New Mexico Bureau of Mines & Mineral Resources

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY 1983

Nomenclature for Cenozoic rocks of northeast Mogollon-Datil volcanic field, New Mexico

Introduction

stratigraphic units has been delineated in the ized nomenclature. and formalization of the nomenclature are now given in the glossary. stratigraphic names have been retained where possible; however, several existing names were aban- proximately 500 mi² (1,300 km²) of detailed mapdoned because they had been used elsewhere, or because multiple names existed for the same strati- canic rocks within an area of approximately 3,000 graphic unit, or because, as mapping progressed mi² (7,760 km²). Most of this work was completed from reconnaissance to detailed coverage, particuas thesis and dissertation studies by graduate stu-

reasons for abandonment are stated. mary so that the essential information on all strati- mapped the San Acacia quadrangle and provided graphic units will be available in one place. The much assistance on the Pliocene to Holocene stratifront of the sheet presents general supportive fig- graphy. J. W. Hawley of the New Mexico Bureau ures including location maps, an index to mapping, of Mines and Mineral Resources also helped to and stratigraphic columns describing currently ac-solve problems at the upper end of the stratigraphic cepted stratigraphic units. These stratigraphic col-column. Individual study areas are shown in fig. 2, umns are organized into three sections: the Santa and each study is listed in table 1. We are deeply in-Fe Group and interbedded volcanic rocks, outflow- debted to these people for their contributions. volcanic units, and cauldron-related rocks. On the

The New Mexico Bureau of Mines and Mineral reverse side of the sheet are a glossary listing both Resources supported most of the thesis and dissercurrent and obsolete nomenclature, a correlation tation projects through research assistantships, diagram illustrating the chronologic development summer field support, maps and photographs, and

by Glenn R. Osburn and Charles E. Chapin rately. The chart will be followed by a series of cirporting geologic mapping of the Socorro geotherculars examining the major stratigraphic units and mal area and the Riley-Alamo area. The U.S. Geo-A sequence of lithologically distinct, rock- a series of 7½-min quadrangles using the standard- logical Survey also contributed some funds toward

Machette's Socorro 1° x 2° quadrangle project. Socorro-Magdalena-Datil area (fig. 1) of the In the following stratigraphic descriptions thick- Finally, we wish to thank the exploration com-Mogollon-Datil volcanic field during the past 12 nesses given in meters have been rounded off to re- panies who made major contributions to our yrs. Informal names were used for most of these flect approximately the same degree of accuracy as understanding of the stratigraphy by allowing us to units while the mapping was in progress. Most of that implied by the measurements given in feet. K- log their drill cuttings and cores and the numerous the area has now been mapped at 1:24,000 or Ar ages have been corrected for the revised 1976 landowners who graciously allowed us access to larger, and the stratigraphic relationships are well IUGS constants using the tables of Dalrymple their private lands. We hope that this publication established. Therefore, descriptions of the units (1979). References for published age dates are and the ones to follow will significantly aid both presented in Stratigraphic Chart 1. Previously used ACKNOWLEDGMENTS—The data base supporting and development.

lar units became untenable stratigraphically. Ob- dents from the New Mexico Institute of Mining solete units are listed in the glossary, and the and Technology; however, several students from other universities participated (fig. 2). In addition, This chart has been prepared as a concise sum- M. N. Machette of the U.S. Geological Survey

mineral exploration and ground-water evaluation

of the nomenclature, and a reference list; more de- use of field vehicles in the more rugged terrain. FIGURE 1—INDEX MAP OF NEW MEXICO SHOWING LOCAtailed descriptions of type sections or type areas for Research grants to C. E. Chapin from the New TION OF AREA COVERED BY THIS STRATIGRAPHIC CHART those units being formalized are enclosed sepa- Mexico Energy Institute were a major help in sup- AND THE SOCORRO-MAGDALENA PROJECT (fig. 2).

25 0 25 50 75 mi

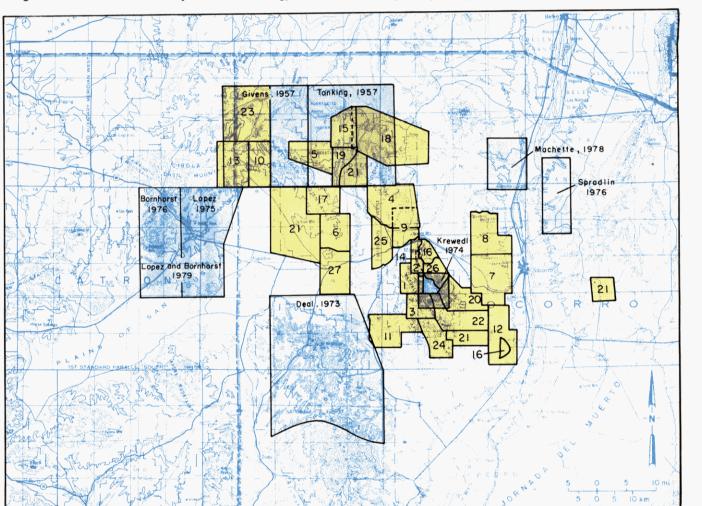
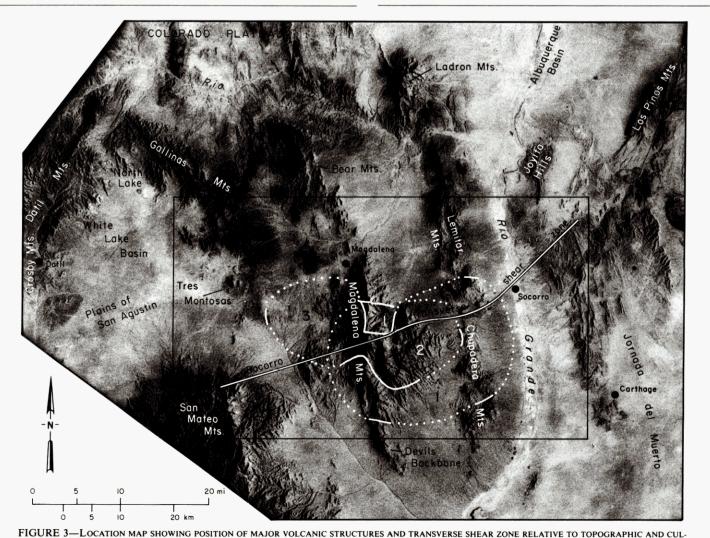


FIGURE 2—LOCATION MAP SHOWING MAJOR GEOLOGIC STUDIES THAT PROVIDE DATA BASE FOR THIS CHART Areas screened in pale yellow are studies carried out within the New specific area in the figure. Areas screened in pale blue are independent Mexico Bureau of Mines and Mineral Resources Socorro-Magdalena projects, some from other institutions. These studies are labeled on the Project. These consist of 23 M.S. thesis projects and five Ph.D. disserfigure with the appropriate reference and are not listed in table 1. Green tation projects. These areas of stratigraphic work and mapping are represents areas where Socorro-Magdalena Project studies overlap keyed to table 1. Five thesis and dissertation projects within the older studies.

Socorro-	Magdalena Project were topical st	udies that are not keyed to a			
TABLE 1—Socorro-Mage	ALENA PROJECT STUDIES; NMIMT	, New Mexico Institute of Minin	ng and Technology; NMBMMR,	, New Mexico Bureau of Mine	s and Mineral Resources.

ap no.	Name	Date	S	tudy	Map no.	Name	Date		Study
1	P. Allen	1979	M.S.	NMIMT	15	R. A. Jackson	1979		NMBMMR, Open-file
2	R. B. Blakestad, Jr.	1978	M.S.	University of Colorado					Rept. 103
3	S. A. Bowring	1980	M.S.	NMIMT	16	S. C. Kent	1982		NMBMMR, Open-file
4	D. M. Brown	1972	M.S.	NMIMT					Rept. 170
	J. E. Bruning	1973	Ph.D.	NMIMT	17	T. M. Laroche	1981	M.S.	NMIMT
5	S. M. Cather	1980	M.S.	University of Texas (Austin)		J. I. Lindley	1979	M.S.	University of North Carolina
6	R. M. Chamberlin	1974	M.S.	NMIMT					(Chapel Hill)
7	R. M. Chamberlin	1980	Ph.D.	Colorado School of Mines	18	G. R. Massingill	1979	Ph.D.	University of Texas (El Paso)
8	R. M. Chamberlin	1982		NMBMMR, Open-file	19	D. L. Mayerson	1979	M.S.	NMIMT
				Rept. 169	20	G. R. Osburn	1978	M.S.	NMIMT
9	C. E. Chapin			NMBMMR, unpublished map	21	G. R. Osburn			NMBMMR, unpublished map
	•			of southern Bear Mts.	22	D. M. Petty	1979	M.S.	NMIMT
10	G. C. Coffin	1981	M.S.	NMIMT	23	B. R. Robinson	1981	Ph.D.	University of Texas (El Paso)
	J. F. D'Andrea	1981	M.S.	Florida State University	24	S. J. Roth	1980	M.S.	NMIMT
11	M. A. Donze	1980	M.S.	NMIMT		W. T. Siemers	1973	M.S.	NMIMT
12	T. L. Eggleston	1982	M.S.	NMIMT		W. T. Siemers	1978	Ph.D.	NMIMT
13	R. W. Harrison	1980	M.S.	NMIMT	25	D. B. Simon	1973	M.S.	NMIMT
14	J. Iovenitti	1977	M.S.	NMIMT	26	W. Sumner	1980	M.S.	NMIMT
					27	W. H. Wilkinson, Jr.	1976	M.S.	NMIMT



TURAL FEATURES. Base is reproduced from a NASA Skylab infrared photograph (G30A026195000). Solid lines mark exposed cauldron-wall segments; cauldron-margin intervals inferred beneath younger units are dotted. The Socorro cauldron (1) is the source for the Hells Mesa Tuff, and

Peak Tuff of Elston (1976) is thought to have been erupted from the

From reconnaissance, source cauldrons for the Lemitar and South Canyon Tuffs are thought to be in the northern and central San Mateo Mountains. The transverse shear zone represents a domain the composite Sawmill Canyon-Magdalena cauldrons (2 and 3) are boundary between fields of tilted fault blocks that have undergone thought to be the sources for La Jencia Tuff. The overlying Vicks rotation in opposite directions (Chapin and others, 1978).

Nogal Canyon cauldron in the southeast San Mateo Mountains

Santa Fe Group

a lower Popotosa Formation (Denny, 1940) and an overlying Sierra Ladrones at a mappable stratum or unconformity, below which the strata tend to be Formation (Machette, 1978). Within the main valley of the Rio Grande, the better indurated, have steeper dips, contain clasts mainly of volcanic rocks, break between these two formations is mapped at the first occurrence of and are usually (but not always) redder in color. All Popotosa- and Sierra main-stem river deposits, which signal the integration of drainage to form the Ladrones-type deposits above this level are then mapped as Santa Fe gravels ancestral Rio Grande. Outside the Rio Grande valley, where main-stem undivided. Volcanic units of limited lateral extent interbedded in the Popofluvial deposits are not present, the top of the Popotosa Formation is often tosa and Sierra Ladrones Formations are here included in the Santa Fe problematic, because sedimentation was relatively continuous in closed Group.

In the Socorro area, rocks of the Santa Fe Group have been separated into basins. In these places the top of the Popotosa Formation is placed arbitrarily

Ladrones Formation Socorro Canyon. Flows commonly contain sparse olivine and pyroxene phenocrysts and typically have a seriate texture. May be CARROLL STORY

"Twcm",

Sierra Ladrones Formation [Machette, 1978]-0-1,000 ft (0-300 m); piedmont-slope, river-channel, and floodplain Fanglomerates shed from present highlands plus channel and floodplain deposits of the ancestral Rio Grande. Deposits consist of poorly indurated, buff to red fanglomerates intertonguing with light-gray, friable sandstones and red or green mudstones and silt-

stones. Formation is locally interbedded with basalt flows including: Socorro Canyon, basalt of [new name]— 4.1 ± 0.3 m.y.; 0–100 ft (0–30 m); basalt flows. One to two dark-gray, fine-grained basalt flows that occur just west of Socorro on Black Mesa and in scattered outcrops east along

correlative with the basalt of Sedillo Hill. Sedillo Hill, basalt of [Chamberlin, 1980; Socorro Canyon]—age poorly constrained; 0-110 ft (0-33 m); basaltic

As many as three dark-gray, fine-grained basaltic lava flows and a local near-vent accumulation of reddish-brown bedded tuffs and agglomerate. Lavas typically similar to basalt of Socorro Canyon containing small, sparse phenocrysts of olivine and pyroxene in a

grainy-looking groundmass. One flow near the northern end of the exposures contains a few percent large, tabular plagioclase phenocrysts, xenocrystic (?) quartz, and no olivine phenocrysts. Two local vent areas identified just north of US-60 on Sedillo Hill. Popotosa Formation [Denny, 1940]—0-3,000+ ft (0-900+ m); fanglomerates, mudflow deposits, mudstones, and

Bolson deposits interbedded locally with contemporaneous volcanic rocks. Near Socorro the lowermost rocks are usually red, wellindurated mudflow deposits that are overlain by a thick sequence of red and green playa claystones; however, regionally, these lithologies grade into or intertongue with other facies. Two formal volcanic units and several informal sedimentary and volcanic members have been mapped within or interbedded with the Popotosa Formation. These units are listed below.

Broken Tank, basalt of [Osburn and others, 1981; central Chupadera Mountains]—0-150 ft (0-45 m); basaltic lava Gravish-black, microvesicular, slightly porphyritic basaltic lava flow. Contains sparse phenocrysts of plagioclase and clinopyroxene in a coarse-grained groundmass with subophitic texture.

Bear Canyon, basalt of [Chamberlin, 1980; Chupadera Mountains]—0-50 ft (0-15 m); basaltic lava flow. Dense, black, fine-grained basalt with well-developed ophitic texture.

 \pm 0.5 m.y.), Radar Peak (11.5 \pm 1.0 m.y.), Signal Flag Hill (10.8 \pm 0.4 m.y.), Stonewall Hill (10.6 \pm 1.5 m.y.), 6001 Mesa (10.3 \pm 0.5 m.y.), 6633 Peak (Railroad quarry; 9.2 ± 0.4 m.y.), Grefco mine (7.4 ± 0.4 m.y.), and several lesser known hills in the Socorro Peak area. See Chamberlin (1980) for locations of these features and for more details on vent areas and petrography. Pound Ranch, rhyolite of, member of Socorro Peak Rhyolite [Osburn, 1978; eastern Magdalena Mountains south

Rhyodacite to rhyolite lava flows, domes, and minor associated pyroclastic rocks. Domes of this unit make up Strawberry Peak (12.1

of Sedillo Hill]—rhyolite to quartz-latite lavas with minor ash-flow tuffs at base. Two distinct lavas and a thin interval of ash-flow tuff mapped separately.

Lower flow—12.1 \pm 0.5 m.y.; 0-500 ft (0-150 m); rhyolite lavas and domes. Dense, pale-red-brown, porphyritic rhyolite lavas containing 20-30% phenocrysts of plagioclase (10%), quartz (10%), sanidine

Socorro Peak Rhyolite [Chamberlin, 1980; Socorro Peak area]—silicic lavas and domes.

(1-3%), biotite (1-3%), and traces of hornblende.

Upper flow—10.8 \pm 0.4 m.y.; 0-400 ft (0-120 m); rhyolite lavas. Dense, flow-banded, porphyritic lava flows containing 10-25% phenocrysts of plagioclase (9-20%), biotite (2%), and hornblende (1.5%).

Ash-flow tuffs—0-300 ft (0-90 m). Sequence of thin ash-flow and air-fall tuffs at base of lava flows. Two distinct lithologies usually compiled together. Lower, buff, poorly welded interval has mineralogical composition similar to the lower lava; the upper, usually vitric, densely welded

tuff is similar in mineralogy to the upper lava. Magdalena Peak Rhyolite [Allen, 1979; just south of Magdalena]—14.8 m.y., average of 2 dates; 0-600 ft (0-180 m); rhyolite lavas and minor ash-flow tuffs at base.

