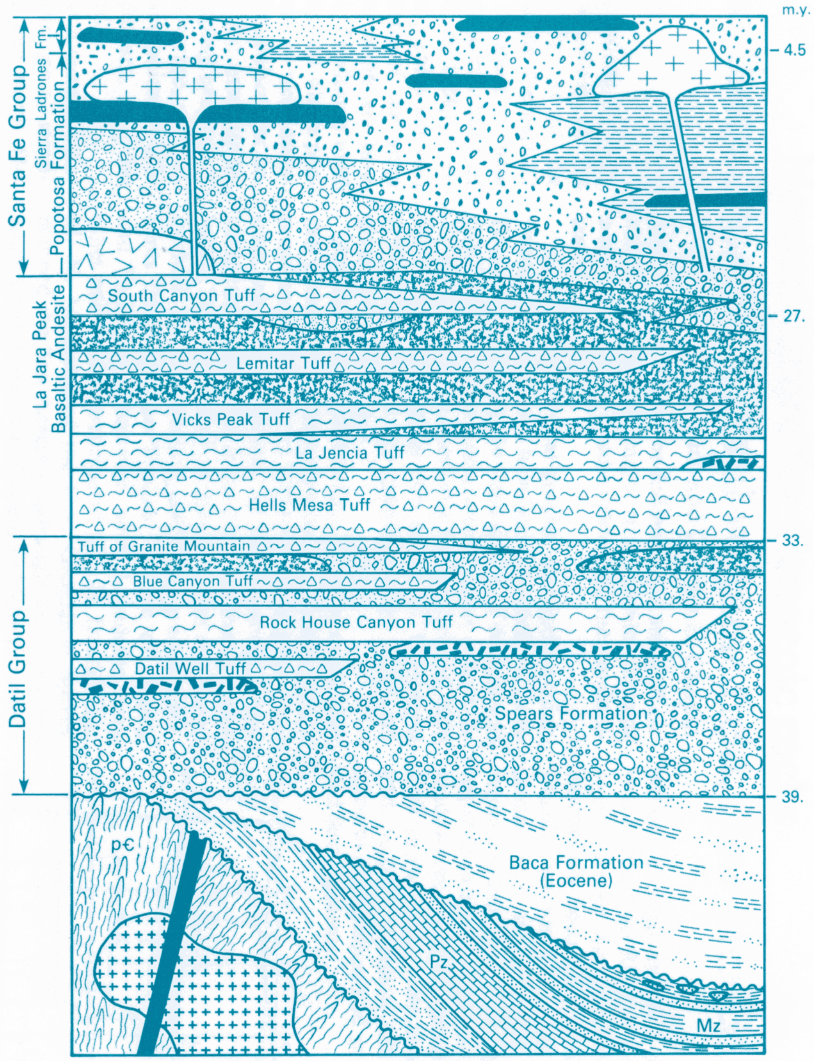
Nomenclature for Cenozoic rocks of northeast Mogollon–Datil volcanic field, New Mexico

by GLENN R. OSBURN and CHARLES E. CHAPIN



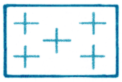
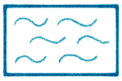
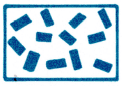
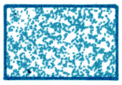
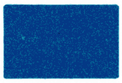
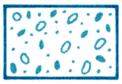
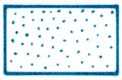
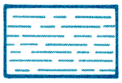
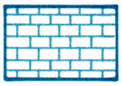
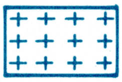
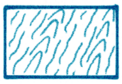
Generalized stratigraphic column for the northeast Mogollon–Datil volcanic field, New Mexico

STRATIGRAPHIC CHART 1 New Mexico Bureau of Mines & Mineral Resources 1983

A DIVISION OF

NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY

LITHOLOGIC SYMBOLS

	Rhyolite lavas and domes
	Rhyolite lavas and domes
	Rhyolite ash-flow tuff, crystal rich
	Rhyolite ash-flow tuff, crystal poor
	Andesite, plagioclase porphyritic
	Andesite and basaltic andesite
	Basalt and diabase
	Conglomerate, coarse and mudflow deposits
	Conglomerate, fine
	Sandstone
	Shale and mudstone
	Limestone
	Plutonic granitic rock
	Metamorphic rock

Stratigraphic Chart 1

New Mexico Bureau of Mines & Mineral Resources

A DIVISION OF
NEW MEXICO INSTITUTE OF MINING & TECHNOLOGY
1983

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

by Glenn R. Osburn and Charles E. Chapin

Introduction

A sequence of lithologically distinct, rock-stratigraphic units has been delineated in the Socorro–Magdalena–Datil area (fig. 1) of the Mogollon–Datil volcanic field during the past 12 yrs. Informal names were used for most of these units while the mapping was in progress. Most of the area has now been mapped at 1:24,000 or larger, and the stratigraphic relationships are well established. Therefore, descriptions of the units and formalization of the nomenclature are now presented in Stratigraphic Chart 1. Previously used stratigraphic names have been retained where possible; however, several existing names were abandoned because they had been used elsewhere, or because multiple names existed for the same stratigraphic unit, or because, as mapping progressed from reconnaissance to detailed coverage, particular units became untenable stratigraphically. Obsolete units are listed in the glossary, and the reasons for abandonment are stated.

