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PRECAMBRIAN METAVOLCANIC ROCKS OF THE TUSAS MOUNTAINS, NEW MEXICO: MAJOR ELEMENTS AND OXYGEN ISOTOPES

by

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INTRODUCTION

The Precambrian volcanic rocks of the Tusas Mountains, north-central New Mexico, have been studied in rather spasmodic fashion since the 1930's. Just (1937) reported the results of a brief but commendable reconnaissance. He recognized two types of metaigneous rocks; those of basaltic and andesitic composition he named the Picuris Basalts, and those of rhyolitic type he named Vallecitos Rhyolites. He suggested that both types originated as flows, and indicated that they were closely interlayered with quartzite, conglomerate, and other sedimentary rocks of Proterozoic age. In particular, Just (1937) noted that the metarhyolite typically is flow banded, contains phenocrysts of quartz and alkali feldspar, has an aphanitic groundmass, and is conformably interlayered with the enclosing sedimentary rocks.

In his inclusive report on the pegmatites of the Petaca district, Jahns (1946) briefly mentioned amphibole schist and metarhyolite. He noted field relations of these rocks similar to those found by Just (1937).

The geology of the 15-minute Las Tablas quadrangle was studied by Barker (1958), by what now would be called semireconnaissance methods. The mafic-flow rocks were renamed the Moppin Metavolcanic Series, and the metarhyolite, the Burned Mountain Metarhyolite. A number of layers of each of these units were delineated on Barker's geologic map. Just's conclusion that the mafic layers and most of metarhyolite are extrusive was substantiated, although Barker did find several bodies of metarhyolite that apparently transected the bedding of the enclosing quartzite. He concluded that the rhyolite was emplaced largely as flows, and partly as sills and dikes. Much of the metarhyolite probably originated as ash flows, for crushed pumice fragments are prominent in sample BLT 1, which was collected just northwest of Burned Mountain (Table 1). In any case, a detailed restudy of the Burned Mountain Metarhyolite should be made. Similar metavolcanic

