OPEN-FILE REPORT
90-212

Base from U.S. Geological Survey
Burro Mesa, 1980

SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

Geology mapped by Ward and Nealey, 1985,
and by Ward, 1989.

CORRELATION OF UNITS

Map units		Period	Epoch
Qal		QUATERNARY	Holocene
Qls			Holocene?
Tbx	Tbxi		Pliocene
Tbq			Pliocene
Tbo			Pliocene to Middle Miocene
Tbg			Pliocene to Middle Miocene
Tg			Pliocene to Middle Miocene
Trf, Trb, Tri		TERTIARY	Middle Miocene
Tdf, Tdb, Tdfp, Tdbp, Tdbb			Early to Middle Miocene
Ta			Early Miocene?
Tb			Pre-Miocene?

DESCRIPTION OF MAP UNITS

Surficial Units

Qal **Recent alluvium (Holocene)**--Silt, sand, gravel, cobbles, and boulders in active washes. Consists of angular to subrounded, poorly sorted, unconsolidated material of local derivations. Includes late Quaternary terraces and fans in Francis Creek

Qls **Landslide (Quaternary)**--Large landslide of Tertiary sediments and basalt flows on the north side of Bozarth Mesa. Base apparently is at contact between Tertiary sediments and Tertiary rhyolite flows. Forms moderately hummocky terrain, though modified by floods in Conger Creek.

Bedrock Units

Tbx, Tbxi **Xenolithic basalt (Pliocene)**--Thin, gray-black basalt flows from from dikes (Tbxi) and cinder cones. Basalt contains granite, granulite, gabbro, and peridotite xenoliths, as well as quartz, plagioclase, olivine, clinopyroxene, magnetite, and amphibole megacrysts. Ultramafic xenoliths attain maximum dimensions of 16 cm. Plagioclase and amphibole xenocrysts contain tubular voids, indicative of volatile loss and perhaps also indicating shallow crystallization. Thickness of flows typically less than 1 m; width of dikes typically less than 0.5 m

Tbq **Quartz Basalt (Pliocene)**--Quartz-bearing flood basalts intercalated with olivine basalts and Tertiary sediments on Burro Mesa and at Shirttail Mesa. Quartz crystals are xenocrysts a few mm in length and have very thin reaction rims. Several flows are exposed at Hellzapoppin Canyon, each 3-4 m thick

Tbo **Olivine basalt (Late Miocene to Pliocene)**--Fine-grained lava flows interlayered with and overlying Tertiary gravels (Tg) and quartz basalts (Tbq). Known sources are local dikes; many flows may be from vents in the Aquarius Cliffs to the west. As many as a dozen flows are recognized in this quadrangle. Most of the flows are interlayered with Tertiary gravels, and two to four are capping flows that form a lava plateau. Limited sampling of six lavas has yielded potassium-argon ages of 8-13 Ma. Basalts are tentatively correlated with the Sanders Basalt of Anderson and others (1955), dated by R.J. Miller (U.S. Geological Survey) at 10.4 ± 0.3 Ma. Each flow is typically 5-7 m thick

Tbg **Basalt and gravels, undivided (Middle to Late Miocene)**--Consists of interlayered basalts (Tbo and Tbq) and Tertiary gravels (Tg)

Tg **Gravels (Middle to Late Miocene)**--Tan, white, and gray, thin-bedded deposits of silt, sand, gravel, and cobbles. Derived principally from dacitic and rhyodacitic lava flows and breccias, although lower beds contain Precambrian clasts that may have been derived from the Aquarius, Juniper, or Santa Maria Mountains, and upper beds contain volcanic ash from an unknown source. Well indurated, containing sub-rounded to well-rounded clasts. Thin beds and small, well-rounded clasts suggest that these may be stream deposits. Bedding indicates current flow to the south. Interlayered with plateau basalts at the top of unit. Base of unit is not exposed in this quadrangle. Thickness greater than 250 m

Tri **Rhyolite Dike (Middle Miocene)**--Massive, K-feldspar, and hornblende-bearing rhyolite dike intruding rhyolite breccias near Burro Creek