Pink, buff, or gray, flow-banded rhyolite lavas. Frequently have flow lineation, elongate gas cavities, and flow folds. Contain 10-20% phenocrysts consisting of plagioclase, biotite (2-3%), sanidine (1%), and traces of hornblende. Some samples southeast of Magdalena Peak, the only known vent area, contain more quartz and sanidine. This variation in mineralogy may indicate older flows

Kelly Ranch, basalt of [Chamberlin, 1980; eastern Lemitar Mountains]—0-165 ft (0-50 m) composite of all flows; basaltic lava flows. Gravish-black, dense, slightly porphyritic basalt or basaltic-andesite lavas. Series of from one to four flows, locally interbedded with Popotosa sedimentary rocks at several stratigraphic horizons. All flows older than the quartz-latitic lavas of the Socorro Peak

Rhyolite. Contain a few percent plagioclase and olivine phenocrysts. Council Rock, basaltic andesite of [Chamberlin, 1974; Wilkinson, 1976; Mulligan Gulch west of Magdalena]—17.4 m.y., average of 2 dates; 0-100 ft (0-30 m); basalt or basaltic-andesite lavas and intrusive rocks. Dense, gray to black, fine-grained, porphyritic, vesicular lavas. Contain 10-15% phenocrysts consisting of plagioclase (10%),

olivine (3-6%), and pyroxene (2-4%). Known related intrusive rocks occur in a linear trend for 2 mi (3.2 km) south of Council Rock (sec. 1, T. 2 S., R. 6 W.) Water Canyon Mesa, rhyolite of [Osburn, 1978]—20.5 \pm 0.8 m.y.; 0-600+ ft (0-180+ m); rhyolitic lava flows. Dense, pinkish-gray to red, porphyritic, flow-banded rhyolite lavas. Finely to crudely flow foliated and moderately to very por-

phyritic. Usually contain 15-40% phenocrysts consisting of plagioclase (15-35%), biotite (1-2%), hornblende (0.5-1%), and magnetite. In most areas the rock is considerably altered by potassium metasomatism with resultant oxidation of hornblende and replacement of plagioclase by potassium feldspars or clays. Dry Lake Canyon, fanglomerate of [Brown, 1972; Mulligan Gulch west of Magdalena]—0-1,200 + ft (0-360 + m); volcaniclastic sedimentary rocks.

Upper member of the Popotosa Formation along the western side of the Bear Mountains. Deposits consist of fanglomerates and mudflow deposits (dominantly of La Jara Peak Basaltic Andesite clasts), sandstones, and siltstones. Shed westward from ancestral

Arroyo Montosa, unit of [Simon, 1973; Mulligan Gulch west of Magdalena]—volcanic and sedimentary rocks. Volcanic facies—25.9 \pm 1.2 m.y.; 0-100 ft (0-30 m); lava flows.

Light-gray to reddish-gray, porphyritic lava flows of intermediate composition. Contain 20-30% phenocrysts of plagioclase, sanidine (2-15%), quartz (1-3%), and traces of highly altered biotite and hornblende. Plagioclase phenocrysts reach 1.5 inches Conglomerate facies—0-700 ft (0-215 m); volcaniclastic sedimentary rocks.

Reddish-brown, highly indurated, pebble to cobble conglomerates, and interbedded medium- to coarse-grained sandstone lenses. Basal Popotosa unit in area of occurrence.

Outflow volcanic units

Magdalena, Lemitar, Bear, and eastern Gallinas Mountains and the Joyita Hills

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Intermediate and mafic lavas. ocal accumulations of mafic to intermediate lavas above the South Canyon Tuff in parts of the Magdalena Mountains. Include the desitic lavas on Water Canyon Mesa (Osburn, 1978), lavas in the South Baldy-Hardy Spring area (Bowring, 1980), and basaltic ansites (possible tongue of La Jara Peak [Tlpd]) south of Squaw Peak (Donze, 1980). The volcanic facies of the unit of Arroyo Mona (Simon, 1973) also occupies this interval. Lithologies vary from sparsely porphyritic basaltic andesites (La Jara Peak Basaltic ndesite?) to very porphyritic quartz latites. See individual studies for details of occurrence and petrology of units. Many of the outops in the central Magdalenas are considerably altered.

buth Canyon Tuff [Osburn, 1978]—26.7 m.y., average of 2 dates; 0-650 ft (0-200 m); ash-flow tuffs. mple to compound cooling unit of quartz-rich, one-feldspar rhyolite tuff. Lower member of light-gray to brownish-gray, crystalpor (1-4%) tuff and an upper member of medium-gray to purple-gray, moderately crystal-rich (15-25%), one-feldspar tuff with undant chatoyant sanidine and euhedral quartz. The two members are usually mapped together. Source unknown. a Jara Peak Basaltic Andesite [Tonking, 1957]—0-600 ft (0-180 m); basaltic-andesite lavas.

arsely porphyritic, fine-grained, basaltic-andesite lava flows continuous in some areas and interfingering laterally as tongues with her units in many areas. Commonly containing small, red, deuterically altered, ferromagnesian phenocrysts. This tongue present in emitar, Bear, Gallinas, and Magdalena Mountains and in the Joyita Hills; absent on Devils Backbone and in northern Jornada del

emitar Tuff [Osburn, 1978; Chamberlin, 1980]—28.4 m.y., average of 4 dates; 0-400 ft (0-125 m) outflow; 800-000 ft (250-600 m) in Sawmill Canyon-Magdalena cauldrons; ash-flow tuffs. mple to compound cooling unit of densely welded tuff showing strong compositional zoning. Usually divided into lower, light-gray pale-red, crystal-poor (10-15%), rhyolitic member and an upper, medium-red to light-yellowish-gray, crystal-rich member. The per member is zoned from a lower, plagioclase-rich, quartz-poor, quartz latite at the base to a quartz-rich rhyolite at the top. In neral, the lower member is thin and restricted in distribution on the outflow sheet and thick where the unit has puddled in older aldrons. Source is probably in northern or central San Mateo Mountains.

a Jara Peak Basaltic Andesite—0-100 ft (0-30 m); basaltic-andesite lavas. nis tongue is present in the Lemitar, Gallinas, and Bear Mountains and in the Joyita Hills; absent in Chupadera, Magdalena, and ntral San Mateo Mountains.

icks Peak Tuff [Deal and Rhodes, 1976]—31.3  $\pm$  2.6 m.y.; 0-800 ft (0-250 m) outflow; ash-flow tuffs. ultiple-flow, simple cooling unit of densely welded, crystal-poor, one-feldspar ash-flow tuff. Lower gray, very densely welded, nmonly lithophysal, very crystal poor interval grades upward into a less crystal-poor interval containing abundant large pumice, ich often contain euhedral vapor-phase minerals. Upper interval not present in south and central San Mateo Mountains. Equivant to former upper member A-L Peak Tuff and upper member tuff of Bear Springs.

a Jara Peak Basaltic Andesite—0-100 ft (0-30 m); basaltic-andesite lavas. is tongue is present in the Lemitar, Bear, and Gallinas Mountains and in the Joyita Hills. Equivalent stratigraphic unit, the basaltic desite of Deep Well, present in the Datil Mountains.

wmill Canyon Formation [Tx_].

quartz, and traces of pyroxene

verlies La Jencia Tuff within the Sawmill Canyon-Magdalena cauldrons. See Cauldron stratigraphy section. Jencia Tuff [new name; formerly lower member A-L Peak Tuff]—30.9 ± 1.5 m.y., date on overlying basaltic ansite of Deep Well; 0-500 ft (0-150 m) outflow; > 2,500 ft (>750 m) cauldron facies; ash-flow tuffs. ltiple-flow, compound cooling unit of densely welded, crystal-poor, often flow-lineated, one-feldspar tuff. Lower pumice-poor inval grades upward into a flow-banded interval that typically has strongly lineated pumice. Unit erupted from interconnected wmill Canyon and Magdalena cauldrons. The intracauldron member is well exposed in the Sawmill Canyon cauldron. These two uldrons were later filled by the Sawmill Canyon Formation. See Cauldron stratigraphy section. ndesite to basaltic-andesite lava flows—0-300 ft (0-90 m).

named intermediate to mafic lavas filling broad, shallow paleovalleys in the Bear and Lemitar Mountains and in the Joyita Hills. Luis Lopez Formation [Tz_]. Overlies the Hells Mesa Tuff within the Socorro cauldron. See Cauldron stratigraphy section.

Hells Mesa Tuff [Deal, 1973; Simon, 1973]—33.1 m.y., average of several dates; 0-800 ft (0-245 m) outflow; > 3,000ft (>900 m) cauldron facies; ash-flow tuffs. Simple cooling unit of densely welded, crystal-rich, quartz-rich, two-feldspar rhyolite tuff. Pink to reddish-brown when fresh, gray when propylitically altered (mainly in the western half of the cauldron and in the Magdalena mining district). Pumice foliation typically indistinct in outcrop. Unit is zoned from quartz-free quartz latite at base to quartz-rich rhyolite; abrupt increase in quartz usually

occurs 10-25 ft (3-8 m) above base. Erupted from Socorro cauldron (fig. 3) and overlain by Luis Lopez Formation within cauldron.

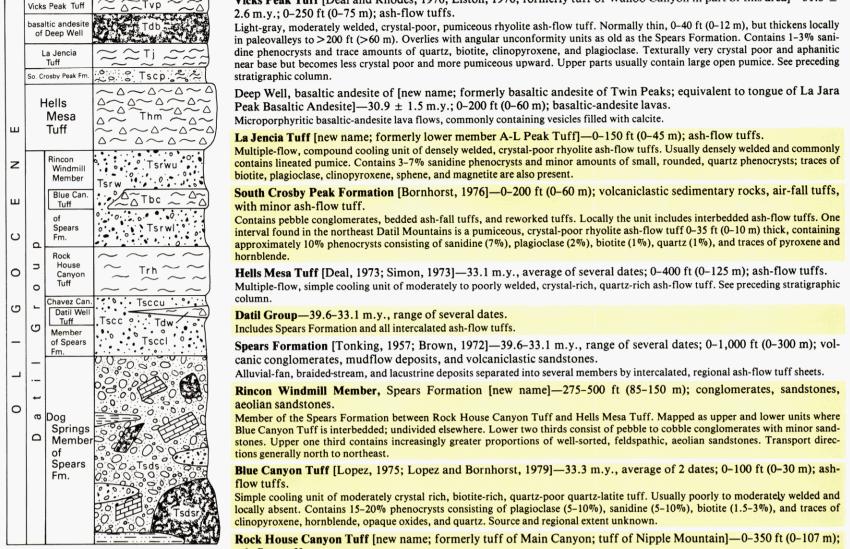
See Cauldron stratigraphy section. Granite Mountain, tuff of—0-200 ft (0-60 m); ash-flow tuffs. Simple cooling unit of reddish-brown (fresh) to dark-greenish-gray (propylitically altered), densely welded, crystal-rich, lithic-rich tuff. Quartz latite in mineralogy, containing 25-45% phenocrysts consisting of plagioclase, sanidine, biotite, magnetite, minor

Rock House Canyon Tuff [new name; formerly tuff of Main Canyon, tuff of Nipple Mountain]—0-350 ft (0-107 m); Light-gray, poorly to moderately welded, crystal-poor, moderately pumiceous rhyolite ash-flow tuff. Contains 4-10% phenocrysts consisting mainly of sanidine with minor plagioclase and biotite and traces of quartz, clinopyroxene, and opaque oxides. Source unknown. Unit is usually altered in the Socorro-Magdalena area but is much fresher in the Datil and western Gallinas Mountains.

canic conglomerates, mudflow deposits, and volcaniclastic sandstones. Alluvial-fan, braided-stream, and lacustrine deposits separated into several members by intercalated, regional ash-flow tuff sheets. In the Socorro-Magdalena area most deposits consist of purple to gray conglomerates, mudflow deposits, and sandstones with minor mafic to intermediate lava flows. Deposits coarsen and contain more lava flows upward and to the south.

Spears Formation [Tonking, 1957; Brown, 1972]—39.6-33.1 m.y., range of several dates; 0-3,000 ft (0-900 m); vol-

# Datil and western Gallinas Mountains



# Vicks Peak Tuff [Deal and Rhodes, 1976; Elston, 1976; formerly tuff of Wahoo Canyon in part of this area]—31.3 ± 2.6 m.y.; 0-250 ft (0-75 m); ash-flow tuffs.

Light-gray, moderately welded, crystal-poor, pumiceous rhyolite ash-flow tuff. Normally thin, 0-40 ft (0-12 m), but thickens locally in paleovalleys to > 200 ft (>60 m). Overlies with angular unconformity units as old as the Spears Formation. Contains 1-3% sanidine phenocrysts and trace amounts of quartz, biotite, clinopyroxene, and plagioclase. Texturally very crystal poor and aphanitic near base but becomes less crystal poor and more pumiceous upward. Upper parts usually contain large open pumice. See preceding stratigraphic column.

Deep Well, basaltic andesite of [new name; formerly basaltic andesite of Twin Peaks; equivalent to tongue of La Jara Peak Basaltic Andesite]—30.9  $\pm$  1.5 m.y.; 0-200 ft (0-60 m); basaltic-andesite lavas. Microporphyritic basaltic-andesite lava flows, commonly containing vesicles filled with calcite

La Jencia Tuff [new name; formerly lower member A-L Peak Tuff]—0-150 ft (0-45 m); ash-flow tuffs. Multiple-flow, compound cooling unit of densely welded, crystal-poor rhyolite ash-flow tuffs. Usually densely welded and commonly

contains lineated pumice. Contains 3-7% sanidine phenocrysts and minor amounts of small, rounded, quartz phenocrysts; traces of biotite, plagioclase, clinopyroxene, sphene, and magnetite are also present.

South Crosby Peak Formation [Bornhorst, 1976]—0-200 ft (0-60 m); volcaniclastic sedimentary rocks, air-fall tuffs, with minor ash-flow tuff. Contains pebble conglomerates, bedded ash-fall tuffs, and reworked tuffs. Locally the unit includes interbedded ash-flow tuffs. One

interval found in the northeast Datil Mountains is a pumiceous, crystal-poor rhyolite ash-flow tuff 0-35 ft (0-10 m) thick, containing approximately 10% phenocrysts consisting of sanidine (7%), plagioclase (2%), biotite (1%), quartz (1%), and traces of pyroxene and

Hells Mesa Tuff [Deal, 1973; Simon, 1973]—33.1 m.y., average of several dates; 0-400 ft (0-125 m); ash-flow tuffs. Multiple-flow, simple cooling unit of moderately to poorly welded, crystal-rich, quartz-rich ash-flow tuff. See preceding stratigraphic

Datil Group—39.6-33.1 m.y., range of several dates. Includes Spears Formation and all intercalated ash-flow tuffs.

rocks. Transport directions are to the north and northeast.

Spears Formation [Tonking, 1957; Brown, 1972]—39.6-33.1 m.y., range of several dates; 0-1,000 ft (0-300 m); volcanic conglomerates, mudflow deposits, and volcaniclastic sandstones.

Alluvial-fan, braided-stream, and lacustrine deposits separated into several members by intercalated, regional ash-flow tuff sheets. Rincon Windmill Member, Spears Formation [new name]—275-500 ft (85-150 m); conglomerates, sandstones, aeolian sandstones. Member of the Spears Formation between Rock House Canyon Tuff and Hells Mesa Tuff. Mapped as upper and lower units where

Blue Canyon Tuff is interbedded; undivided elsewhere. Lower two thirds consist of pebble to cobble conglomerates with minor sandstones. Upper one third contains increasingly greater proportions of well-sorted, feldspathic, aeolian sandstones. Transport directions generally north to northeast. Blue Canyon Tuff [Lopez, 1975; Lopez and Bornhorst, 1979]—33.3 m.y., average of 2 dates; 0-100 ft (0-30 m); ash-

Simple cooling unit of moderately crystal rich, biotite-rich, quartz-poor quartz-latite tuff. Usually poorly to moderately welded and locally absent. Contains 15-20% phenocrysts consisting of plagioclase (5-10%), sanidine (5-10%), biotite (1.5-3%), and traces of clinopyroxene, hornblende, opaque oxides, and quartz. Source and regional extent unknown.