	Metatholeiite and metabasaltic andesite										Metarhyolite									
	BMV1	BLT25	BLT30	BLT27	BMV4	BLT37	BLT36	BLT34	BMV3	BMV2	BLT35	BLT32	BLT33	BLT4	BLT31	BMR	BLT29	BLT28	BLT26	BLT1
SiO_2	44.44	47.1	47.6	48.6	48.78	49.0	49.2	49.9	52.53	54.57	71.9	72.0	72.7	73.9	75.4	75.47	75.7	76.0	76.1	77.50
Al_2O_3	15.04	14.4	15.2	15.4	14.82	14.6	14.1	15.8	14.22	16.27	13.3	12.9	12.8	12.7	11.9	11.42	12.4	12.1	12.1	11.95
Fe_2O_3	3.19	3.8	4.2	4.4	6.15	3.1	6.0	4.0	4.33	3.48	3.1	1.5	1.3	1.9	1.6	2.26	1.8	1.0	2.2	1.72
FeO	9.94	9.8	7.8	7.7	8.52	9.1	7.6	7.4	7.72	6.88	.48	1.8	1.6	.68	.4	.31	.16	.96	.24	.14
MgO	7.34	6.6	6.7	6.3	5.02	7.5	4.9	7.0	5.49	2.50	.14	.24	.36	.32	.11	.30	.11	.05	.18	.03
CaO	8.70	8.3	8.7	8.9	8.67	9.9	11.8	7.8	9.00	6.93	.50	1.20	1.30	.83	.55	.55	.59	.60	.79	.09
Na_2O	1.51	2.3	2.8	1.8	3.46	1.8	1.4	2.1	2.05	3.54	3.2	3.5	2.4	2.7	3.0	3.29	3.6	3.1	2.8	3.81
K_2O	.13	.47	.51	.34	.26	.42	.27	.31	.56	2.11	5.9	5.3	5.9	5.6	5.8	4.90	4.6	5.1	4.9	3.80
H_2O	5.21	3.4	3.0	3.8	.79	2.1	1.4	3.2	1.58	1.07	.93	.78	.81	.72	.24	.45	.62	.61	.18	.22
TiO_2	1.84	2.0	1.8	1.7	2.28	1.5	1.7	1.5	1.41	1.50	.35	.35	.37	.33	.21	.40	.19	.18	.21	.15
P_2O_5	.35	.86	.60	.60	.64	.51	.71	.41	.45	.61	.08	.06	.09	.07	.02	.05	.02	.02	.04	.01
MnO	.23	.22	.20	.22	.28	.18	.22	.27	.25	.16	.09	.05	.08	.03	.02	.07	n.a.	.04	.03	.05
CO_2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	.01
F	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	.01
Total	97.92	99.25	99.11	99.76	99.67	99.71	99.30	93.03	99.59	99.62	99.97	99.68	99.71	99.78	99.25	99.47	99.79	99.76	99.77	99.49
Q	2.1	3.01	1.2	7.9	3.2	3.8	11.3	7.4	11.3	7.3	29.6	28.3	32.5	34.7	34.8	36.3	35.8	36.9	39.3	40.8
C											.9		.3	.8			.4	.4	.8	1.4
OR	.7	2.7	3.0	2.0	1.5	2.4	1.6	1.8	3.1	12.5	34.8	31.4	34.9	33.1	34.5	29.1	27.2	30.2	29.0	22.5
AB	13.0	19.6	23.9	15.2	29.3	15.2	11.9	17.8	17.4	30.0	27.0	29.7	20.3	22.8	25.5	27.9	30.5	26.2	23.7	32.4
AN	34.5	27.7	27.6	33.0	24.2	30.6	31.6	32.9	28.0	22.3	1.9	3.8	5.8	3.6	1.8	1.9	2.8	2.8	3.6	.2
WO	2.9	3.3	4.9	3.0	6.1	6.3	9.4	1.4	5.7	3.4		.7			.3	.2				
EN	18.6	16.5	16.8	15.7	12.5	18.7	12.2	17.5	13.7	6.2	.3	.6	.8	.7	.2	.7	.2	.1	.4	0.0
FS	13.2	12.0	8.3	8.1	7.3	12.0	6.6	8.3	8.7	7.6		1.5	1.4					.7		
MT	4.7	5.5	6.1	6.3	8.9	4.5	8.7	5.8	6.3	5.0	.8	2.1	1.8	1.3	.7	0.0		1.4	.2	.1
HM											2.5		n.a.	.9	1.0	2.2	1.8		2.0	1.6
IL	3.5	3.8	3.4	3.2	4.3	2.8	3.2	2.9	2.5	2.8	.6	.6	.7	.6	.4	.7	.3	.3	.4	.2
TN																				
RU																	0.0			
AP	.8	2.1	1.4	1.4	1.5	1.2	1.6	1.0	1.1	1.4	.2	.1	.2	.2	0.0	.1	0.0	0.0	0.1	0.0
FR																				.01
CC																				.02
Total	94.7	96.6	97.0	96.2	99.2	97.9	98.6	96.8	98.4	98.9	99.0	99.2	99.1	99.2	99.7	99.5	99.3	99.3	99.8	99.7
Salic	50.6	53.2	55.8	58.2	58.5	52.1	56.5	60.0	60.1	72.3	94.5	93.3	94.0	95.3	96.8	95.4	96.9	96.7	96.5	97.5
Femic	44.0	43.4	41.1	37.9	40.8	45.7	42.1	36.8	38.3	26.6	4.5	5.9	5.1	3.9	2.8	4.1	2.4	2.6	3.2	2.2
Al_2O_3/SiO_2	.34	.31	.32	.32	.30	.31	.29	.32	.27	.30	.18	.18	.18	.17	.16	.15	.16	.16	.16	.15
δO^{18}	n.a.	5.4	5.0	6.7	n.a.	6.5	7.7	8.6	n.a.	n.a.	9.4	6.8	8.9	8.7	9.5	n.a.	9.0	9.7	9.9	n.a.

