrizozo-Broken Back.

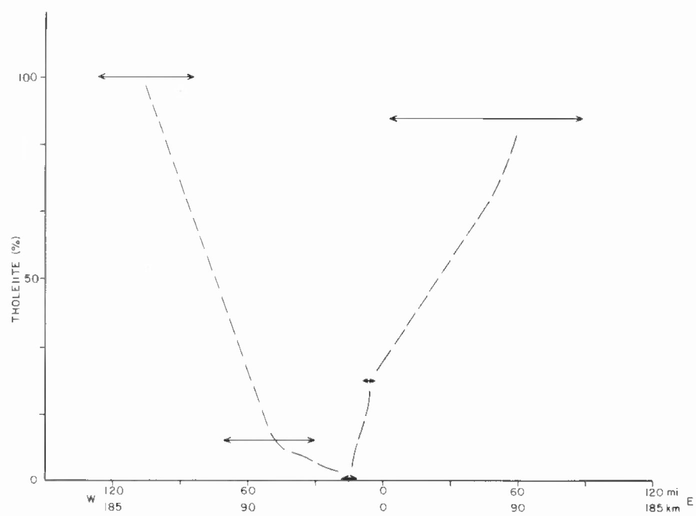

FIGURE 2. Distribution of basalt types across southwestern New Mexico (O: location of Rio Grande; arrows: width of basalt occurrence).

TABLE 2. Major element chemistry of late Cenozoic basalts, southwestern New Mexico. *FeO = total iron, 1—Lynch, 1978; 2—Gates, 1985; 3—Aoki and Kudo, 1976; 4—Renault, 1970; all other analyses by XRF (Hoffer and Hoffer, 1984). n.d. = not determined; (7) = no. of samples; TB = tholeiite basalt; B = basanite; AOB = alkali olivine basalt; OB = olivine basalt.

	Animas[1] TB(1)	Hachita TB(6)	Deming TB(2)	Palomas B(11)	AOB(16)	OB(1)	TB(6)	West Potrillo B(57)	AOB(15)	TB(2)
SiO_2	49.70	49.87	49.22	43.61	45.35	46.93	47.22	44.71	46.06	47.68
TiO_2	1.80	1.89	1.49	2.20	2.30	2.19	2.28	2.27	2.35	2.41
Al_2O_3	15.20	14.42	15.44	14.16	14.79	14.52	15.46	13.77	14.70	14.76
FeO	10.40	12.67	11.55	11.30	11.34	13.07	11.50	12.11	12.08	11.71
MnO	n.d.	0.19	0.13	0.16	0.24	0.19	0.15	0.17	0.17	0.18
MgO	8.30	6.78	7.80	12.01	12.15	9.91	9.28	10.28	9.43	8.25
CaO	10.00	9.61	10.32	9.82	8.85	8.60	8.24	10.77	9.54	10.83
Na_2O	3.00	2.50	3.04	2.87	2.89	2.98	2.97	2.86	2.81	2.69
K_2O	0.80	0.69	0.81	1.26	0.99	0.95	1.14	1.35	1.34	0.75
P_2O_5	n.d.	0.28	0.56	0.50	0.76	0.51	0.50	0.62	0.63	0.77

	Aden B(30)	AOB(16)	Afton B(2)	AOB(3)	Black Mtn. B(4)	AOB(9)	OB(3)	TB(1)	Carrizalillo[2] Hills B(1)
SiO_2	44.87	45.83	43.91	44.93	45.83	46.94	48.32	48.44	45.13
TiO_2	2.49	2.40	2.37	2.25	2.33	2.34	2.39	2.40	2.21
Al_2O_3	16.09	15.47	15.64	13.59	15.49	15.75	16.28	16.36	14.92
FeO	10.82	10.48	11.83	12.35	11.51	11.81	11.56	11.68	10.95
MnO	0.16	0.19	0.17	0.19	0.18	0.18	0.18	0.18	0.16
MgO	8.98	9.48	9.34	10.22	8.86	7.99	6.59	6.79	9.89
CaO	10.52	9.71	11.44	10.70	11.06	10.00	9.35	9.53	9.27
Na_2O	3.30	3.06	2.86	2.54	3.00	2.92	2.99	1.99	3.22
K_2O	1.85	1.85	1.63	1.46	1.59	1.77	2.06	2.11	1.44
P_2O_5	0.51	0.50	0.52	0.37	0.47	0.63	0.76	0.72	0.53