Light-gray, poorly to moderately welded, crystal-poor, moderately pumiceous rhyolite ash-flow tuff. Unit forms steep bluffs and extensive dip slopes. Contains 4-10% phenocrysts consisting mainly of sanidine with minor plagioclase and biotite and traces of quartz, clinopyroxene, and opaque oxides. Source unknown.

Chavez Canyon Member, Spears Formation [new name]—250-500 ft (75-150 m); sandstones, conglomerates, and debris-flow deposits. Member of the Spears Formation between the Dog Springs Member and the Rock House Canyon Tuff. Consists of lower feldspathic sandstone beds that are usually approximately 175-200 ft (50-60 m) thick and a thick overlying sequence of more conglomeratic beds. Minor debris-flow deposits are present. Locally, the Datil Well Tuff is interbedded in the conglomeratic interval and separates the

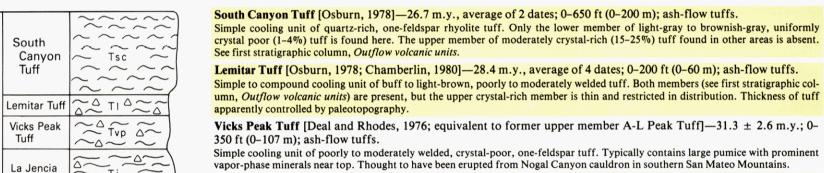
upper and lower units of the Chavez Canyon Member. Quartz is scarce throughout the unit, and almost all clasts are of volcanic

Datil Well Tuff [Lopez, 1975; Lopez and Bornhorst, 1979]—36.7 m.y., average of 2 dates; 0-80 ft (0-25 m); ash-flow Gray to pinkish-gray, densely welded, moderately crystal rich rhyolite ash-flow tuff. Contains 16-25% sanidine phenocrysts with

minor clinopyroxene and biotite and traces of quartz and plagioclase (Harrison, 1980). Source and regional extent unknown. Dog Springs Member, Spears Formation [new name; Dog Springs area in the western Gallinas Mountains]—39.1 m.y., average of 2 dates; 0-3,000 ft (0-900 m); mudflow breccias, volcaniclastic sedimentary rocks, autobrecciated intrusive rocks, and local tuffaceous lacustrine rocks.

Thick accumulation of volcaniclastic rocks, dominantly mudflow deposits, especially light-tan to brown, crystal-rich, nonpumiceous quartz-latite breccias with clasts similar in mineralogy to the matrix. In the Dog Springs area, these breccias contain large exotic blocks of limestone and autobrecciated volcanic rocks as much as 0.5 mi (800 m) long and 250 ft (75 m) thick; these were probably carried into the area in major mudflows. Rocks with the same lithology are known both to the east and west of the Dog Springs area but apparently lack the abundant exotic blocks. A few large bodies of autobrecciated andesitic to latitic rocks appear to be intrusives. Minor local accumulations of well-stratified, tuffaceous pond deposits are interbedded in the mudflow breccias. Bedding within the Dog Springs breccias is typically highly contorted and chaotic, whereas bedding in underlying and overlying units is consistent and gently dipping. This contorted bedding is probably the result of penecontemporaneous soft-sediment deformation.

#### North Jornada del Muerto



La Jencia Tuff [new name; formerly lower member A-L Peak Tuff]—0-350 ft (0-107 m); ash-flow tuffs Compound cooling unit of crystal-poor, moderately to densely welded, one-feldspar tuff. Only locally contains lineated pumice. Erupted from composite Sawmill Canyon-Magdalena cauldrons. See Cauldron stratigraphy section. Tuffs and tuffaceous sediments, South Crosby Peak Formation (?) [Bornhorst, 1976]—0-100 ft (0-30 m).

Sequence of unwelded, white, moderately crystal-poor tuffs and tuffaceous sandstones. Occurs above Spears volcaniclastic rocks and below La Jencia Tuff. Thickness controlled by paleotopography. Resembles in mineralogy and occurrence the South Crosby Peak Formation (see Datil and western Gallinas Mountains stratigraphic column). Contains approximately 10% phenocrysts consisting of

Spears Formation [Tonking, 1957; Brown, 1972]—0-325 ft (0-100 m); basaltic andesite to andesite lavas, coarse conglomerates and breccias. Sequence of fine-grained, aphanitic to coarsely porphyritic andesite lavas intertonguing with coarse-grained sediments consisting of andesitic, cobble- to pebble-size clasts in a sandy matrix. Porphyritic andesite lavas typically contain 5-20% phenocrysts of pyroxene

Rock House Canyon Tuff [new name; formerly tuff of Main Canyon; tuff of Nipple Mountain] -0-350 ft (0-107 m); Light-gray, poorly to moderately welded, crystal-poor, moderately pumiceous rhyolite ash-flow tuff. Contains 4-10% phenocrysts consisting mainly of sanidine with minor plagioclase and biotite and traces of quartz, clinopyroxene, and opaque oxides. Source un-

Datil Well Tuff(?)—0-80 ft (0-25 m); ash-flow tuffs. Gray to pinkish-gray, densely welded, moderately crystal-rich ash-flow tuffs. Contain 15-25% sanidine phenocrysts with minor clino-

pyroxene and biotite and traces of quartz and plagioclase. Source and regional extent unknown. Very similar to, and possibly correlative with, Datil Well Tuff. See Datil and western Gallinas Mountains stratigraphic column. Spears Formation—approximately 2,200 ft (670 m); sandstones, conglomerates, and minor mudflow deposits and

Thick sequence of volcaniclastic sedimentary rocks resting conformably on the Baca Formation. Basal contact is a sharply gradational change from clasts of Precambrian rocks and Paleozoic sedimentary rocks to latitic volcanic detritus containing subordinate clasts of basement lithologies.

#### Cauldron stratigraphy Socorro cauldron

The Socorro cauldron, the source of the oldest major ash-flow sheet in the readily inferred in a fourth location near Puertecito Gap in the southwest Mag-Socorro-Magdalena area, the Hells Mesa Tuff, is located just southwest of dalena Mountains, because exposures of outflow- and cauldron-facies Hells Socorro. Segments of the cauldron margin, mainly topographic wall segments, Mesa can be identified south and north of this area, respectively. Exposures of are exposed on Socorro Peak, in the southern Chupadera Mountains, and on the cauldron-facies Hells Mesa and the cauldron-filling Luis Lopez Formations North Baldy in the central Magdalena Mountains. The cauldron margin can be are delineated on the location photo (fig. 4).



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MAGDALENA CAULDRONS RELATIVE TO SURROUNDING TOPOGRAPHIC AND GEOGRAPHIC FEATURES. Reproduced from fig. 3. Areas with outcrops of cauldron-facies Hells Mesa Tuff shown in lined pattern; areas containing outcrops of cauldron-filling Luis Lopez Formation shown in stippled pattern.

flow tuffs. Very thick, massive sequences of lithic-rich to lithic-poor, crystal-rich, quartz-rich ash-flow tuff. Interbedded cauldron-collapse breccias with blocks as thick as 165 ft (50 m) on a side are common in the eastern half of

Hells Mesa Tuff, cauldron facies—as thick as 5,000 ft (1,500 m); ash-

Luis Lopez Formation [Chamberlin, 1980]—0-3,500 ft (0-1,000 m); rhyolite lavas and domes, intermediate lavas, ash-flow tuffs, and sedimentary rocks

Heterolithic fill of the Socorro cauldron. Occurs between underlying cauldron-facies Hells Mesa Tuff and the overlying La Jencia Tuff, Major outcrop areas are found in the northern and south-central Chupadera Mountains and in the southeast Magdalena Mountains (fig. 4). The central Chupadera Mountains, which expose a thick pile of cauldron-facies Hells Mesa Tuff, are considered to be a remnant of a resurgent dome. Smaller occurrences of Luis Lopez rocks are found in the south-central and western Magdalena Mountains. Figs. 5 and 6 are diagramatic cross sections through the northern and southern Chupadera Mountains, respectively. The Luis Lopez Formation in the Magdalena Mountains is not depicted graphically. Luis Lopez rocks exposed in the southeast Magdalena Mountains correlate in general with the exposures in the southern Chupadera Mountains. Different lithologies are present on Hardy Ridge in the western Magdalena Mountains; these rocks are described below in the section titled Stratigraphic units in the southwest Magdalena Mountains.

# Stratigraphic units in the southwest Magdalena Mountains

Hardy Ridge, rhyolite of [Bowring, 1980; Donze, 1980]—up to 1,200 ft (365 m); rhyolite lavas. Sequence of two rhyolitic lavas consisting of a lower, light-bluish-gray,

ulites in the lower lava tend to be small, 0.4 inch (1 cm) or less, whereas

crystal-poor interval and an upper, pale-pink, crystal-free interval sepa- Tza Andesitic lavas—0-440 ft (0-130 m). rated locally by thin, discontinuous andesitic lavas. Lower rhyolite contains approximately 5% phenocrysts consisting of approximately equal amounts of quartz and sanidine; the upper lavas contain essentially no phenocrysts. occurrences observed between the two varieties of rhyolite. Correlation be-Both lavas contain abundant spherulitic devitrification textures. The sphertween the two outcrop areas is uncertain. Similar to andesites of Luis Lopez

those in the upper lava are larger, up to 4 inches (10 cm), and often have well-developed rinds (Bowring, 1980)

Dark-gray to spotted, aphanitic, andesitic layas. Occur in one location between the Hells Mesa Tuff and overlying crystal-free, rhyolite lava; other

Formation in other areas.

#### Stratigraphic units in northern Chupadera Mountains Stratigraphic units in the south-central Chupadera Mountains and southeast Magdalena Mountains and on Socorro Peak

looking east

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FIGURE 5—STRATIGRAPHIC RELATIONSHIPS OF LUIS LOPEZ FORMATION IN NORTHERN

rhyolite lavas of Blue Canyon]—rhyolitic lava flows and domes.

Light-red to reddish-brown, flow-banded, moderately porphyritic lava

flows. Typically contain 10-30% phenocrysts consisting of sanidine (8-

20%) and quartz (2-10%). Several vent areas are known along the front of

rhyolitic lavas of Highway Sixty]—29.4  $\pm$  1.1 m.y.; rhyolitic lavas

under the lavas in Blue Canyon. One densely welded ash-flow tuff in this

unit contains lineated pumice and is strikingly similar to La Jencia Tuff.

Two intervals of light-brownish-gray to purplish-gray, poorly to moder-

ately welded, pumiceous, lithic-rich rhyolitic ash-flow tuff. The two inter-

vals, which are distinguishable by lithic content, are locally separated by

(Spears-type) lithic fragments, whereas the upper interval [Tzt₂] is charac-

terized by abundant clasts of reddish-brown, lithic-rich (cauldron-facies)

Hells Mesa Tuff. Both intervals contain 5-10% phenocrysts consisting of

subequal amounts of quartz and sanidine. Thin intervals of similar lithic-

Several intervals of purplish, aphanitic to moderately porphyritic lavas sep-

arated by rhyolitic lavas and tuffs. Lower two intervals are aphanitic to

to moderately porphyritic, and the upper interval is moderately porphyritic

throughout. Andesitic agglomerates are present locally in all intervals. Sev-

eral vents for the third interval, commonly associated with agglomerates,

Minor exposures of sedimentary deposits in two widely separated areas.

Northern outcrops consist of poorly sorted, heterolithic conglomerates and

breccias that contain clasts of Spears-type andesites, Madera Limestone,

and tuff of Granite Mountain in a muddy to sandy matrix. These deposits

are mostly colluvial breccias on the northern topographic wall of the

Socorro cauldron. The second outcrop area is found several miles to the

south in the northern Chupadera Mountains. Here, pink to gray, medium-

to coarse-grained, parallel-bedded sandstones and tuffaceous sandstones

overlie the Hells Mesa Tuff and are overlain by andesitic lavas.

are marked by dikes and plugs near Socorro Canyon and at Blue Canyon.

moderately porphyritic, whereas the third interval from the base is slightly

rich tuffs that rest on the Hells Mesa Tuff in the southern Lemitar Moun-

rhyodacite mineralogy exposed along US-60.

tains have been mapped with La Jencia Tuff.

Heterolithic sedimentary rocks—0-325 ft (0-100 m).

Intermediate lavas.

Ash-flow tuffs—0-1,250 ft (0-380 m).

Cook Spring, rhyolitic lavas of, lower member [new name; formerly

Socorro Peak between Blue Canyon and the area just northeast of M

CHUPADERA MOUNTAINS AND SOCORRO PEAK AREA. Data from Chamberlin (1980).

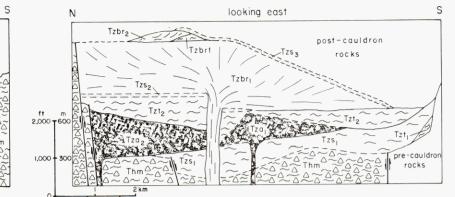


FIGURE 6—STRATIGRAPHIC RELATIONSHIPS OF LUIS LOPEZ FORMATION IN THE SOUTHERN CHUPADERA MOUNTAINS. After Eggleston (1982).

Heterolithic sedimentary rocks—0-50 ft (0-15 m). Tzc₂ Cook Spring, rhyolitic lavas of, upper member [new name; formerly Tzs₃ Thin, discontinuous, and variable sediment interval containing conglomer ates, sandstones, and mudstones. Usually white, buff, or pale red in color

> and often containing prominent crossbedding. Bianchi Ranch, rhyolite of [Eggleston, 1982]—0-2,000 ft (0-600 m); rhyolite domes and lava flows.

> > Upper member—0-200 ft (0-60 m); rhyolitic lavas and tuffs.

Reddish to brown lava commonly having a basal breccia zone (possibly a

vent breccia) overlain by a black vitrophyre and a devitrified interval containing abundant spherulites. Contains approximately 3% phenocrysts Light-gray to pinkish-gray, finely flow banded, crystal-poor rhyolite lavas and thin, associated air-fall and ash-flow tuffs (Tzct) present locally beconsisting of plagioclase (2%), sanidine (1%), and a trace of ferromagneath Tzc₁. Both the tuffs and lavas contain 2-5% phenocrysts consisting of subequal amounts of sanidine and plagioclase, minor biotite, and traces

Ash-flow tuffs and tuffaceous sandstones—0-70 ft (0-20 m). Air-fall and ash-flow tuffs similar mineralogically to Tzc2 are present

Minor volumes of coarsely porphyritic flows and dikes (third interval) of Lower member—0-1.800 ft (0-550 m).

flow-banded, and locally vitric rhyolitic domes and lava flows. Contain approximately 5% phenocrysts consisting of plagioclase (3%), sanidine (1%), and altered ferromagnesian minerals (1%). Steep foliation in Nogal Canyon probably indicates the vent area.

Heterolithic sedimentary rocks and andesitic lava flows-0-100 ft (0andesite flows. The lower interval [Tzt₁] contains abundant andesitic Tzs₂ Thin, largely eroded andesitic lava flow, which is underlain and overlain by sedimentary rocks containing abundant andesitic clasts.

Ash-flow tuffs and mudflow deposits—0-700 ft (0-215 m). Numerous thin, white, poorly welded, lithic-rich tuffs intercalated with mudflow and possible talus deposits. Lithic fragments are dominantly andesites and Hells Mesa Tuff. Contain 3-5% phenocrysts consisting of sani-

Intermediate to mafic lava flows—0-600 ft (0-185 m). The northern outcrops consist of dark-gray, slightly porphyritic, consider ably altered mafic to intermediate lavas. These lavas are commonly altered to lighter colors and a more felsic appearance. Contain a few percent completely altered feldspar (plagioclase) phenocrysts, as much as 7% pyroxene,

Intermediate to mafic lava flows—0-300 ft (0-90 m). Two intervals of dark-gray to black, dense to vesicular lavas. Southern outcrops consist of dark-gray to black basaltic lava flows, which contain a few percent ferromagnesian phenocrysts (probably olivine) that have been

Coarse sediments to the south appear to have been derived from the southern cauldron margin, whereas the conglomerates to the north were transported from north to south, probably away from a resurgent dome.

Ash-flow tuffs—0-700 ft (0-215 m).