Table 1. Major-element and oxygen-isotopic analyses and C.I.P.W. norms of metatholeiite, metabasaltic andesite, and metarhyolite of the Burned Mountain, Cañon Plaza, and Las Tablas quadrangles, New Mexico. Locations of samples are given in the appendix. Analyses of BMV1, BMV2, BMV3, BMV4, and BMR are from Barker (1958). Analysis of BLT1 by C. L. Parker by standard methods; analyses of other samples by rapid methods by P. Elmore, G. Chloe, H. Smith, J. Kelsey, and J. Glenn. Oxygen isotopic analyses are positive values per mil relative to SMOW (n.a.: not analyzed).

rocks also have been mapped in the Cebolla 15-minute quadrangle by Doney (1968) and in the Brazos Peak 15-minute quadrangle by Muehlberger (1968).

Four analyses of metabasalt and metabasaltic andesite and one of metarhyolite were given by Barker (1958). This paper presents fifteen new analyses of these rocks, along with oxygen isotopic ratios of fourteen of these samples.

MAJOR ELEMENTS

Major-element contents and CIPW rock norms of 20 samples of the Moppin Metavolcanic Series and the Burned Mountain Metarhyolite are given in Table 1. Nine of the Moppin samples are quartz-normative tholeiitic in type. The tenth, BMV2, contains 2.11 percent of K_20 and 54.57 percent of $Si0_2$. This rock would be classed as an alkalic basaltic andesite, using Lipman and Mehnert's classification (in press). The analyses of the Burned Mountain show two notable features: (1) The ratios of $Fe20_3$/Fe0 are high; this is because much of the iron present is in hematite, which formed during metamorphism. (2) Abundances of K_20 and Na_20 show what is very nearly a sympathetic relationship (Fig. 1). Alkali exchange probably took place before or during devitrification.

Normative quartz, albite, and orthoclase are plotted in Figure 2. The metatholeiites and metabasaltic andesite contain normative quartz and spread across a relatively Ab-poor part of the diagram. The metarhyolites cluster near the experimentally determined minima of James and Hamilton (1969) for melts containing 3 and 5 percent of An component at 1 kb water pressure. Normative An contents of the metarhyolite range from 0.2 to 5.8 percent; thus, these two minima are compositionally suitable, and we may conclude that these rhyolites are of near-minimum compositions. We have no indication as to whether the rhyolitic liquids were water saturated or not, or as to the magnitude of P_{H20} of these liquids. The two points that plot at more quartzose positions than either of the two minima contain 0.2 and 3.6 percent normative An; positions of the other points on the diagram appear to be randomly related to their normative An contents. A minimum water pressure of these liquids cannot be inferred from the disposition of points relative to any experimentally determined minima.

An Alk-F-M plot of the data (Fig. 3) indicates that the metabasalts are typically tholeiitic.