Trf, Trb **Rhyolite Flows (Middle Miocene)**--Hornblende- and alkali feldspar-bearing rholite lava flows, with minor breccias and glasses. White, gray, and tan, flow-banded, with grayish bands of glass in lavas, and nodules of black glass in whitish breccias (Trb) composed mainly of moderately compacted pumice

Tdf/Tdb, Tdfp/Tdbp, Tdbb **Dacitic lavas of Mohon Mountain (Early to Middle Miocene)**--Dacitic lava flows and flow breccias erupted from Mohon Mountain (Mohon Mountain quadrangle) and Red Canyon vent. Typical lavas and breccias are grayish to pinkish, and contain quartz, plagioclase, and alkali feldspars. Units may be distinguished on the basis of accessory and essential mafic phases. Tdf and Tdb are dacite flows and breccias with hornblende, clinopyroxene, and biotite. Tdfp and Tdbp are dacite flows and breccias (res.) with hornblende and clinopyroxene; Tdbb is a dacite breccia with hornblende and biotite. Breccias are generally monolithologic and are interlayered with lava flows; in some instances, breccias are succeeded by a lava of the same mineralogy. The flows and breccias form prominent constructs. Individual flows are typically less than 3 m thick

Ta **Andesitic lava (Early Miocene?)**--Biotite- and hornblende-bearing andesite flow; often dark, locally porphyritic. Probably erupted from Red Canyon vent west of the quadrangle. Up to 1 m thick

Tb **Older Basalt (Pre-Miocene?)**--Olivine-pyroxene basalt, medium to dark gray, locally highly weathered to light, medium, and dark green and gray clays occurring in bands and as rinds. At least six flows are recognized in Burro Creek, with thicknesses of 1-3 m

Contact approximately located--dashed where inferred

Fault--Dashed where inferred, dotted where concealed. Bar and ball on downthrown side

GEOLOGIC SETTING

This map is part of a regional study of the Mohon Mountains volcanic field (MMVF) in west-central Arizona. Ward and Nealey began work in the Burro Mesa quadrangle in 1985, and Ward continued mapping in this and adjacent quadrangles from 1986-89.

The Mohon Mountains Volcanic Field is located approximately 70 km east-southeast of Kingman, Ariz.; the field is in the Transition Zone physiographic province between the Basin and Range and the Colorado Plateaus and covers approximately 2400 km^2. It comprises several large volcanic centers, including Mohon Mountain (elevation 2273 m, relief 900 m), Mount Hope (elevation 2201 m, relief 515 m), and two small unnamed silicic centers near Red Canyon and Orejana Canyon, as well as the surrounding plateau basalts of Goodwin, Bozarth, and Behm Mesas (Fig. 1).

Reconnaissance mapping of the Mohon Mountains Volcanic Field is included in the state geologic map of Wilson and others (1969). The first detailed studies in the MMVF include those of Ward and others (1986), Nealey and others (1986a, b), and Simmons (1986), which were used in the new state geological map of Reynolds (1988). Studies of adjacent volcanic terranes include those of Anderson and others (1955), Fuis (1973), Young and Brennan (1974), Luedke and Smith (1978), Moyer (1982, 1986), and Goff and others (1983). This summary is based on the studies of Simmons (1986, 1989) at Mt. Hope and Mohon Mountain, and those of Ward and Nealey for the remainder of the field.