White, poorly welded ash-flow tuff containing abundant lithic fragments mostly of Precambrian lithologies. Unit is exposed only along southern cauldron margin. Moderately crystal rich, containing approximately 20% phenocrysts consisting of altered feldspar (10-15%), quartz (8%), and bio-

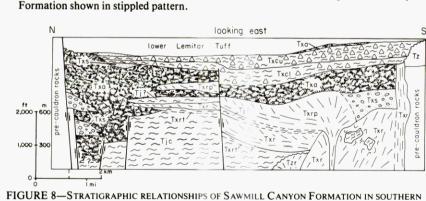
## Sawmill Canyon-Magdalena cauldrons

The overlapping Sawmill Canyon and Magdalena cauldrons form a dumbbell-but exposed in only one small area on the northeast rim of the Magdalena caulshaped complex oriented east-west across the central Magdalena Mountains (fig. dron. Cauldron margins are well exposed over large areas near the center of the the lower member A-L Peak Tuff and lower member tuff of Bear Springs). The the complex are covered by younger units, and margins are inferred. cauldron-facies La Jencia Tuff is well exposed in the Sawmill Canyon cauldron

(0-365 m); ash-flow tuffs. the northwest San Mateo Mountains. Upper member

FIGURE 7—LOCATION MAP SHOWING SAWMILL CANYON AND MAGDALENA CAULDRONS RELATIVE TO THE SOCORRO CAULDRON AND SURROUNDING TOPOGRAPHIC AND GEOGRAPHIC FEATURES. Reproduced from fig. 3. Areas with outcrops of cauldron-facies La Jencia

Tuff shown in lined pattern; areas with outcrops of cauldron-filling Sawmill Canyon



MAGDALENA MOUNTAINS. This diagram is essentially a north-south cross section parallel to the eastern wall of Sawmill Canyon. Data from Bowring (1980) and Roth (1980).

La Jencia Tuff, cauldron facies [new name; formerly A-L Peak Tuff] —as thick as 3,000 ft (900 m) with no exposed base; ash-flow tuffs Very thick sequence of crystal-poor ash-flow tuff that typically has welldeveloped primary flow structures including lineated pumice and flow fold ing. Most lineation directions are oriented approximately east-west. Contains variable amounts of small lithic fragments, as well as several large exotic blocks, up to 900 ft (300 m), of sandstone, andesite lavas, and tuffs. Includes a thin, crystal-rich interval and an interbedded rhyolite lava near the top of the section. Interval above the lava [Tj?] may be the Vicks Peak Tuff. Usually contains 1-5% sanidine, minor quartz, and traces of biotite and magnetite. The upper, crystal-rich interval can have as much as 25% phenocrysts consisting mainly of sanidine (Bowring, 1980).

Sawmill Canyon Formation [new name; formerly unit of Sixmile Canyon]-0-2,500 ft (0-800 m); andesite lavas, rhyolite lavas, ashflow tuffs, conglomerates, and mudflow deposits. Heterolithic fill of Sawmill Canyon cauldron. Occurs between underlying cauldron-facies La Jencia Tuff and the overlying Lemitar Tuff. Fig. graphically depicts the Sawmill Canyon Formation in the western half of the cauldron. In the northern part the fill consists largely of andesitic lavas and interbedded, mainly andesitic mudflow and debris-flow deposits. To the south andesite lavas interfinger with rhyolite lavas and conglomeration sandstones and are overlain by a thick intracaldera ash-flow tuff, the tuff of Caronita Canyon (30.2 ± 1.1 m.y.). The Lemitar Tuff approximately doubles in thickness within the margins of the Sawmill Canyon cauldron, thus serving as the last of the cauldron-filling units. Within the Magdalena

Sawmill Canyon cauldron.

cauldron, only andesitic lavas are exposed. These are called the andesite of

Landavaso Reservoir (Simon, 1973) and are described after units from the

Thin interval of white, poorly welded, lithic-poor, crystal-poor ash-flow tuff and crossbedded, tuffaceous sandstones found locally between upper and lower members. Tuff contains approximately 2% plagioclase and traces of quartz and biotite. Brown where fresh but commonly altered to lighter colors; spherulitic

dine (3%), plagioclase (2%), quartz (1%), and a trace of biotite.

and a trace of quartz. Possibly correlative with the southern flows; however, intervening areas with no outcrops and slightly different petrographic characteristics prevent a clear-cut correlation.

altered to iddingsite. Heterolithic sedimentary rocks—0-800 ft (0-245 m). Coarse breccias and conglomerates in southern outcrops fine northward to mainly sandstones and mudstones with an upper conglomeratic interval.

7). These two cauldrons are thought to be the source of La Jencia Tuff (formerly complex in the central Magdalena Mountains. The eastern and western parts of

Caronita Canyon, tuff of [Petty, 1979]—30.2  $\pm$  1.1 m.y.; 0-1,200 ft Multiple-flow, simple cooling unit of ash-flow tuffs showing strong zoning. Usually divided into two members at a sharply gradational upward increase in phenocryst content and change from quartz latite to rhyolite mineralogy Known only from Sawmill Canyon cauldron and from a few outcrops in

White to medium-gray, crystal-rich, moderately to densely welded tuff. Contains 30-50% phenocrysts of sanidine, quartz, biotite, and minor magnetite. Quartz is often large and conspicuously dipyramidal. Locally

(secs. 5 and 6, T. 5 S., R. 2 W.) contains at least one thin sandstone inter-

Brown to reddish, moderately crystal-poor, poorly to densely welded ashflow tuff. Contains 5-20% phenocrysts of plagioclase, biotite, magnetite and traces of clinopyroxene, quartz, and sanidine. Locally has basal black Porphyritic rhyolite lava—0-1,200 ft (0-365 m); lava flows.

banded rhyolitic lavas locally overlying minor tuffs of similar lithology

Brown to pinkish-gray, porphyritic lava flow. Contains 5-30% phenocrysts of sanidine, quartz, and minor magnetite and biotite. Usually contains 1 to a few percent brownish-gray, partially embayed, andesitic lithic fragments. Crystal-poor rhyolitic lavas and domes—0-750 ft (0-230 m). Fine-grained, pink, gray, or brown, crystal-poor to crystal-free, flow-

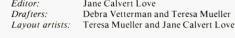
[Txrt]. Form several intrusive plugs in Sawmill Canyon (Roth, 1980) and lava flows in both Sawmill and Ryan Hill Canyons. Andesitic lavas—0-1,500 ft (0-450 m).

Variable sequence of andesitic lavas including both fine-grained and porphyritic lithologies. Plagioclase porphyritic lavas are concentrated in the northern part of the cauldron along Sixmile and South Canyons. The uppermost andesites are similar to La Jara Peak Basaltic Andesite. Similar andesitic lavas in the Magdalena cauldron were referred to as "red andesite," "red rhyolite," and "upper andesite" by Loughlin and Koschmann (1942) and as andesite of Landavaso Reservoir by Simon (1973).

Landavaso Reservoir, andesite of [Simon, 1973]—0-800 ft (0-240 m); andesitic lavas. Highly variable sequence of intermediate lava flows. Flows are typically porphyritic, containing 15-25% phenocrysts. Plagioclase is most abundant in all samples, followed by pyroxene, biotite, and hornblende in varying proportions. Flows occur in scattered outcrops in the northern part of the Magdalena cauldron; most outcrops are poorly exposed.

Mudflow deposits, conglomerates, and sandstones—29.7 ± 1.1 m.y.; 0-750 ft (0-230 m). Northern exposures consist of coarse, angular, heterolithic mudflow deposits and minor conglomerates shed from the northern cauldron margin. These are interbedded with andesite layas. Southern exposures consist of conglomerates, mudflow deposits, sandstones, and bedded tuffs interbedded with rhyolites and andesites. Clast lithologies in the northern deposits include Spears-type andesites. Hells Mesa Tuff, and rhyolitic lavas. Southern deposits contain all of the lithologies found in the north plus numerous clasts of the Luis Lopez Formation, which crops out just to the

Jane Calvert Love Debra Vetterman and Teresa Mueller



# Glossary of major stratigraphic units

This glossary lists only stratigraphic names pertinent to the northeast Mogollon-Datil volcanic field (fig. 1). Units outside the area are not listed except for those units that have been correlated into the northeast part of the field in maps or other publications. Units of limited lateral extent, such as local basalt flows or members of complex cauldron-fill units, are not listed unless they have appeared in a publication or have some special stratigraphic significance. Both formal and informal names are included. Obsolete names are included to facilitate transition

to the new nomenclature. The numbered entries listed under each stratigraphic unit refer to the cate-

gories below (N/A signifies not applicable). The format follows that used by Elston (1976) for ease of comparison with his more comprehensive glossary.

(2) Origin of the name and/or location of the type locality (3) First mention in the literature; other important references

(4) Rock type; general nature of thickness and continuity (5) Age, radiometric dates (published K-Ar dates have been adjusted for the

new IUGS constants using the tables of Dalrymple, 1979) (6) Stratigraphic position (youngest underlying and oldest overlying unit; intertonguing units)

(7) Source of eruption (8) Suggested correlation, synonyms

(1) Area of occurrence

(9) Comments For obsolete names, only items two and three and the reasons for abandonment are given. The reader is referred to the original papers for details of these units. For more detailed information on units listed, the reader is referred to the unit descriptions on the stratigraphic columns and to the references cited. Formal names previously used and accepted are shown in bold type, accepted informal names are shown in medium type using the informal format of geographic name and lithologic designation; for example, Bear Canyon, basalt of, member of Popotosa Formation. Obsolete names are shown in medium type followed by the word "obsolete" enclosed in brackets. For several units not previously used in a formal sense, we here state our intention to name them formally. These units are capitalized and shown in bold type on a pale yellow background throughout this publication. For each of these units, the information required by the Code of Stratigraphic Nomenclature for formal naming can be found in this glossary and in a separately enclosed section. More detailed treatment of supporting data for these units will be given in a subsequent series of New Mexico Bureau of Mines and Mineral Resources circulars.

A-L Peak Rhyolite, A-L Peak Tuff, A-L Peak Formation [OBSOLETE] (2) A-L Peak in northeast San Mateo Mountains, approximately 20 mi (32 km) southwest of Magdalena; secs. 33, 34, 35, T. 4 S., R. 6 W., Mount Withington 7½-min quadrangle. (3) Deal, 1973; Simon, 1973; and Deal and Rhodes, 1976. (9) Name abandoned in this report because the type section on A-L Peak was miscorrelated with outflow exposures of an older unit, now called La Jencia Tuff (formerly tuff of Bear Springs). The rocks on A-L Peak are now correlated with and called the South Canyon Tuff, the third regional ash-flow tuff above La Jencia Tuff. See La Jencia Tuff and Vicks Peak Tuff. Allen Well, tuff of [OBSOLETE]

(2) Allen well in Dry Lake Canyon, approximately 7 mi (11 km) northwest of Magda lena; sec. 36, T. 1 S., R. 5 W., Silver Hill 7½-min quadrangle. (3) Brown, 1972; and Simon, 1973, (9) Name no longer used, because unit is correlative with the Lemitar Tuff Both members of the Lemitar Tuff are present at Allen well; however, only the crystalrich upper member of the Lemitar Tuff was called tuff of Allen Well by Simon (1973). He miscorrelated the crystal-poor lower member of the Lemitar Tuff with the lower part of La Jencia Tuff (then called A-L Peak Tuff) and, therefore, concluded that the tuff of Allen Well was part of La Jencia (A-L Peak) Tuff. Both crystal-poor and crystal-rich members are now known to be Lemitar Tuff, the second regional ash-flow tuff above La Arroyo Montosa, unit of, member of the Popotosa Formation

(1) Mulligan Gulch graben, approximately 6 mi (10 km) northwest of Magdalena. (2) Arroyo Montosa; secs. 14, unsurveyed, 23, 24, T. 2 S., R. 5 W., Silver Hill 71/2-min quadrangle. (3) Simon, 1973; and Chapin and Seager, 1975. (4) Interbedded fanglomerates and quartz-latite to dacite lava flows; local unit. (5) 25.9 ± 1.2 m.y. K-Ar date (plagioclase) on quartz-latite flow. (6) Above South Canyon Tuff and Hale Well stock; below Tertiary-Quaternary piedmont gravels. (7) Vent not exposed but must be local. (8) Correlative in age and lithologic character to basal Popotosa Formation.

Ary Ranch, tuff of [OBSOLETE] (2) Earl Ary Ranch, approximately 1.3 mi (2 km) east-northeast of Datil; sec. 7, T. 25 S.,

R. 9 W., Datil 7½-min quadrangle. (3) Lopez, 1975; Bornhorst, 1976; and Lopez and Bornhorst, 1979. (9) Name abandoned in this report because unit is correlative with Hells Mesa Tuff and, therefore, name is unnecessary. The tuff of Ary Ranch is not interbedded with the volcaniclastic rocks of South Crosby Peak Formation as described by Lopez and Bornhorst (1979), nor does it overlie the tuff of Rock Tank. Both the tuff of Ary Ranch and the tuff of Rock Tank (Lopez and Bornhorst, 1979) are part of the outflow sheet of the Hells Mesa Tuff.

(1) Along north edge of Mogollon-Datil volcanic field from near Springerville, Arizona, to Riley, New Mexico; also present east of Rio Grande in Joyita Hills, northern Jornada del Muerto, and Carthage areas. (2) Baca Canyon in northeast Bear Mountains, approximately 15 mi (24 km) north of Magdalena; secs. 4, 5, 8, 9, T. 1 N., R. 4 W., Mesa Cencerro 7½-min quadrangle. (3) Wilpolt and others, 1946; Tonking, 1957; Snyder, 1971; Johnson, 1978; and Cather, 1980. (4) Red to light-gray sandstones, red mudstones, local coarse conglomerates; little or no detritus of Tertiary volcanic rocks except possibly in Quemado-Springerville area. (5) Contains Eocene vertebrate fossils. (6) Above Crevasse Canyon Formation (Cretaceous); below Spears Formation; contact with Spears commonly gradational over 20-30 ft (6-9 m). (7) N/A. (8) Eager Formation in Springerville area, Arizona; Mogollon Rim gravels in Arizona

Bear Canyon, basalt of, member of the Popotosa Formation (1) Socorro area. (2) Bear Canyon, approximately 7 mi (11 km) southwest of Socorro and just south of US-60 in the northern Chupadera Mountains; sec. 1, T. 4 S., R. 2 W., Luis Lopez 7½-min quadrangle. (3) Chamberlin, 1980, 1981. (4) Basalt flow, thin, local, discontinuous. (5) Not dated. (6) Interbedded with playa-claystone section of Popotosa

Bear Springs, tuff of [OBSOLETE]

(2) Bear Springs in southern Bear Mountains, approximately 8 mi (13 km) north of Mag dalena; sec. 9, T. 1 S., R. 4 W., Magdalena NW 71/2-min quadrangle. (3) Brown, 1972. (9) Name abandoned by Deal (1973) and Simon (1973) in favor of A-L Peak Tuff, which is here renamed La Jencia Tuff (formerly lower member A-L Peak Tuff) and Vicks Peak Tuff (formerly upper member A-L Peak Tuff). See La Jencia Tuff and Vicks Peak Tuff.

Beartrap Canyon formation [DEFINITION INADEQUATE, USE WITH CAUTION (2) Beartrap Canyon, San Mateo Mountains, approximately 22 mi (35 km) southwest of

Magdalena; secs. 7, 18, T. 6 S., R. 7 W., Bay Buck Peaks 7½-min quadrangle. (3) Deal, 1973: and Deal and Rhodes, 1976. (9) Definition inadequate because the Beartrap Canyon formation (Deal and Rhodes, 1976) included cauldron-fill units of two or more overlapping cauldrons in the northern San Mateo Mountains plus younger units in the western Magdalena Mountains (Deal, 1973) that are correlative with the Popotosa Formation (Donze, 1980). Deal and Rhodes (1976) and Deal (1978, fig. S33) also extended the Beartrap Canyon formation into the southern San Mateo Range to include cauldron-fill deposits in the Nogal Canyon cauldron. Thus, the formation was used to include deposits of at least three cauldrons plus younger synrift deposits and ranges in age from about 30 m.y. to 14 m.y. The name, Beartrap Canyon formation, should not be used outside the northern San Mateo Range and should be used with caution until the San Mateo Range is mapped in detail and the stratigraphic relationships established.