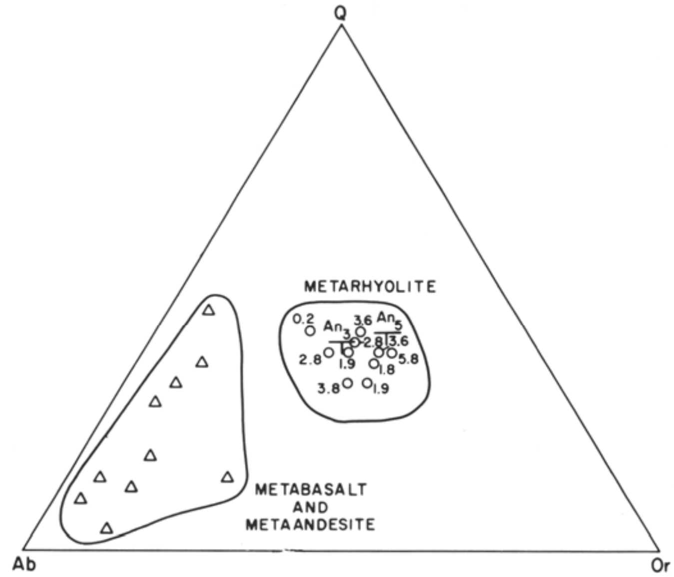

Figure 2. Normative Q-Ab-Or plot of metavolanic rocks of the Tusas Mountains. Normative An contents of metarhyolite are shown by figures adjacent to points. Projections of quaternary minima at An_3 and An_5 compostitions to the Q-Ab-Or face of the tetrahedron are from James and Hamilton (1969).

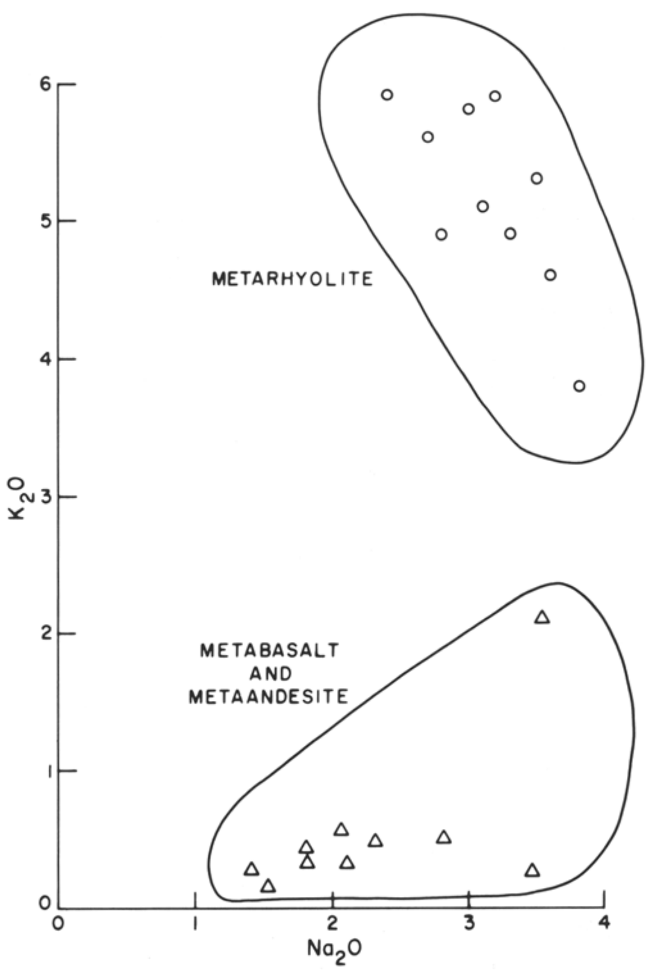

Figure 1. Plot of K_2O versus Na_2O (in weight percentages) of metavolanic rocks of the Tusas Mountains, New Mexico.

OXYGEN ISOTOPES

The average $\delta\ 0_{18}$ value of the mafic rocks is +6.64 per mil, and that of the metarhyolites is +8.98 per mil (Table 1). These values are typical of fresh tholeiite and of glassy, continental rhyolite, respectively (Taylor, 1968), and we conclude that most of these samples suffered little or no exchange with the enclosing sedimentary rocks during metamorphism.