The MMVF comprises two distinct rock suites -- early Miocene (22-20 Ma) rocks of an andesite-dacite series erupted from Mohon Mountain and its satellitic centers, and late Miocene-early Pliocene (13-5 Ma) basalts and rhyolites that form a bimodal series. The Mohon Mountains volcanic field developed through six stages (Ward and others, 1986; Nealey and others, 1986a, b; Simmons, 1989). The first stage was characterized by central-vent eruptions from Mohon Mountain and the Red Canyon vent, with the production of pyroclastic andesitic-dacitic breccias and lavas flows at both centers, and trachyandesite lava flows and trachybasalt cinder cones at Mohon Mountain. Most of this activity occurred 20-22 Ma. Dacite domes were emplaced in the western part of the field in the second stage, around 15 Ma. Following a significant period of erosion, olivine tholeiites erupted from vents in the southwest part of the field (stage 3, 13-8 Ma); these are best exposed along Burro Creek and Francis Creek (in the Pilot Knob quadrangle). Volcanism migrated northeast during stage 4, with the emplacement of quartz-bearing alkalic basalts at about 12 Ma. The Mount Hope rhyodacite dome and surrounding basaltic lava flows were emplaced between 9 and 8 Ma (stage 5), and the Orejana Canyon rhyolite dome was emplaced about 8.4 Ma. The last episode of volcanic activity (stage 6) is recorded by the emplacement of widespread xenolith-bearing alkalic basalts flows from dikes and cinder cones

On the basis of major and trace element geochemistry (Tables 1, 2) and K-Ar geochronology, we consider the rocks of the entire Mohon Mountain Volcanic Field are of two distinct origins. The (older) rocks erupted from Mohon Mountain and the Red Canyon center represent various mixtures of lower and upper crustal melts, whereas the (younger) basalt-rhyolite series of mesa basalts, The Orejana Canyon rhyolite lava and breccia flows, and the Mt. Hope rhyolite dome and lava flows were derived from the mantle and lower crust. We suggest that the andesites and dacites arose from crustal melting and mixing in early Tertiary time, before regional detachment faulting. Later, mantle-derived basalts erupted through a crust that had been significantly thinned by regional extension, and reached the surface relatively unaltered, although some magma locally stagnated long enough to produce the rhyolites.

ROCKS IN THE BURRO MESA QUADRANGLE

The oldest rocks in the quadrangle are olivine basalt flows (Tb) exposed in the bottom of Burro Creek. The flows are deeply weathered to green and gray clays.

The next oldest rocks are andesites (Ta) and dacites (Tdf, Tdb; Tdfp, Tdbp; Tdbb) related to the Mohon Mountain and Red Canyon eruptive centers of neighboring quadrangles. One of the dacite breccia flows in the adjacent Pilot Knob quadrangle has been dated at approximately 22 Ma (Ward and Nealey, 1990). These lavas and breccias were eroded and redeposited as Tertiary gravels (Tg), apparently filling a shallow (<1 km?) basin adjacent to the Mohon volcanic vents. Although predominantly derived from dacite sands and gravels, the lower sediments also contain large clasts of Precambrian and Paleozoic rocks, derived from both the Aquarius Mountains to the west and the Juniper and Santa Maria Mountains to the east. Volcanic ash beds up to several cm thick occur in the upper third of the gravel unit. As of yet, no source for has been recognized for these ashes. They may be related to the rhyolite lavas and breccias in Orejana Canyon, which in turn might also be related to ash units found at Bagdad, Arizona of the Wilder Formation and Gila(?) Conglomerte of Anderson and others (1955).

Volcanic rocks of Orejana Canyon are rhyolitic lava (Trf) and breccia (Trb) flows, and some associated dikes (Tri) located in the central and eastern portion of this quadrangle, and in adjacent quadrangles. These rocks are younger than the dacite lavas and breccias of Mohon Mountain and Red Canyon (and most of the Tertiary gravels), and are contemporaneous with the plateau basalts. The Orejana Canyon rhyolite flows are white, moderately compacted pumiceous rocks, which locally are monolithic breccias that may display banding. In places they contain nodules of black glass a few cm in diameter. These nodules have been dated at 8.4 ± 0.3 Ma (R. J. Miller, U.S. Geological Survey). The surface of the lavas is relatively flat, except for a central highland. This highland, comprising many flows and flow units, may represent a vent area such as a breached dome.