(1972)(1973)(1957) (1978)Beartrap outflow units Formation La Jara Peak Formation intermediate to lavas Peak tongue Potato Canvo rhyolite porphyr tuff of South Canyor pink rhyolite South Canyon Tuff tuff of Allen Wel La Jara Peak Basalticandesite Basaltic Andesi upper andesite La Jara Peak Bear Springs lower member rhyolite porph andesites La Jara Peak lower member lower red andesit tuff of Vicks Peak Tuff unit of tongue Peak tongue La Jencia Tuff Tuff of Hidden Spring member andesite lavas volcaniclastic rocks of So. Crosby Pea Crosby Peak Fm. lells Mesa Tuff latitic tuffs "upper latite tuff of unit B Granite Mtn. tuff of Blue Canyo rocks unit A
tuff of
Main Canyo Canyon Tuf Nipple Mt volcaniclastic member white felsite tuff of Datil Well rocks lower latita Hells Mesa Tuff Lemitar Tuff Baca Formation Formation La Jencia Tuff Spears Formation FIGURE 9—CORRELATION CHART SHOWING APPROXIMATE CHRONOLOGY OF DEVELOPMENT OF PALEOGENE STRATIGRAPHIC NOMENCI ATURE FOR SOCORRO-MAGDALENA AREA

Studies included are those that introduced lasting changes in the stratigraphic stratigraphic sequence from Blakestad (1978). Elevated to group status by Weber nomenclature and/or those that are in widely available publications. The reader seek- (1971). ³Elevated to formation status by Chapin (1971). ⁴Tuffs of Ary Ranch and ing detailed correlations of individual units should see either the appropriate stratigraphic column or the glossary. 'Nomenclature from Loughlin and Koschmann; can nowhere be demonstrated to have this interfingering relationship.

Bianchi Ranch, rhyolite of, member of Luis Lopez Formation

moat of Socorro cauldron. (7) Local vents. (8) Correlative in stratigraphic position and age with rhyolitic lavas of Cook Spring. Black Mountain, basalt of [OBSOLETE] (2) Black Mountain, approximately 5 mi (8 km) southwest of Socorro; sec. 30, T. 3 S.

(1) Central Chupadera Mountains. (2) Bianchi Ranch along Nogal Canyon, approxi

mately 12 mi (19 km) southwest of Socorro; sec. 6, T. 5 S., R. 1 W., Luis Lopez 71/2-min

quadrangle. (3) Eggleston, 1982. (4) Rhyolitic lavas, thick but local. (5) Not dated. (6)

Overlies cauldron-facies Hells Mesa Tuff and overlain by La Jencia Tuff. Restricted to

R. 1 W., Socorro 71/2-min quadrangle. (3) Bachman and Mehnert, 1978. (9) Abandoned in this report because of possible confusion with other Black mountains and Black mesas. See Socorro Canyon, basalt of for description.

Blue Canyon, rhyolite of [OBSOLETE] Blue Canyon in Socorro Peak area, approximately 3 mi (5 km) west of Socorro; secs. 9. 16. 21. T. 3 S., R. 1 W., Socorro 7½-min quadrangle, (3) Chamberlin, 1980. (9) Name abandoned here because of possible confusion with the Blue Canyon Tuff. The rhyolite domes and flows near Blue Canyon in the Socorro Peak area are part of the Luis Lopez Formation and have been renamed the rhyolitic lavas of Cook Spring.

Rlue Canyon Tuff of the Datil Group (1) Datil Mountains and northwest Gallinas Mountains. (2) Blue Canyon, approximately

7 mi (11 km) north of Datil: type section in Main Canyon near junction with Blue Canon: NE 4SE 4 sec. 1, T. 1 S., R. 10 W., Cal Ship Mesa 7½-min quadrangle. (3) Lopez 1975; Bornhorst, 1976; and Lopez and Bornhorst, 1979. (4) Quartz-latite ash-flow tuff, noderately crystal rich; as thick as 100 ft (30 m) and continuous in Datil Mountains but thins to east and is largely absent in Socorro-Magdalena area. (5) 33.3 ± 1.2 m.y. K-Ar jotite date and 33.2 ± 1.7 zircon fission-track date (Bornhorst and others, 1982), (6) Above Rock House Canyon Tuff; below Hells Mesa Tuff; interbedded with volcaniclastic rocks of Spears Formation. (7) Unknown. (8) Correlative with [Tst2] of Mayerson



FIGURE 10—Type Section of Blue Canyon Tuff. Route of section measurement was up cliff along dashed line, then N. 60° W, across bench to first exposure of upper part of Rincon Windmill Member. Tsrwl = lower part of Rincon Windmill Member of Spears Formation, **Tbc** = Blue Canyon Tuff. Arrow points to geologist for scale.

(1) Northeast end of Datil Mountains. (2) Blue Mesa, approximately 20 mi (32 km) northeast of Datil and approximately 5 mi (8 km) south of D Cross Mountain (unsurveved). D Cross Mountain 7½-min quadrangle. (3) Harrison, 1980; and Robinson, 1981 (4) Basalt flows, thin and local. (5) Not dated. (6) Above Spears Formation and Hells Mesa Tuff: caps mesa. (7) Vent on Blue Mesa. (8) Part of Santa Fe basalt as used by Givens (1957). (9) Probable Pliocene age judging from K-Ar dates on other basalt flows and necks along the southern boundary of the Colorado Plateau.

Broken Tank, basalt of (1) West-central Chupadera Mountains. (2) Broken tank, approximately 13 mi (21 km) outhwest of Socorro; secs. 25, 35, 36, T. 4 S., R. 2 W., Molino Peak 71/2-min quad-

rangle. (3) Eggleston, 1982. (4) Basalt flows, local. (5) Not dated. (6) Interbedded in, or overlying, uppermost gravels of the Santa Fe Group. (7) Unknown. (8) None. Caronita Canyon, tuff of, member of the Sawmill Canyon Formation (1) Southern and central Magdalena Mountains; north and northwest San Mateo Mountains, (2) Caronita Canyon in southeast Magdalena Mountains, approximately 15 mi (24) km) southwest of Socorro: secs. 5, 6, T. 4 S., R. 2 W., Molino Peak 7 ½-min quadrangle

(3) Petty, 1979; Bowring, 1980; Roth, 1980; and Osburn, 1982. (4) Rhyolite ash-flow tuffs; thick but restricted in extent; red, crystal-poor (biotite, plagioclase) lower member light-gray, crystal-rich (quartz, sanidine) upper member. (5) 30.2 ± 1.1 m.y. K-Ar biotite date. (6) Above La Jencia Tuff; below Lemitar Tuff; near top of cauldron fill in Sawmill Canyon cauldron. (7) Possibly from Sawmill Canyon cauldron. (8) Informal member, Cerritos de las Minas, basaltic andesite at, tongue of La Jara Peak Basaltic

(1) Lemitar Mountains. (2) Cerritos de las Minas (small hills) on east side of Lemita

dountains, approximately 18 mi (29 km) north-northwest of Socorro and 3 mi (5 km) south of the Rio Salado; well exposed along Cañon del Ojito; Sevilleta Grant, unsurveyed, San Acacia 71/2-min quadrangle. (3) Machette, 1978. (4) Basaltic-andesite flows, breccias, and plugs; thick but local. (5) 27.0 ± 1.1 m.y. K-Ar biotite date (Bachman and Mehnert, 1978). (6) Mostly below Popotosa Formation but interbedded across 15-30 ft (5-10 m) interval with basal fanglomerate of Popotosa; no base exposed. (7) Local eruptive center. (8) Tongue of La Jara Peak Basaltic Andesite.

Chavez Canvon Member of the Spears Formation of the Datil Group

(1) Datil and Gallinas Mountains. (2) Chavez Canyon in northwest Gallinas Mountains, approximately 17 mi (27 km) northeast of Datil; S1/2 sec. 27, T. 2 N., R. 8 W., unsurveyed, Dog Springs 7½-min quadrangle. (3) Harrison, 1980; and caniclastic conglomerates and sandstones; usually thicker than 1000 ft (300 m) and widespread. (5) Not dated. (6) Above Dog Springs Member of Spears Formation; below Rock House Canyon Tuff, Locally split into two parts by interbedded Datil Well Tuff, (7) N/A. (8) Correlations with units of Lopez (1975), Bornhorst (1976), and Lopez and Bornhorst (1979) uncertain but includes their feldspathic sandstone member and lower volcanic sedimentary unit.



line shows approximate route of section measurement. Tscc = Chavez Canyon Member. Trh = Rock House Canyon Tuff

This report Chapin and cauldron-fill Sawmill Canvon Formation

Cook Spring, rhyolitic lavas of

(1) Northern Chupadera Mountains and southern part of Socorro Peak. (2) Cook Spring, approximately 2 mi (3.2 km) west-southwest of Socorro; sec. 15, T. 3 S., R. 1 W., unsurveyed, Socorro 71/2-min quadrangle. (3) New name. (4) Rhyolite lavas. domes. and minor associated pyroclastic rocks; local. (5) 29.4 ± 1.1 m.y. K-Ar biotite date. (6) Domes and flows within Luis Lopez Formation; fill of Socorro cauldron. (7) Local. (8) Formerly rhyolite of Blue Canyon (obsolete) and rhyolite of Highway Sixty (obsolete) of Chamberlin (1980). Correlative in age and stratigraphic position with rhyolite of Bianchi Ranch in southern Chupadera Mountains.

Council Rock, basaltic andesite of, member of the Popotosa Formation (1) Mulligan Gulch graben west of Magdalena. (2) Council Rock, approximately 15 mi (24 km) northwest of Magdalena; T. 2 S., R. 5 W., unsurveyed, Gallinas Peak 71/2-min quadrangle. (3) Chamberlin, 1974; and Wilkinson, 1976. (4) Basalt and basaltic-andesite ava flows: thin, erosional remnants scattered along Mulligan Gulch graben from Council Rock to Cat Mountain. (5) 17.4 m.y., average of two K-Ar whole-rock dates. (6) Caps piedmont gravels of Santa Fe Group that fill Mulligan Gulch graben; also caps Cat Mountain where it rests on South Canyon Tuff. (7) Dikes in Council Rock area. (8)

Crosby Mountain, tuff of [OBSOLETE] (2) Crosby Mountain, approximately 6 mi (10 km) southwest of Datil; sec. 25, T. 2 S.

R. 11 W., Sugarloaf Mountain 7½-min quadrangle. (3) Lopez, 1975. (9) Name abandoned by Bornhorst (1976) and Lopez and Bornhorst (1979) in favor of including this tuff within the volcaniclastic rocks of South Crosby Peak, herein referred to as the South Crosby Peak Formation.

Crosby Mountains, basaltic andesite of

(1) Crosby Mountains. (2) Crosby Mountains, approximately 6 mi (10 km) west of Datil; secs. 10, 11, T. 2 S., R. 11 W., Crosby Springs 7½-min quadrangle. (3) Bornhorst, 1976; and Lopez and Bornhorst, 1979. (4) Basaltic-andesite flows, thick but local. (5) 24.3 ± 0.6 m.y. K-Ar whole-rock date (Bornhorst and others, 1982). (6) Above Vicks Peak Tuff; below isolated remnants of an ash-flow tuff that caps mesa in SE1/4 sec. 2, T. 2 S., R. 11 W. and SE 1/4 sec. 18, T. 2 S., R. 11 W. This higher tuff may be South Canyon Tuff or a tuff from the west. (7) Unknown but probably local. (8) Correlative with northern outcrop area of basaltic andesite of Hidden Spring (Lopez and Bornhorst, 1979), secs. 1, 2, T. 2. S., R. 11 W.; stratigraphically equivalent to tongue b or c of La Jara Peak Basaltic Andesite but not considered here as part of La Jara Peak because of geographic separa-

(1) Present throughout northeast Mogollon-Datil volcanic field. (2) Datil Mountains. (3) Winchester (1920) introduced the term Datil Formation for "the Tertiary bedded volcanic rocks, sandstones, and conglomerates . . . which make up these mountains . 'These mountains' referred to the Datil, Gallinas, and Bear Mountains. The formation was named for the Datil Mountains, but the type section was measured at the north end of the Bear Mountains, Wilpolt and others (1946) removed the lower 684 ft (208 m) from Vinchester's Datil Formation and named them the Baca Formation (Eocene). Tonking (1957) subdivided the remaining Datil Formation into a basal Spears Member of volcaniclastic rocks, a medial Hells Mesa Member of welded tuffs, and an upper La Jara Peak Member of mafic lava flows. Willard (1959) removed the mafic lava flows from Tonking's Datil Formation, and Weber (1971) elevated the remaining Datil Formation (Spears and Hells Mesa Members) to group status. As detailed mapping progressed during the 1970's, geologists realized that other major ash-flow sheets and thick sequences of cauldron-fill rocks belonged to the stratigraphic interval of Weber's Datil Group but were not present at the type locality. Because these rocks vary in chemical and mineralogical characteristics, come from different source areas, and span a time interval of about 0 m.y., the Datil Group of Weber (1971) became untenable. For several years a gentlemam's agreement existed among various workers to abandon the term Datil or to use it only in an informal, catch-all sense. However, the term is so deeply entrenched in the literature that it seems impossible to kill it. Therefore, we have decided to redefine the term and use it to denote the group of rocks above the Baca Formation (Eocene) and below the Hells Mesa Tuff (restricted sense). The Datil Group represents the early volcaniclastic apron of the northeast Mogollon-Datil volcanic field and the volcanic rocks interbedded within it. Chemically and mineralogically, Datil rocks are similar in that they range from andesite to low-silica rhyolite in composition and generally lack phenocrystic quartz. The derlying Baca Formation and the overlying Hells Mesa Tuff are present throughou most of the northeast part of the volcanic field and provide a well-defined, easily recognized stratigraphic bracket for the Datil Group as here defined. A major advantage of this scheme is that the term Datil, after a long and confusing evolution, will return to a meaning similar to that for which it was coined: "The Tertiary bedded volcanic rocks, sandstones, and conglomerates . . . which make up these mountains" (Winchester, 1920, p. 2). The Datil Mountains are made up largely of volcanic and volcaniclastic rocks that tratigraphically lie between the Baca Formation (Eocene) and the Hells Mesa Tuff (Oligocene; see maps by Lopez and Bornhorst, 1979; Harrison, 1980). The Datil Group as here redefined includes the Spears Formation, which is mostly volcaniclastic rocks with minor lava flows, and several interbedded ash-flow tuff sheets, which are each given for mational names and type localities. (4) Volcaniclastic rocks (Spears Formation), lava lows, and ash-flow tuffs (Datil Well Tuff, Rock House Canyon Tuff, Blue Canyon uff, and tuff of Granite Mountain), all of intermediate composition and generally lacking quartz phenocrysts; thick and continuous. (5) About 39-33 m.y. based on several K-Ar and fission-track dates plus several K-Ar dates on the overlying Hells Mesa Tuff. (6)

Datil Well Tuff of the Datil Group

(1) Datil Mountains and northern Jornada del Muerto. (2) Datil Well Campground, approximately 1.2 mi (1.9 km) northwest of Datil; type section is on northeast side of White House Canyon across US-60 from Datil Well Campground; NW 1/4 SW 1/4 sec. 2, T. 2 S., R. 10 W., Datil 71/2-min quadrangle. (3) Lopez, 1975; Bornhorst, 1976; and Lopez and Bornhorst, 1979. (4) Rhyolite ash-flow tuff, moderately crystal rich; thin but relatively continuous in Datil Mountains; absent to east except for a few isolated remnants. (5) 36.7 m.y., average of a zircon fission-track date and a K-Ar sanidine date (Bornhorst and others, 1982), (6) Above Dog Springs Member of Spears Formation; below Rock House Canyon Tuff; interbedded with Chavez Canyon Member of Spears Formation. (7) Unographically similar to, and possibly correlative with, a tuff in the north ern Jornada del Muerto. See appropriate stratigraphic column.