AGE

A preliminary age of the Burned Mountain Metarhyolite of 1,750-1,800 m.y. has been determined by Prof. L. T. Silver (oral commun., 1974) by the U-Pb isotopic method on zircon. He also reports that the Maquinita Granodiorite (Barker, 1958), which cuts the Moppin Metavolcanic Series, is between 1,700 and 1,750 m.y. in age. The quartz-eye trondhjemite of

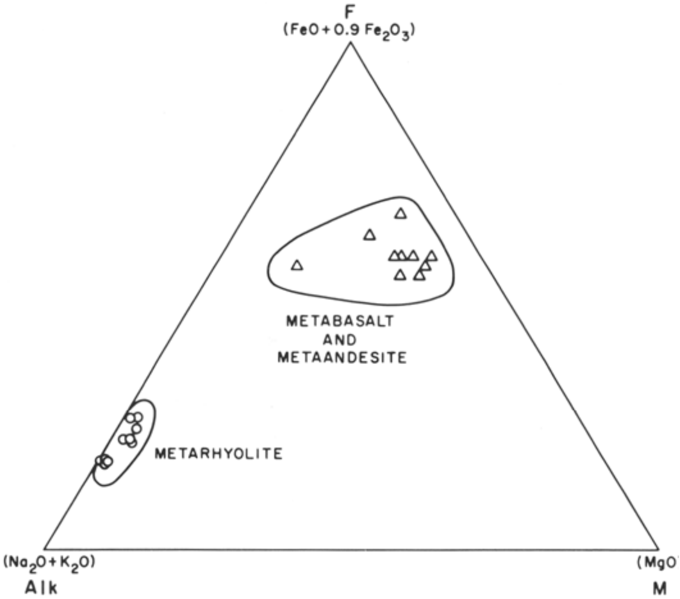

Figure 3. Alk-F-M plot of metavolcanic rocks of the Tusas Mountains, New Mexico.

the Brazos Peak quadrangle (Muehlberger, 1968) also cuts greenschists of Moppin type. This body gives an apparent Rb-Sr whole-rock age of 1,690 ± 34 m.y., which probably is a metamorphic age. A combined plot of this trondhjemite and two apparently cognetic samples of hornblendite gives a line of 1,724 + 34 m.y. age (Barker and others, in press).

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APPENDIX

Locations of samples

BMV 1: SW 1/4 NE 1/4 sec. 26, T. 28 N., R.7 E.
BMV 2: NE 1/4 NE 1/4 sec. 23, T. 28 N., R. 7 E.
BMV 3: SW 1/4 SE 1/4 sec. 9, T. 27 N., R. 8 E.
BMV 4: SE 1/4 SE 1/4 sec. 14,T. 27 N., R.8 E.
I3MR: NE 1/4 SE 1/4 sec. 14, T. 27 N., R. 7 E.
BLT 1: NW 1/4 NW 1/4 sec. 8, T. 28 N., R. 7 E.
BLT 4: SE % SE sec. 14, T. 27 N., R. 7 E.
BLT 25: SE 1/4 SE 1/4 sec. 36, T. 27 N., R. 7 E.
BLT 26: NW 1/4 NE 1/4, sec. 5, T. 26 N., R. 8 E.
BLT 27: NW 1/4 SE 1/4, sec. 4, T. 27 N., R. 7 E.
BLT 28: NW % SE %, sec. 4, T. 27 N., R. 7 E.
BLT 29: SE SE 1/4, sec. 4, T. 27 N., R. 7 E.
BLT 30: SE % SE 1/4, sec. 4, T. 27 N., R. 7 E.
BLT 31: NW 1/4 NW 'A, sec. 10, T. 27 N., R. 7 E.
BLT 32: SW 1/4 SW 'A, sec. 21, T. 27 N., R. 8 E.
BLT 33: SE 1/4 NE 1/4, sec. 4, T. 26 N., R. 8 E.
BLT 34: NW % NE 1/4, sec. 17, T. 27 N., R. 8 E.
BLT 35: SW 1/4 NW 1/4, sec. 16, T. 27 N., R. 8 E.
BLT 36: NW % NW 1/4, sec. 16, T. 27 N., R. 8 E.
BLT 37: SW 1/4 SW 1/4, sec. 9, T. 27 N., R. 8 E.