The plateau basalts are interlayered with (Tbg) and overlie the Tertiary gravels. The basalts are of two types, olivine bearing (Tbo) and quartz bearing (Tbq). The olivine-bearing basalt flows on Burro Mesa, Bozarth Mesa, Shirttail Mesa, and several other smaller mesas. In the Pilot Knob quadrangle, a few of these lavas are known to be fed by dikes; however, olivine basalt flows in the northern quarter of the Burro Mesa quadrangle probably have a source near Mount Hope. The quartz-bearing basalts are 5.1 ± 0.4 ma. (R. J. Miller, USGS), in contrast to the olivine basalts in the Pilot Knob quadrangle of 9-13 Ma and those near Mt. Hope dated at 8-9 Ma (Simmons, 1986).

Basaltic lavas with a variety of xenocrysts (Tbx) are the youngest rock unit in the quadrangle. These lavas erupted from cinder cones and dikes (Tbxi), and contain abundant ultramafic, mafic, and crustal xenoliths, as well as megacrysts of mafic and felsic crystals. They occur as isolated flows throughout the quadrangle.

Table- 1.--Selected Major Element Analyses of MMVF Rocks in the Burro Mesa Quadrangle

Sample Map Unit	NBM-6 Tbx	NBM-7 Tdb	NBM-12 Tbq	NBM-16 Ta	WTI #Trf glass	WTIB Trf breccia
SiO_2	48.4	63.7	50.2	60.2	74.2	72.7
Al_2O_3	16.5	15.8	15.2	14.0	12.5	12.6
$FeTO_3$*	11.6	3.58	11.4	5.95	0.80	0.80
MgO	5.89	2.13	7.02	4.13	0.17	0.20
CaO	7.77	3.69	10.2	5.15	0.73	0.62
Na_2O	4.25	4.22	3.02	2.89	3.39	2.93
K_2O	1.06	3.51	1.08	3.41	4.61	4.71
TiO_2	2.80	0.59	1.64	0.86	0.03	0.03
P^2O5	0.74	0.21	0.30	0.32	<0.05	<0.05
MnO	0.17	0.04	0.16	0.06	0.05	0.05
LOI	0.89	1.74	0.14	2.35	3.09	4.77

X-ray spectroscopy analyses by A.J. Bartel and K. Stewart. All values in weight percent.

* Total iron oxides

Table 2.
Selected Trace Element Analyses of Volcanic Rocks in the Burro Mesa Quadrangle.

Sample Map Unit	NBM-6 Tbx	NBM-7 Tdb	NBM-12 Tbq	NBM-16 Ta	WTI Trf glass	WTIB Trf breccia
*Nb	46	14	213	13	32	32
*Rb	34	72	23	100	205	200
*Sr	710	1050	400	1050	32	34
*Zr	266	210	125	242	76	78
*Y	27	<20	22	25	36	36
*Cu	29	34	82	33	<10	<10
*Ni	78	25	100	95	<10	<10
*Zn	84	50	90	44	46	44
Ni	83	42.0	99	106		
Sr	770	1260	371	1060		
Ba	378	1500	380	1300		
Co	34.6	11.0	42.8	19.4		
Cr	89.2	52.7	268.0	153.0		
Cs	0.33	1.62	0.53	5.78		
Hf	5.6	4.2	3.0	5.3		
Rb	30.0	68.1	21.7	85.1		
Sb	<0.06	0.41	<0.09	0.72		
Ta	3.45	0.95	1.26	0.50		
Th	3.5	6.6	2.8	26.0		
U	1.2	1.5	0.7	6.2		
Zn	107	72	120	106		
Zr	nd	161	127	190		
Sc	17.0	6.1	27.9	13.8		
La	29.4	35.8	20.7	50.2		
Ce	62.1	53.8	30.2	84.0		
Nd	31.9	25.2	18.8	40.9		
Sm	6.99	4.20	4.38	7.81		
Eu	2.36	1.20	1.49	1.87		
Gd	6.92	3.25	4.61	6.00		
Tb	0.97	0.43	0.74	0.79		
Tm	nd	0.16	0.33	0.32		
Yb	2.22	0.95	2.01	1.99		
Lu	0.32	0.13	0.28	0.29		

All values in parts per million. (*) indicates analyses by x-ray spectroscopy. All other analyses by instrumental neutron-activation analysis. "nd" indicates that the element was not detected. Analyses performed by D.V. Vivit, J.R. Budahn, R.J. Knight, and D.M. McKown.