	Jornada del Muerto[3] TB(1)	Broken Back Crater[3] TB(1)	Orogrande AOB(2)	Carrizozo[4] TB(18)
SiO_2	49.23	50.74	46.85	50.73
TiO_2	1.83	1.95	2.55	1.73
Al_2O_3	15.47	16.58	13.67	17.73
FeO	10.67	9.84	12.30	9.73
MnO	0.17	0.16	0.19	0.16
MgO	8.16	6.30	8.86	6.55
CaO	8.00	8.06	9.88	8.52
Na_2O	3.65	3.73	2.50	3.61
K_2O	1.84	1.60	1.83	1.33
P_2O_5	0.44	n.d.	0.41	n.d.

alkalic basalts predominate, flanked on the east and west by mainly tholeiitic basalts. The above changes in basalt types roughly correlate with the proposed boundaries of the Rio Grande rift in southwestern New Mexico (Seager et al., 1984). It is not known at the present time what this distribution means in terms of rift evolution or mantle or crustal structure. Additional samples and analyses are needed from several other occurrences before any hypothesis can be proposed.

CHEMICAL COMPOSITION

Major elements

The major element chemistry of the southern New Mexico basalts is given in Table 2. The average silica values for the basalts range from 43.61% to 50.74%. The silica percentages for the various basalts types are as follows: basanites, 43.61–45.83%; alkali olivine basalts, 44.93–46.94%; olivine basalts, 46.93–48.32% and tholeiites, 47.22–50.74%.

Chemically, there appear to be two distinct basalt types in the region. Figure 3 shows a plot of all the alkalic and tholeiitic basalt samples based on SiO_2 versus TiO_2. The samples separate into two groups; one group (group I) is characterized by SiO_2 values less than 49% and TiO_2 concentrations of greater than 2.0% and the other (group II) by SiO_2 values greater than 49% and TiO_2 less than 2.0%. In addition, the group I basalts have higher average concentrations of MgO (9.34%) than the basalts of group II (7.31%). The first group includes basalts from the West Potrillo, Aden, Afton, Palomas, Black Mountain, Orogrande and Carrizalillo locations. The basalts from the above locations are dominantly of the alkalic variety. The second group represents basalts from the Hachita, Deming, Broken Back Crater, Animas, Carrizozo and Jornada del Muerto regions; these basalts are composed entirely of the tholeiitic type.

The low SiO_2, high TiO_2 group contains all four basalt types whereas the other group contains only tholeiitic basalts. The tholeiitic basalts in group I are thus chemically different than the tholeiitic basalts in group II. With the exception of the Orogrande basalt, the basalts in group I occur in the central portion of study area (i.e., rift) whereas the group II basalts are located to the east and west of the group I basalts (i.e., flanks of the rift).

At the present time, trace element concentrations are being determined on both the alkalic and tholeiitic basalts. To date, the elements Y, Cu, Zr, Cr, Ni, Rb, Sr, Zn and Ba have been analyzed from basalts at the Palomas, West Potrillo, Hachita, Deming, Orogrande, Afton, Aden and Black Mountain areas (Table 3). The results represent six group I occurrences and two from the group II basalts. The trace element data are summarized in Table 3 along with trace element concentrations from average basaltic and granitic rocks.

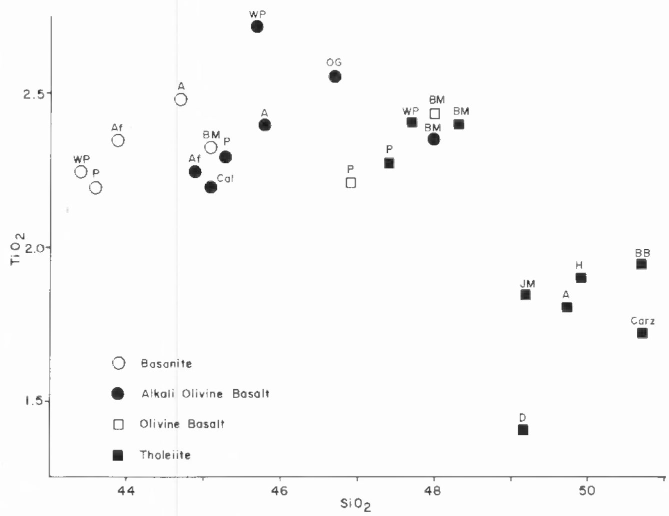

FIGURE 3. TiO_2 versus SiO_2 of southwestern New Mexico basalts (WP: West Potrillo, P: Palomas, Af: Afton, A: Aden, Cal: Carrizalillo, OG: Orogrande, BM: Black Mountain, AN: Animas, JM: Jornada del Muerto, H: Hachita, BB: Broken Back, C: Carrizozo, D: Deming).