Above Baca Formation; below Hells Mesa Tuff, (7) Unknown, (8) See discussion under

(3); equivalent to Rubio Peak Formation of southeast Mogollon-Datil volcanic field.

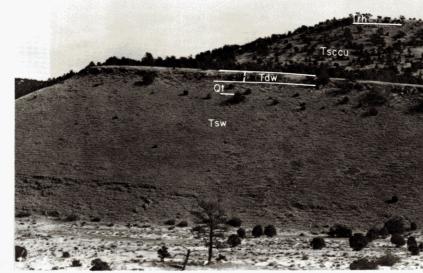


FIGURE 12—Type section of Datil Well Tuff. Route of section measurement was up cliff along dashed line, then across wide bench parallel to strike. Tsw = andesite of White House Canyon (informal member of Spears Formation), Qt = talus, Tdw = DatilWell Tuff, Tsccu = upper part of Chavez Canyon Member of Spears Formation, Trh = Rock House Canvon Tuff.

Deep Well, basaltic andesite of

(1) Datil Mountains and northwest Gallinas Mountains. (2) Outcrops near Deep Well windmill in northeast Datil Mountains, approximately 11 mi (17 km) northeast of Datil and 4 mi (6.4 km) due west of North Lake; sec. 6, T. 1 S., R. 8 W., unsurveyed, Dog Springs 7½-min quadrangle. (3) New name. (4) Basaltic-andesite lava flows, thin and discontinuous. (5) 30.9 ± 1.5 m.y. K-Ar whole-rock date. (6) Above La Jencia Tuff; below Vicks Peak Tuff. (7) Unknown. (8) Formerly called basaltic andesite of Twin Peaks by Lopez (1975), Lopez and Bornhorst (1979), Harrison (1980), and Coffin (1981). Stratigraphically equivalent to a tongue of La Jara Peak Basaltic Andesite but not considered here as part of La Jara Peak because of geographic separation.

Dog Springs Member of the Spears Formation of the Datil Group (1) Datil Mountains and northwest Gallinas Mountains. (2) Dog Springs Canyon in the northwest Gallinas Mountains, approximately 20 mi (32 km) northeast of Datil: S½, T. 2 N., R. 8 W., and north edge of T. 1 N., R. 8 W., unsurveyed, D Cross and Dog Springs 7½-min quadrangles. (3) Harrison, 1980; and Coffin, 1981. (4) Mudflow breccias, vol caniclastic rocks, and autobrecciated intrusive rocks of andesite to quartz-latite composition; includes numerous exotic blocks of Paleozoic limestones and autobrecciated Tertiary volcanic rocks; minor tuffaceous lacustrine rocks. (5) 39.6 ± 1.5 m.y. K-Ar date on biotite from a quartz-latite clast in lower part; 38.6 ± 1.5 m.y. zircon fission-track date on an andesite clast (Bornhorst and others, 1982). (6) Above Baca Formation; below lower interval of Chavez Canyon Member of Spears Formation. (7) Unknown except for local intrusives. (8) Andesite breccia and conglomerate unit of Spears Formation (Lopez and Bornhorst, 1979).

Dry Lake Canyon, fanglomerate of, member of the Popotosa Formation (1) Mulligan Gulch graben between Bear Mountains and Gallinas Mountains. (2) Dry Lake Canyon, approximately 8 mi (13 km) northwest of Magdalena; T. 1 S., R. 5 W., unsurveyed, Silver Hill 71/2-min quadrangle. (3) Brown, 1972; and Chapin and Seager, 1975. (4) Fanglomerate composed mainly of clasts derived from La Jara Peak Basaltic Andesite. (5) Not dated. (6) Above La Jara Peak Basaltic Andesite and an older facies of the Popotosa Formation; below Tertiary-Quaternary piedmont gravels. (7) N/A.

Goat Springs, tuff of [OBSOLETE] (2) Goat Springs, approximately 5 mi (8 km) north of Magdalena; SE1/4 sec. 26, T. 1 S., R. 4 W., Magdalena NW 7½-min quadrangle. (3) Brown, 1972. (9) Name abandoned by Deal (1973) and Simon (1973) in favor of Hells Mesa Tuff (restricted sense).

Granite Mountain, tuff of

(1) Magdalena, Lemitar, and Gallinas Mountains and Tres Montosas area. (2) East slope of Granite Mountain, approximately 1 mi (1.6 km) northeast of Magdalena; secs. 12, 13, T. 2 S., R. 4 W., Magdalena NW 7½-min quadrangle. (3) Wilkinson, 1976. (4) Crystalrich, quartz-latite ash-flow tuff; thick locally but of restricted lateral extent. (5) Not dated. (6) Interbedded in uppermost part or overlying the Spears Formation; overlain by Hells Mesa Tuff. (7) Unknown. (8) None. (9) Can be confused with, and locally may include, lower quartz-poor parts of the Hells Mesa Tuff.

Gray Hill, tuff of [OBSOLETE] (2) Gray Hill, approximately 15 mi (24 km) southwest of Magdalena; secs. 22, 27, T. 3 S., R. 6 W., Tres Montosas 71/2-min quadrangle. (3) Wilkinson, 1976. (9) Name abandoned in this report because most of unit is now correlated with lower member Lemitar Hardy Ridge, rhyolite of, member of the Luis Lopez Formation (1) Southwest Magdalena Mountains. (2) Hardy Ridge, the high ridge of the Magdalena

Mountains extending south from Langmuir Laboratory along the west side of Sawmill Canyon, approximately 16 mi (26 km) south of Magdalena; secs. 23, 24, 25, 26, 35, 36, T. 4 S., R. 4 W., South Baldy 7½-min quadrangle. (3) Petty, 1979; Bowring, 1980; and Roth, 1980. (4) A thick sequence of rhyolitic lavas and minor poorly welded ash-flow tuffs. (5) Not dated. (6) Above cauldron-facies Hells Mesa Tuff and other members of the Luis Lopez Formation; below Lemitar Tuff. (7) Local vents within the Socorro cauldron. (8) Informal member of the Luis Lopez Formation, the cauldron-fill unit of the Socorro cauldron. (9) Reduced to member status and restricted to rhyolitic units in western Magdalena Mountains upon discovery that the North Baldy and Socorro cauldrons are the same structure, making previous Hardy Ridge unit equivalent to Luis Lopez For-

Hells Mesa Tuff (1) Present throughout northeast Mogollon-Datil volcanic field except southern Chupa-

dera Mountains and northern Jornada del Muerto. (2) Hells Mesa in northeast Bear Mountains; type section approximately 17 mi (27 km) north-northwest of Magdalena and approximately 3.6 mi (5.7 km) northwest of Hells Mesa; center of side common to sec. 36, T. 2 N., R. 5 W. and sec. 31, T. 2 N., R. 4 W., Mesa Cencerro 71/2-min quadrangle. (3) Tonking, 1957; Deal, 1973; Simon, 1973; Chapin and Seager, 1975; Deal and Rhodes, 1976; and Lopez and Bornhorst, 1979. (4) Quartz-latite to rhyolite ash-flow tuff, thick and continuous (5) 33 1 m v. average of several K-Ar biotite dates, (6) Above all units of Datil Group; below La Jencia Tuff; overlain by volcaniclastic rocks of South Crosby Peak Formation in Datil area. (7) Socorro cauldron. (8) As originally defined by Tonking (1957), the Hells Mesa Member of the Datil Formation included all rhyolitic rocks between the Spears and La Jara Peak Members of the Datil Formation. Givens (1957) divided the Hells Mesa Member into seven units [Tdh₁ through Tdh₂]. Chapin (1971) raised the Hells Mesa to formation status. Brown (1972) divided the Hells Mesa Formation into a basal tuff of Goat Springs, a medial tuff of Bear Springs, and an upper tuff of Allen Well, Deal (1973) and Simon (1973) restricted the term Hells Mesa to the basal crystal-rich, quartz-rich ash-flow cooling unit of Tonking's Hells Mesa Member. This restricted definition has worked well and is retained here. Correlates with tuff of Rock Tank and tuff of Ary Ranch of Lopez and Bornhorst (1979). (9) The Hells Mesa Tuff is one of the thickest and most widespread ash-flow sheets of the Mogollon-Datil volcanic field. It also marks a compositional boundary in that rocks older than Hells Mesa tend to be intermediate in composition and lack quartz phenocrysts, whereas ash-flow tuffs of Hells Mesa and younger age tend to contain phenocrystic quartz



surement. Ts = Spears Formation, Thm = Hells Mesa Tuff, Tj = La Jencia Tuff, Tvp = Vicks Peak Tuff.

Hidden Spring, basaltic andesite of [OBSOLETE] (2) Hidden Spring in Crosby Mountains, approximately 6 mi (10 km) west of Datil; secs.

1, 2, T, 2 S., R, 11 W.; sec. 18, T, 2 S., R, 10 W., Crosby Springs 7½-min quadrangle. (3) Bornhorst, 1976; and Lopez and Bornhorst, 1979. (9) Abandoned in this report because unit is stratigraphic equivalent of basaltic andesites of Deep Well (Twin Peaks) and Crosby Mountains. Miscorrelation of the tuff capping mesas in SE¼ sec. 2, T. 2 S., R. 11 W. and SE 1/4 sec. 18, T. 2 S., R. 11 W. with their A-L Peak Tuff (Vicks Peak Tuff as used in this report) caused Lopez and Bornhorst (1979) to add an extra basaltic andesite unit to their stratigraphic column.

Highway Sixty, rhyolitic lavas of [OBSOLETE] (2) US-60, approximately 6 mi (10 km) southwest of Socorro; sec. 32, T. 3 S., R. 1 W.; sec. 6, T. 4 S., R. 1 W., Socorro 71/2-min quadrangle. (3) Chamberlin, 1980. (9) Name abandoned in this report because Highway Sixty is not sufficiently site specific. These rhyolitic lavas, domes, and minor pyroclastic rocks are part of the Luis Lopez Formation and are now included as a tongue of the rhyolitic layas of Cook Spring.

Kelly Ranch, basalt of, member of the Popotosa Formation (1) Rio Grande valley just north of Socorro Peak. (2) J. B. Kelly Ranch, approximately 5

mi (8 km) northwest of Socorro; secs. 20, 29, 30, T. 2 S., R. 1 W., Socorro 7½-min quadrangle. (3) Chamberlin. 1980, 1981. (4) Basalt flows, thin and discontinuous. (5) 9.3 + 0.5 m.y. K-Ar whole-rock date is probably too young. (6) Interbedded in the playa facies of the Popotosa Formation; stratigraphically below a tuff horizon believed to have come from the Strawberry Peak dome and dated at 11.9 + 0.8 m.y. (Kim Manley, unpublished fission-track date on zircon 1980). (7) Unknown but local. (8) None.

La Jara Peak Basaltic Andesite (1) Major shield volcano in Bear Mountains with equivalent flows present across the

northern edge of the Mogollon-Datil volcanic field from the Datil Mountains to the Joyita Hills. (2) La Jara Peak, a basaltic neck approximately 20 mi (32 km) north-northwest of Magdalena and approximately 2.5 mi (4 km) north of the Bear Mountains; the type section (Tonking, 1957) is approximately 3 mi (5 km) south-southwest of La Jara Peak; sec. 27, T. 2 N., R. 5 W., Mesa Cencerro 7½-min quadrangle. (3) Tonking, 1957; Chapin, 1971: Brown, 1972: Chapin and Seager, 1975; and Chapin and others, 1978. 1979. (4) Lava flows and dikes ranging from alkali basalt to andesite but predominantly basaltic andesite, thick and continuous. (5) Age ranges from about 31 to 24 m.y. on the basis of nine K-Ar whole-rock dates on flows and dikes and on the age range of ash-flow sheets that are interbedded with tongues of La Jara Peak. (6) Tongues of La Jara Peak Basaltic Andesite occur between La Jencia Tuff and Vicks Peak Tuff [Tlpa], between Vicks Peak Tuff and Lemitar Tuff [Tlpb], between Lemitar Tuff and South Canvon Tuff [Tlpc], and above South Canyon Tuff [Tlpd]. The uppermost tongue is sometimes interbedded with bolson sediments of the basal Popotosa Formation, (7) Major shield volcano and dike swarm in the Bear Mountains-Riley area, smaller volcano at Cerritos de las Minas east of Lemitar Mountains, and widely scattered local vents probable. (8) Named La Jara Peak Member of Datil Formation by Tonking (1957); separated from Datil Formation by Willard (1959): raised to formation status by Chapin (1971): tongues of La Jara Peak have been given informal local names by various authors, such as andesite of Rosa de Castillo (Spradlin, 1976). (9) The basaltic neck after which La Jara Peak Basaltic Andesite was named is a Pliocene feature (3.6  $\pm$  0.2 m.y. K-Ar whole-rock date) completely unrelated to the late Oligocene-early Miocene basaltic andesites. This is unfortunate, but because the name is so well established and so few features are named on maps of that area, we have decided to retain it.

La Jencia Creek, tuff of [OBSOLETE] 2) La Jencia Creek, approximately 3 mi (5 km) northwest of Magdalena; secs. 9, 16, T. 2 S., R. 4 W., Silver Hill 71/2-min quadrangle. (3) Simon, 1973. (9) Abandoned in this re-

port because outcrops were found to be Lemitar Tuff.

Jencia Tuff

 Present throughout the northeast Mogollon-Datil volcanic field. (2) La Jencia Basin; good exposures are present along both sides of the basin in the Bear and Lemitar Mountains; type section is in southern Bear Mountains approximately 6.5 mi (10.5 km) north of Magdalena; NW 1/4 sec. 22, T. 1 S., R. 4 W., Magdalena NW 7 1/2-min quadrangle. See Brown (1972) for measured section. (3) Middle part of Tonking's (1957) Hells Mesa Member of Datil Formation; lower part of tuff of Bear Springs of Brown (1972); later miscorrelated with tuffs on A-L Peak in the San Mateo Mountains by Deal (1973), and Chapin and Deal (1976), and widely referred to as the lower member of the A-L Peak by other authors. (4) Rhyolite ash-flow tuffs, crystal-poor. (5) About 31 m.y. as evidenced by a 30.9 ± 1.5 m.y. K-Ar whole-rock date on the basaltic andesite of Deep Well (Twin Peaks) that overlies the unit; age also constrained by 33.1 m.y. age of underlying Helli Mesa Tuff and 30.2 ± 1.1 m.y. K-Ar biotite date on tuff of Caronita Canyon and 29.7 ± 1.1 m.y. biotite date on a bedded tuff, both of which are in cauldron fill of Sawmill Canyon cauldron from which La Jencia Tuff was erupted. (6) Above Hells Mesa Tuff; below Vicks Peak Tuff; interbedded with tongues of La Jara Peak Basaltic Andesite. (7) Erupted from contemporaneous Sawmill Canyon and Magdalena cauldrons. (8) Outflow sheet is correlative with the original type section of Brown's (1972) lower unit of the tuff of Bear Springs and with the middle part of Tonking's (1957) Hells Mesa Member of the Datil Formation. La Jencia Tuff is not present on nor near A-L Peak, which is made up of a thick section of South Canyon Tuff. Hence, the term A-L Peak has been abandoned

Landavaso Reservoir, andesite of, member of the Sawmill Canyon Formation (1) Magdalena area. (2) Landavaso Reservoir, approximately 4 mi (6 km) southwest of Magdalena; sec. 36, T. 2 S., R. 5 W., Arroyo Landavaso 7½-min quadrangle. (3) Simon. 1973; Chapin and Seager, 1975; and Wilkinson, 1976. (4) Andesite flows of variable composition and character. (5) Not dated. (6) Above La Jencia Tuff; below Lemitar Tuff. (7) Local vents within the Sawmill Canyon and Magdalena cauldrons. (8) Informal member of Sawmill Canyon Formation, the cauldron-fill unit of the contemporaneous Sawmill Canyon and Magdalena cauldrons. (9) Some outcrops originally mapped as Landavaso Reservoir by Chamberlin (1974) and possibly the westernmost outcrops mapped as Landavaso Reservoir by Wilkinson (1976) are a similar but much younger stratigraphic unit now called the andesite of Lion Mountain.