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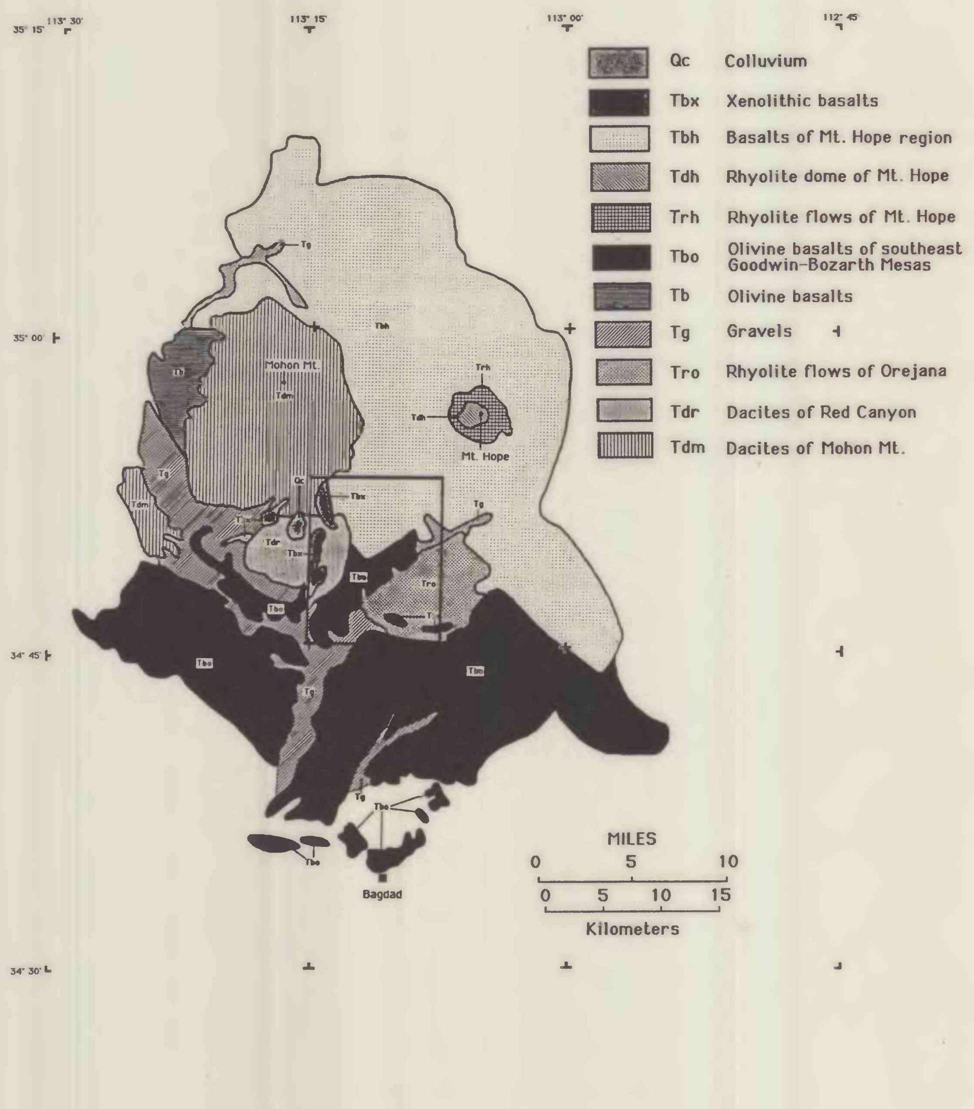

Figure 1. Sketch map of the MMVF; Burro Mesa quadrangle is outlined.

PRELIMINARY GEOLOGIC MAP OF THE BURRO MESA QUADRANGLE, YAVAPAI COUNTY, ARIZONA

By
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1990