TABLE 3. Trace element concentrations in group I and II basalts. Number of samples analyzed = ( ). 1—data from Turekian and Wedephol (1961). Analyses by XRF.

	Group I Basalts (60) (ppm)	Group II Basalts (8) (ppm)	Basaltic[1] Rocks (ppm)	Granitic[1] Rocks (ppm)
Y(±3)	32	25	21	37
Cu(±20)	133	132	87	20
Zn(±8)	128	133	105	50
Cr(±30)	300	303	170	13
Ni(±15)	182	197	130	10
Sr(±7)	588	490	465	270
Zr(±12)	162	119	140	160
Rb(±3)	38	25	30	140
Ba(±40)	493	630	330	630

The preliminary data show that the group I basalts are significantly higher in Y, Sr, Zr, Rb and lower in Ba than the basalts of group II. One source for these higher concentrations in the group II basalts might be assimilation of portions of the granitic upper crust. No explanation is offered for the difference in the Ba concentration of the two basalt groups.

SUMMARY AND CONCLUSIONS

Basalts from 13 separate occurrences in southern New Mexico have been analyzed for major and selected trace elements. The basalts range from alkalic (basanite and alkali olivine basalt) to tholeiitic (olivine basalt and tholeiite) types. The alkalic basalts are restricted to a central zone just west of the Rio Grande and are flanked on the west and east by tholeiitic varieties.

Chemically the basalts can be separated into 2 groups. Group I contains predominantly alkalic varieties and minor tholeiites. All are characterized by low SiO_2 and high TiO_2 and MgO concentration; the trace elements Y, Sr, Zr and Rb are higher than typical basalt. The group II basalts are all tholeiitic and are characterized by high SiO_2 and low MgO and TiO_2; Y, Sr, Zr and Rb concentrations are approximately those of typical basalt.

REFERENCES

Aoki, K. and Kudo, A. M., 1976, Major element variations of late Cenozoic basalts of New Mexico: New Mexico Geological Society, Special Publication 3, p. 82–88.

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.

Frantes, T. J. and Hoffer, J. M., 1982, Palomas volcanic field, southern New Mexico and northern Chihuahua, Mexico: New Mexico Geology, v. 4, p. 6–9.

Gates, E. E., 1985, Geology of the Carrizalillo Hills, Luna County, New Mexico [M.S. thesis]: El Paso, Texas, University of Texas at El Paso, 133 p.

Hoffer, J. M., 1975, The Aden-Afton basalt, Potrillo volcanics, south-central New Mexico: Texas Journal of Science, v. 26, p. 379–390.

Hoffer, J. M., 1976, Geology of the Potrillo basalt field, south-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 149, 30 p.

Hoffer, J. M. and Hoffer, R. L., 1984, A preliminary note on the late Cenozoic basalts and associated volcanic rocks in southern New Mexico, northern Chihuahua, West Texas, and the Rio Grande rift: West Texas Geological Society, Guidebook, p. 202–205.

Lynch, D. J., 1978, The San Bernardino volcanic field of southeastern Arizona: New Mexico Geological Society, Guidebook 29, p. 261–268.

Renault, J., 1970, Major element variations in the Potrillo, Carrizozo, and McCartys Basalt Fields, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 113, 22 p.

Seager, W. R., Shafiqullah, M., Hawley, J. W. and Marvin, R. F., 1984, New K-Ar dates from basalts and the evolution of the southern Rio Grande rift: Geological Society of America Bulletin, v. 95, p. 87–99.

Turekian, K. K. and Wedepohl, K. H., 1961, Distribution of the elements in some major units of the earth's crust: Geological Society of America Bulletin, v. 72, p. 175–192.

Weber, R. H., 1963, Cenozoic volcanic rocks of Socorro County: New Mexico Geological Society, Guidebook 14, p. 132–143.

Yoder, H. S. and Tilley, C. E., 1962, Origin of basalt magmas: an experimental study of natural and synthetic systems: Journal of Petrology, v. 3, p. 437–466.