(1) San Mateo, Magdalena, Lemitar, and Chupadera Mountains, Joyita Hills and northern Jornada del Muerto; missing in Bear, Gallinas, and Datil Mountains. (2) Lemitar

Mountains, approximately 8 mi (13 km) northwest of Socorro; NW 4SE 4SE 4 sec. 12, Γ. 2 S., R. 2 W., Lemitar 7½-min quadrangle. (3) Osburn, 1978; and Chapin and others, 1978. See Chamberlin (1980) for type section. (4) Rhyolite ash-flow tuffs; crystal-poor ower member grades upward to crystal-rich upper member; thick and continuous. (5) 28.4 m.y., average of four K-Ar biotite dates. (6) Above Vicks Peak Tuff; below South Canyon Tuff; underlain and overlain by tongues of La Jara Peak Basaltic Andesite on outflow sheet. Above Sawmill Canyon Formation in Sawmill Canyon and Magdalena cauldrons where Vicks Peak Tuff is apparently absent. (7) Probably a cauldron in the northern San Mateo Mountains. (8) Part of Potato Canyon Rhyolite of Deal (1973), tuff of Allen Well (Brown, 1972; and Simon, 1973), tuff of La Jencia Creek (Simon, 1973), and part of upper tuffs (Simon, 1973); not present at type section of Tonking's (1957) Hells Mesa Member of Datil Formation.

Lion Mountain, andesite of (1) Western edge of Gallinas Mountains from US-60 north for approximately 9 mi (14.5 km), (2) Lion Mountain, approximately 16 mi (26 km) east-northeast of Datil; secs. 34, 35, T. 1 S., R. 7 W., unsurveyed, Lion Mountain 7½-min quadrangle. (3) Osburn and Laroche, 1982. (4) Porphyritic andesite lavas; thick local flows. (5) Not dated. (6) Overlies South Canyon Tuff; unconstrained upper contact. (7) Local sources. (8) Correlates with andesite of Landavaso Reservoir of Chamberlin (1974) and perhaps with westernmost outcrops of Landavaso Reservoir of Wilkinson (1976). (9) Similar in lithology to turkey-track andesites in the Spears Formation.

(1) Socorro Peak and Chupadera and Magdalena Mountains. (2) Luis Lopez manganese listrict, approximately 11 mi (18 km) southwest of Socorro and 7 mi (11 km) southwest of the village of Luis Lopez; secs. 20, 29, 31, 32, T. 4 S., R. 1 W.; secs. 4, 5, 6, 8, 9, T. 5 S., R. 1 W., Luis Lopez 71/2-min quadrangle. (3) Chapin and others, 1978; Chamberlin, 980, 1981; and Eggleston, 1982. (4) Cauldron-fill unit of Socorro cauldron; includes hyolite domes and flows, local ash-flow tuffs, volcaniclastic rocks, breccias, andesite lows, and intrusives; very thick but restricted to Socorro cauldron and immediate vicinty. (5) Not dated. (6) Above Hells Mesa Tuff; below La Jencia Tuff. (7) Local vents in Socorro cauldron. (8) Unit of Hardy Ridge (Petty, 1979; Bowring, 1980; and Roth, 1980); Luis Lopez Formation placed too high in section by Chapin and others (1978) and Chamberlin (1980) because of miscorrelation of cauldron-facies Hells Mesa Tuff with upper member Lemitar Tuff.

Madera Canyon, basalt of, member of the Popotosa Formation (1) Eastern Magdalena Mountains, (2) Madera Canyon, approximately 13 mi (21 km) southwest of Socorro; sec. 21, T. 4 S., R. 2 W., Molino Peak 7½-min quadrangle. (3) Osburn and others, 1981. (4) Basaltic lava flows, thin to thick, discontinuous, local. (5) Not dated. (6) Above South Canyon Tuff; below rhyolite of Pound Ranch, Socorro Peak Rhyolite. (7) Unknown but local. (8) None.

agdalena Peak Rhyolite of the Santa Fe Group ) West flank of Magdalena Range. (2) Magdalena Peak, approximately 1.25-5 mi (2-8 (m) south of Magdalena; sec. 34, T. 2 S., R. 4 W.; secs. 2, 3, 10, 11, 14, 15, T. 3 S., R. 4 W., Magdalena SW 71/2-min quadrangle. (3) Allen, 1979; Bowring, 1980; Donze, 1980; Bobrow, 1983; and Bobrow and others, 1983. (4) Rhyolite domes and flows; thick and continuous for approximately 10 mi (16 km), (5) 14.8 m.y., average of two K-Ar biotite dates. (6) Above fanglomerates of Popotosa Formation: erosional top. (7) Magdalena Peak: other vents may be found. (8) None. (9) Similar in age and petrographic character to Pound Ranch and Socorro Peak rhyolites.

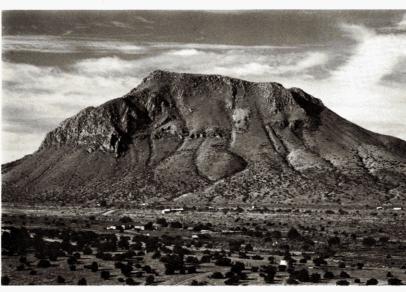


FIGURE 14-MAGDALENA PEAK, TYPE AREA FOR MAGDALENA PEAK RHYOLITE. A plug of intrusive rhyolite fills the former vent and forms the rugged nonlayered area on the left (SE) shoulder. The prominent ledge to the right (NW) of the vent is well-indurated pyroclastic material from an early violent stage of the eruptions. The upper third of the mountain consists of rhyolitic lavas, which piled up around the vent; silicic lavas from this vent also flowed several miles to the south to form one of the larger rhyolite lava fields in New Mexico.

Main Canyon, tuff of [OBSOLETE] (2) Main Canyon in Datil Mountains, approximately 6 mi (10 km) north of Datil; secs. 1, 12, T. 1 S., R. 10 W., Datil 71/2-min quadrangle. (3) Lopez, 1975; and Lopez and Bornhorst, 1979. (9) Abandoned here in favor of Rock House Canyon Tuff because name preempted by prior use elsewhere.

Nipple Mountain, tuff of IOBSOLETEL Nipple Mountain, approximately 4 mi (6 km) northeast of Magdalena; sec. 1, T. 2 S. R. 4 W., Magdalena NW 71/2-min quadrangle. (3) Brown, 1972; Chamberlin, 1974; and Wilkinson, 1976. (9) Abandoned here in favor of Rock House Canyon Tuff because relationships are better exposed in Rock House Canyon.

Piñon Well, rhyolite of

(1) Southwest Gallinas Mountains. Occurs from US-60 north for approximately 5 mi (8 km), (2) Piñon well, approximately 20 mi (32 km) west of Magdalena; sec. 8, T. 1 S., R. 6 W., unsurveyed, Gallinas Peak 7½-min quadrangle. (3) Osburn and Laroche, 1982. (4) Quartz-latite to rhyolite layas: local unit. (5) Not dated. (6) Overlies La Jencia Tuff (inferred since contact nowhere exposed) and overlain by South Canyon Tuff. (7) Local vents. (8) Correlative in age with Sawmill Canyon Formation. (9) Similar in mineralogy to La Jencia Tuff

Popotosa Formation of the Santa Fe Group

1) Socorro-Magdalena area. (2) Cañada Popotosa, a tributary of the Rio Salado that drains the southeast side of the Ladron Mountains, approximately 22 mi (35 km) northwest of Socorro; T. 2 N., R. 2 W., unsurveyed, San Acacia 71/2-min quadrangle. (3) Denny, 1940; Bruning, 1973; Chapin and Seager, 1975; Machette, 1978; Chapin and others, 1978; and Chamberlin, 1980. (4) Bolson deposits ranging from fanglomerates to playa mudstones; volcanic clasts predominate; interbedded volcanic rocks; thick and continuous, (5) Age ranges from about 27 m.y. to about 7 m.y. as evidenced by flows of La Jara Peak Basaltic Andesite, dated at 27.0 and 27.3 m.y., that are interbedded with basal Popotosa and by rhyolitic domes and flows as young as 7 m.y. that are interbedded with upper Popotosa in Socorro Peak area, (6) Generally above South Canyon Tuff although Popotosa-like sediments occur beneath the South Canyon Tuff in the northern Gallinas Mountains: below upper beds of Santa Fe Group and below Sierra Ladrones Formation (Machette, 1978); interbedded with La Jara Peak Basaltic Andesite at base: also interlayered with two major volcanic units of formation rank, the Socorro Peak Rhyolite and the Magdalena Peak Rhyolite; and including as members several other volcanic and volcaniclastic units of local extent. These are the unit of Arroyo Montosa, the fanglomerate of Dry Lake Canyon, the rhyolite of Water Canyon Mesa, the basaltic andesite of Council Rock, the basalt of Kelly Ranch, and the basalt of Bear Canyon. Other volcanic units, including the basalt of Broken Tank and the basalt of Sedillo Hill. are of uncertain age but may be within the age span of the Popotosa Formation. (7) N/A. (8) Late Oligocene to late Miocene basal portion of Santa Fe Group; commonly lumped with other Santa Fe units as Santa Fe undifferentiated; miscorrelated with Spears Formation by DeBrine and others (1963).

Potato Canyon Rhyolite Tuff [OBSOLETE]

(2) Potato Canyon in northern San Mateo Mountains, approximately 20 mi (32 km) southwest of Magdalena; sec. 12, T. 5 S., R. 6 W., Mount Withington 71/2-min quadrangle. (3) Deal, 1973; Deal and Rhodes, 1976; Chapin and Seager, 1975; and Wilkinson, 1976. (9) Abandoned in this report because unit is mixture of South Canyon Tuff, Lemitar Tuff, La Jencia Tuff, Hells Mesa Tuff, and tuff of Caronita Canyon. The type locality contains South Canyon Tuff; the other units were miscorrelated with this unit in other parts of the San Mateo Mountains.

Pound Ranch, rhyolite of, member of the Socorro Peak Rhyolite (1) Eastern Magdalena Mountains. (2) Pound (Gianero) Ranch, approximately 12 mi (19 km) southwest of Socorro; secs. 3, 4, 9, 10, 15, 16, T. 4 S., R. 2 W., Molino Peak 71/2min quadrangle. (3) Osburn, 1978; Petty, 1979; Chapin and others, 1978; and Chamberlin, 1980. (4) Rhyolite flows, domes, and minor tuffs; thick but local. (5) Lower flow,  $12.1 \pm 0.5$  m.y. K-Ar biotite date; upper flow,  $10.8 \pm 0.4$  m.y. K-Ar biotite date. (6) Unconformably above South Canyon Tuff, basalt of Madera Canyon, and lower Popotosa fanglomerates and mudflow deposits; below upper Popotosa playa mudstones. (7) Local vents. (8) Similar in age and lithology to some flows of Socorro Peak Rhyolite;

lumped with Socorro Peak Rhyolite by Chapin and others (1978).

Rincon Windmill Member of the Spears Formation (1) Datil and Gallinas Mountains. (2) Rincon windmill in northeast Datil Mountains, approximately 14 mi (22.5 km) northeast of Datil; type section at NW 1/4 NW 1/4 sec. 18, T. 1 N., R. 8 W., unsurveyed, Dog Springs 71/2-min quadrangle. (3) New name; Harrison, 1980. (4) Volcaniclastic sandstones and conglomerates; widespread fluvial and eolian sandstones at top; thick and widespread. (5) Not dated. (6) Above Rock House Canyon Tuff; below Hells Mesa Tuff. Locally split into two tongues by interbedded Blue Canyo Tuff. (7) N/A. (8) Middle and upper sedimentary units of Lopez (1975), second and third volcanic sedimentary units of Bornhorst (1976), upper part of volcaniclastic sedimentar

unit A and volcaniclastic sedimentary unit B of Lopez and Bornhorst (1979), middle sedi-

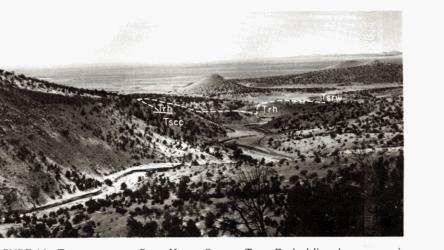
mentary unit of Harrison (1980), and middle volcaniclastic rocks of Coffin (1981).



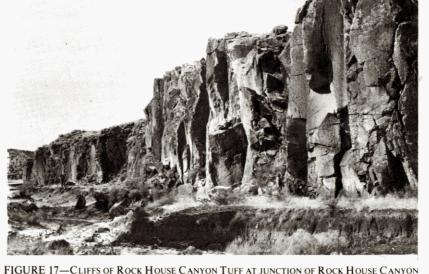
FIGURE 15—Type Section of Rincon Windmill Member of Spears Formation. Dashed line shows approximate route of section measurement. Trh = Rock House Canyon Tuff Tsrwl = lower part of Rincon Windmill Member, Tbc = Blue Canyon Tuff, Tsrwu = upper part of Rincon Windmill Member, Thm = Hells Mesa Tuff.

Rock House Canvon Tuff of the Datil Group (1) Datil, Gallinas, Crosby, and Magdalena Mountains and Tres Montosas-Magdalena

km) northeast of Datil; type section at junction of Rock House Canyon and Long Canvon; SW 1/4 sec. 13, T. 1 N., R. 8 W., unsurveyed, Dog Springs 71/2-min quadrangle. (3) Coffin, 1981. (4) Rhyolite ash-flow tuff, crystal poor; relatively thick and continuous in Datil and Gallinas Mountains and Tres Montosas area; thins to east and is usually absent east of the Magdalena area. (5) Not dated. (6) Above Chavez Canyon Member of Spears Formation; below Rincon Windmill Member of Spears Formation. (7) Unknown. (8) Tuff of Nipple Mountain; tuff of Main Canyon.



mate route of section measurement. Tscc = Chavez Canyon Member of Spears Forma-Formation. Plains of San Agustin in distance.



AND LONG CANYON (FOREGROUND).

secs. 35, 36, T. 2 S., R. 11 W.; secs. 1, 2, T. 3 S., R. 11 W., Sugarloaf Mountain 7 ½-min quadrangle, (3) Bornhorst, 1976; and Lopez and Bornhorst, 1979, (9) Abandoned in this report because unit is correlative with Hells Mesa Tuff. The tuff of Rock Tank and the tuff of Ary Ranch (Lopez and Bornhorst, 1979) are indistinguishable and are part of the outflow sheet of the Hells Mesa Tuff.

Rock Tank Canvon, conglomerate of (1) Northeast end of Datil Mountains. (2) Rock Tank Canyon, approximately 20 mi (32 km) northeast of Datil and approximately 6 mi (10 km) southeast of D Cross Mountain;

T. 2 N., R. 8 W., unsurveyed, D Cross Mountain 7½-min quadrangle. (3) Robinson, 1981. (4) Conglomerates and sandstones, thick but local. (5) Not dated. (6) Above Spears, Baca, and Crevasse Canyon Formations; below Quaternary gravels. (7) N/A. (8) Part of gravel deposits assigned to Santa Fe Formation by Givens (1957); part of Tertiary piedmont deposits of Harrison (1980). (9) Stratigraphic position within Santa Fe Group

Rosa de Castillo, andesite of, tongue of La Jara Peak Basaltic Andesite (1) Joyita Hills. (2) Arroyo Rosa de Castillo in the Joyita Hills, approximately 12 mi (19 km) north-northeast of Socorro; Sevilleta Grant, T. 1 S., R. 1 E., unsurveyed, Mesa del Yeso 7½-min quadrangle. (3) Spradlin, 1976. (4) Basaltic-andesite lava flows. (5) Not dated. (6) Above Lemitar Tuff; below South Canyon Tuff. (7) Unknown. (8) Equivalent to tongue c of La Jara Peak Basaltic Andesite.

San Acacia, basalt of, member of the Sierra Ladrones Formation

(1) Rio Grande valley. (2) San Acacia, approximately 14 mi (22 km) north of Socorro; T 1 S., R. 1 E., unsurveyed, San Acacia 7 ½ min quadrangle, (3) Machette, 1978, (4) Basaltic flows, thin and local. (5) 4.6  $\pm$  0.1 m.y. K-Ar whole-rock date (Bachman and Mehnert, 1978). (6) Interbedded in lowest exposed part of piedmont-slope and alluvialflat deposits of the Sierra Ladrones Formation, (7) Feeder dike exposed at southwest con ner of mesa on north side of Rio Grande. (8) None.

Santa Fe Group

(1) Present in all basins of the northeast Mogollon-Datil volcanic field. (2) Santa Fe, Española Basin. (3) Hayden, 1869; Bryan, 1938; Denny, 1940; Baldwin, 1963; Hawley and others, 1969; Galusha and Blick, 1971; Hawley, 1978; and Machette, 1978. (4) Bolson deposits ranging from fanglomerates to playa mudstones, interbedded volcanic rocks, axial-river deposits of the ancestral Rio Grande, and laterally equivalent piedmont gravels. (5) Late Oligocene to middle Pleistocene. (6) Above South Canyon Tuff and La Jara Peak Basaltic Andesite; below middle Pleistocene to Holocene deposits that postdate the incision of drainage following capture of the Rio Grande at El Paso. (7) N/A. (8) Arbitrary geographic boundary between Santa Fe Group and Gila Formation placed at Continental Divide. (9) The Santa Fe Group is the basin-fill deposits of the Rio Grande rift and adjacent late Cenozoic basins. In the Socorro-Magdalena area, it consists of the very thick and complex Popotosa Formation (Denny, 1940) overlain by the Pliocene to middle Pleistocene Sierra Ladrones Formation (Machette, 1978). We are here defining the Santa Fe Group to include synrift volcanic units, the Magdalena Peak Rhyolite, Socorro Peak Rhyolite, and several local lava flows: basalts of Socorro Canyon, Sedillo Hill, Broken Tank, Bear Canyon, and Kelly Ranch; rhyolite of Water Canyon Mesa; basaltic andesite of Council Rock; fanglomerate of Dry Lake Canyon; and unit of Arroyo Montosa. See Santa Fe Group stratigraphic column. The alluvial deposits of the San Agustin Basin and northern Jornada del Muerto Basin are not exposed and have not

Sawmill Canyon Formation (1) Magdalena Mountains. (2) Exposures along Sawmill Canyon in the southern Magda

lena Mountains, approximately 16 mi (26 km) southeast of Magdalena; secs. 3, 4, 9, 100, 11, 14, 15, T. 5 S., R. 3 W., South Baldy 71/2-min quadrangle. (3) Formerly unit of Sixmile Canyon (Osburn, 1978; and Chapin and others, 1978). (4) Complex cauldron-fill unit of the contemporaneous Sawmill Canyon and Magdalena cauldrons; andesite flows, rhyolite flows and domes, exotic blocks, and volcaniclastic rocks; tuff of Caronita Canyon at top. (5) About 31-29 m.y. as evidenced by 31 m.y. age of both basaltic andesite of Deep Well and Vicks Peak Tuff, a 29.7 ± 1.1 m.y. K-Ar biotite date on a bedded tuff within the cauldron fill, and a 30.2 ± 1.1 m.y. K-Ar biotite date on tuff of Caronita Canyon at the top of the cauldron fill. (6) Above La Jencia Tuff; below Lemitar Tuff. (7) Local vents in Sawmill Canyon and Magdalena cauldrons. (8) Unit of Sixmile Canyon. Informal members include andesite of Landavaso Reservoir and tuff of Caronita Canyon. Name Sawmill Canyon Formation used by Krewedl (1974) for La Jencia Tuff of this

Sawmill Canyon, unit of [OBSOLETE] (2) Sawmill Canyon in the southern Magdalena Mountains, approximately 18 mi (29

Baldy 7½-min quadrangle. (3) Roth, 1980; and Donze, 1980. (9) Name abandoned in this report because of duplication with Sawmill Canyon Formation (new name). The rhyolite intrusives and pyroclastic deposits for which Roth and Donze used the term unit of Sawmill Canyon are local rocks that will be given a different informal name when mapping of the southern Magdalena Range is completed. Sedillo Hill, basalt of (1) Socorro Peak area. (2) Sedillo Hill on US-60, approximately 9 mi (14 km) southwest

km) south of Magdalena; secs. 30, 31, 32, T. 4 S., R. 3 W.; sec. 5, T. 5 S., R. 3 W., South

of Socorro; secs. 14, 15, 23, 26, T. 3 S., R. 2 W., Magdalena SE 7½-min quadrangle. (3) Chapin and others, 1978; and Chamberlin, 1980, 1981. (4) Basaltic lava flows, thin and local. (5) Not dated. (6) Above playa claystone facies of Popotosa Formation; below piedmont gravels of La Jencia Basin, which are probably equivalent to Sierra Ladrones Formation. (7) Two local vents. (8) Previously correlated (Chapin and others, 1978; and Chamberlin, 1980, 1981) with basalt of Socorro Canyon, but this correlation is now in doubt. (9) Because of reservations about the above correlation, we have given the basalt flows on Black Mountain the informal designation basalt of Socorro Canyon until further work can prove or disprove the correlation. Sierra Ladrones Formation of the Santa Fe Group

(1) Rio Grande valley. (2) Exposures in the Sierra Ladrones (low foothills east and southeast of the Ladron Mountains), approximately 25 mi (40 km) north-northwest of Socorro; T. 1, 2 N., R. 1, 2 W., unsurveyed, San Acacia 71/2-min quadrangle. (3)

Machette, 1978; Chapin and others, 1978; and Chamberlin, 1980. (4) Axial-river sands of the ancestral Rio Grande plus related floodplain, piedmont, and alluvial-fan deposits; thick and continuous along Rio Grande valley. (5) Early Pliocene to middle Pleistocene based on K-Ar ages of interbedded basalts, vertebrate fossils, and soils data (Machette, 1978). (6) Above Popotosa Formation; below middle Pleistocene to Holocene deposits that postdate incision of the ancestral Rio Grande deposits. (7) N/A. (8) Upper formation of Santa Fe Group. Sixmile Canyon andesite [OBSOLETE]

(2) Sixmile Canyon in eastern Magdalena Mountains, approximately 11 mi (18 km)

southeast of Magdalena; sec. 4, T. 4 S., R. 3 W., unsurveyed, South Baldy 7½-min

port in favor of Sawmill Canyon Formation because of better exposures and a more rep-

resentative cross section of the cauldron-fill stratigraphy in the Sawmill Canyon cauldron

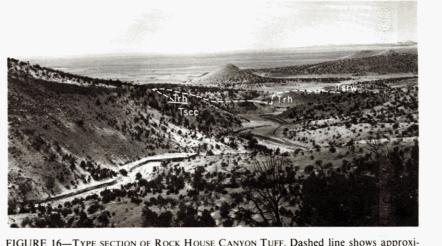
quadrangle. (3) Krewedl, 1974. (9) Name changed by Osburn (1978) and Chapin and others (1978) to unit of Sixmile Canyon to include all postcollapse cauldron-fill units of the Sawmill Canyon cauldron. Name abandoned here in favor of Sawmill Canyon For-

and because the name has been preempted by prior use elsewhere.

(2) Sixmile Canyon in eastern Magdalena Mountains, approximately 11 mi (18 km) southeast of Magdalena; secs. 3, 10, T. 4 S., R. 3 W., unsurveyed, South Baldy 7½-min quadrangle. (3) Osburn, 1978; and Chapin and others, 1978. (9) Abandoned in this re-

Sixmile Canyon, unit of [OBSOLETE]

(1) Socorro Peak area. (2) Socorro Canyon, approximately 6 mi (10 km) southwest of area. (2) Rock House Canyon in northwest Gallinas Mountains, approximately 15 mi (24 Socorro; secs. 27, 30, T. 3 S., R. 1 W., Socorro 7½-min quadrangle. (3) Previously called Sedillo Hill, but this correlation is uncertain. (8) Basalt of Sedillo Hill(?).



tion, Trh = Rock House Canyon Tuff, Tsrw = Rincon Windmill Member of Spears

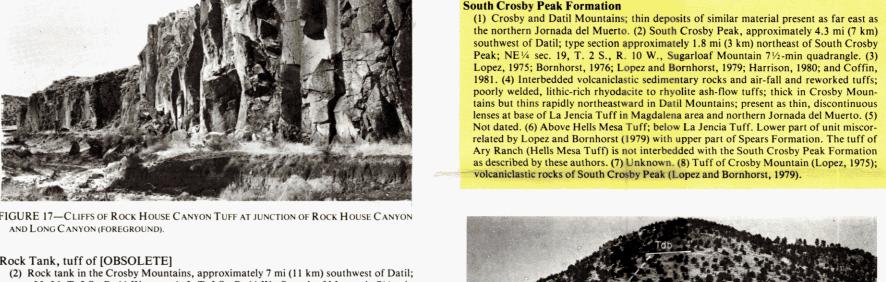


FIGURE 18—Type Section of South Crosby Peak Formation. Dashed line shows approximate route of section measurement. **Tscp** = South Crosby Peak Formation, **Tdb** =

Socorro Canvon, basalt of, member of the Sierra Ladrones Formation

as evidenced by several K-Ar dates. (6) Above Popotosa fanglomerate and playa de-

(1) Present throughout the northeast Mogollon-Datil volcanic field except in the Datil

crystal poor to moderately crystal rich, thick and continuous. (5) 26.7 m.y., average o

posits; interbedded with upper Popotosa playa mudstones. Includes rhyolite of Pound

Socorro Peak Rhyolite of the Santa Fe Group

slightly younger than Magdalena Peak Rhyolite.

South Baldy Peak andesite [OBSOLETE]

Basaltic Andesite (western one third of area).

South Canvon Tuff

of Chamberlin (1974).

Spears Formation of the Datil Group (1) Present throughout northeast Mogollon-Datil volcanic field. (2) Spears Ranch on

basaltic andesite of Deep Well.

northeast side of Bear Mountains, approximately 14 mi (22 km) north of Magdalena: secs. 8, 17, T. 1 N., R. 4 W., Mesa Cencerro 7½-min quadrangle. (3) Spears Member of Datil Formation (Tonking, 1957); Spears Formation (Chapin, 1971; Brown, 1972; Chamberlin, 1974; Wilkinson, 1976; Spradlin, 1976; and Chapin and others, 1978). (4) Volcaniclastic rocks consisting mainly of andesitic to latitic clasts and subordinate lava flows of basaltic andesite to dacite composition. (5) About 39-33 m.y. as evidenced by several K-Ar and fission-track dates and the age of the overlying Hells Mesa Tuff (6) Above Baca Formation (Eocene); below Hells Mesa Tuff. As used here, the Spears Formation includes all volcaniclastic rocks and lava flows between the underlying Baca Formation and the overlying Hells Mesa Tuff. In the Datil and Gallinas Mountains, the Spears volcaniclastic rocks have been divided into three members, which, in ascending order, are the Dog Springs, Chavez Canyon, and Rincon Windmill Members. Elsewhere, the Spears Formation has not been split into members. Three regional ash-flow sheets. the Datil Well Tuff, Rock House Canyon Tuff, and Blue Canyon Tuff, are interbedded in the Spears Formation. Together, the Spears Formation and the interbedded ash-flow sheets comprise the Datil Group as defined herein. (7) Vent areas not known except for several intrusives in the Dog Springs Member and an andesitic volcano in the Gallinas Mountains. (8) Spears Member of Datil Formation (Tonking, 1957); Lopez and Bornhorst (1979) used the following terms, from bottom up, to describe various units within the Spears: andesite breccia and conglomerate unit, andesitic flows and volcaniclastic rocks, volcaniclastic sedimentary unit A, volcaniclastic sedimentary unit B.

Timber Peak rhyolite [OBSOLETE] (2) Timber Peak in central Magdalena Mountains, approximately 11 mi (18 km) south of

Magdalena; sec. 9, T. 4 S., R. 3 W., unsurveyed, South Baldy 7½-min quadrangle. (3) Krewedl, 1974. (9) Abandoned here because several different ash-flow tuffs and local lavas were included in this unit. Twin Peaks, basaltic andesite of [OBSOLETE]

W., Datil 7½-min quadrangle. (3) Lopez, 1975; Lopez and Bornhorst, 1979; Harrison,

1980; and Coffin, 1981. (9) Abandoned in this report because overlying Vicks Peak Tuff

is not present at type locality. Without this upper constraint these rocks could be correla-

tive with the basaltic andesite of Crosby Mountains. Type section moved to better con-

strained locality near Deep Well windmill approximately 10 mi (16 km) to the northeast.

(1) Southern San Mateo, Datil, Gallinas, Bear, Lemitar, and Magdalena Mountains and

the Joyita Hills. Also present in northern Black Range. (2) Vicks Peak, the high point at

Unit renamed basaltic andesite of Deep Well.

Vicks Peak Tuff

the south end of the San Mateo Mountains, approximately 42 mi (68 km) south-southwest of Magdalena; secs. 2, 11, T. 9 S., R. 6 W., Vicks Peak 7½-min quadrangle. (3) Rhyolite of Vicks Peak (Furlow, 1965) and Vicks Peak Rhyolite (Farkas, 1969); redefined by Deal and Rhodes (1976). (4) Rhyolite ash-flow tuff, crystal poor, quartz poor. A distinctive tuff in the southern San Mateo Mountains where the cauldron facies and thick proximal facies are very crystal poor and pumice poor with abundant lithophysal cavities. This distinctive facies of the Vicks Peak Tuff thins rapidly north of San Juan Peak in the central San Mateo Mountains and loses most of its lithophysal cavities. To the north, the very crystal poor facies comprises only the basal part of the unit and changes gradationally upward into tuff that contains more crystals and pumice and is very similar in appearance to the underlying La Jencia Tuff. However, the pumice in the Vicks Peak Tuff tends to be larger and usually contains drusy fillings of quartz and other vapor-phase crystals. (5) 31.3 ± 2.6 m.y. zircon fission-track date (Bornhorst and others, 1982). (6) Above La Jencia Tuff; below Lemitar Tuff. (7) Nogal Canyon cauldron. (8) Equivalent to Brown's (1972) upper tuff of Bear Springs, upper part of Tonking's (1957) Hells Mesa Member, upper or pinnacles member of Deal's (1973) A-L Peak Tuff. (9) We considered using upper member La Jencia Tuff for this unit but decided in favor of Vicks Peak Tuff because of historic precedent and because of the distance separating the cauldron sources of La Jencia and Vicks Peak Tuffs. The type section on Vicks Peak is poorly constrained; therefore, Brown's (1972) measured section of the upper tuff of Bear Springs (S1/2 sec. 22, T. 1 S., R. 4 W., Magdalena NW 71/2-min quadrangle) is here declared a principal reference section.

Wahoo Canyon, tuff of [OBSOLETE] (2) Wahoo Canyon near Dusty in northern Black Range, approximately 36 mi (58 km)

south-southeast of Datil; secs. 2, 3, 4, 9, 10, 11, T. 8 S., R. 9 W., Dusty 71/2-min quadrangle. (3) Fodor, 1976; and Lopez and Bornhorst, 1979. (9) Abandoned here because type locality consists of La Jencia and Vicks Peak Tuffs. Where mapped in the Datil Mountains by Lopez and Bornhorst (1979), tuff of Wahoo Canyon is the Vicks Peak Tuff.

(1) Eastern Magdalena Range. (2) Water Canyon Mesa, approximately 15 mi (24 km) west of Socorro; secs. 25, 26, 35, 36, T. 3 S., R. 3 W., Magdalena SE 71/2-min quadrangle. (3) Osburn, 1978; and Chapin and others, 1978. (4) Silicic lavas and tuffs, thick but local. (5) 20.5 ± 0.8 m.y. K-Ar biotite date. (6) Above interval of mafic to intermediate lavas that overlie South Canyon Tuff; below fanglomerate and mudflow de-

Water Canyon Mesa, rhyolite of, member of the Popotosa Formation

upper Lemitar Tuff. (7) Unknown but local. (8) Water Canyon Mesa lavas (Osburn, White House Canyon, andesite of, member of the Spears Formation

dated. (6) Above volcaniclastic rocks of Spears Formation; below Datil Well Tuff. (7)

Unknown but local. (8) Informal member of Spears Formation.

Mexico Bureau of Mines and Mineral Resources, Bulletin 41, 67 pp.

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