This chart has been prepared as a concise summary so that the essential information on all stratigraphic units will be available in one place. The front of the sheet presents general supportive figures including location maps, an index to mapping, and stratigraphic columns describing currently accepted stratigraphic units. These stratigraphic columns are organized into three sections: the Santa Fe Group and interbedded volcanic rocks, outflow-volcanic units, and cauldron-related rocks. On the reverse side of the sheet are a glossary listing both current and obsolete nomenclature, a correlation diagram illustrating the chronologic development of the nomenclature, and a reference list; more detailed descriptions of type sections or type areas for those units being formalized are enclosed separately. The chart will be followed by a series of circulars examining the major stratigraphic units and a series of 7½-min quadrangles using the standardized nomenclature.

In the following stratigraphic descriptions thicknesses given in meters have been rounded off to reflect approximately the same degree of accuracy as that implied by the measurements given in feet. K-Ar ages have been corrected for the revised 1976 IUGS constants using the tables of Dalrymple (1979). References for published age dates are given in the glossary.

ACKNOWLEDGMENTS—The data base supporting this sheet and the ensuing circulars consists of approximately 500 mi² (1,300 km²) of detailed mapping, which includes most of the exposures of volcanic rocks within an area of approximately 3,000 mi² (7,760 km²). Most of this work was completed as thesis and dissertation studies by graduate students from the New Mexico Institute of Mining and Technology; however, several students from other universities participated (fig. 2). In addition, M. N. Machette of the U.S. Geological Survey mapped the San Acacia quadrangle and provided much assistance on the Pliocene to Holocene stratigraphy. J. W. Hawley of the New Mexico Bureau of Mines and Mineral Resources also helped to solve problems at the upper end of the stratigraphic column. Individual study areas are shown in fig. 2, and each study is listed in table 1. We are deeply indebted to these people for their contributions.

The New Mexico Bureau of Mines and Mineral Resources supported most of the thesis and dissertation projects through research assistantships, summer field support, maps and photographs, and use of field vehicles in the more rugged terrain. Research grants to C. E. Chapin from the New Mexico Energy Institute were a major help in supporting geologic mapping of the Socorro geothermal area and the Riley–Alamo area. The U.S. Geological Survey also contributed some funds toward Machette's Socorro 1° x 2° quadrangle project. Finally, we wish to thank the exploration companies who made major contributions to our understanding of the stratigraphy by allowing us to log their drill cuttings and cores and the numerous landowners who graciously allowed us access to their private lands. We hope that this publication and the ones to follow will significantly aid both mineral exploration and ground-water evaluation and development.

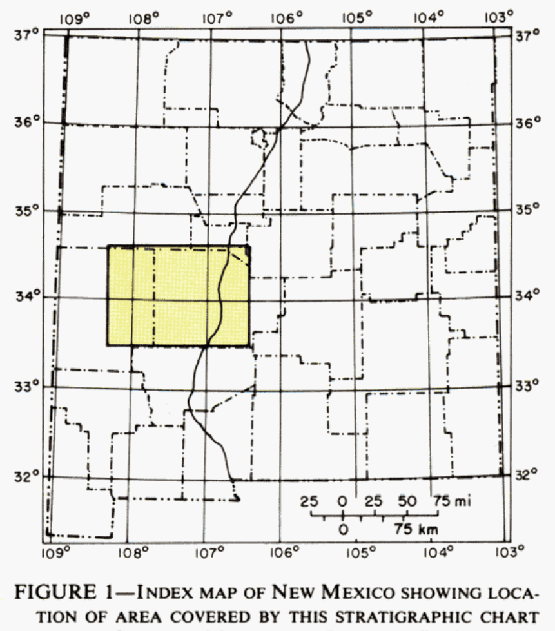


FIGURE 1—INDEX MAP OF NEW MEXICO SHOWING LOCATION OF AREA COVERED BY THIS STRATIGRAPHIC CHART AND THE SOCORRO-MAGDALENA PROJECT (fig. 2).

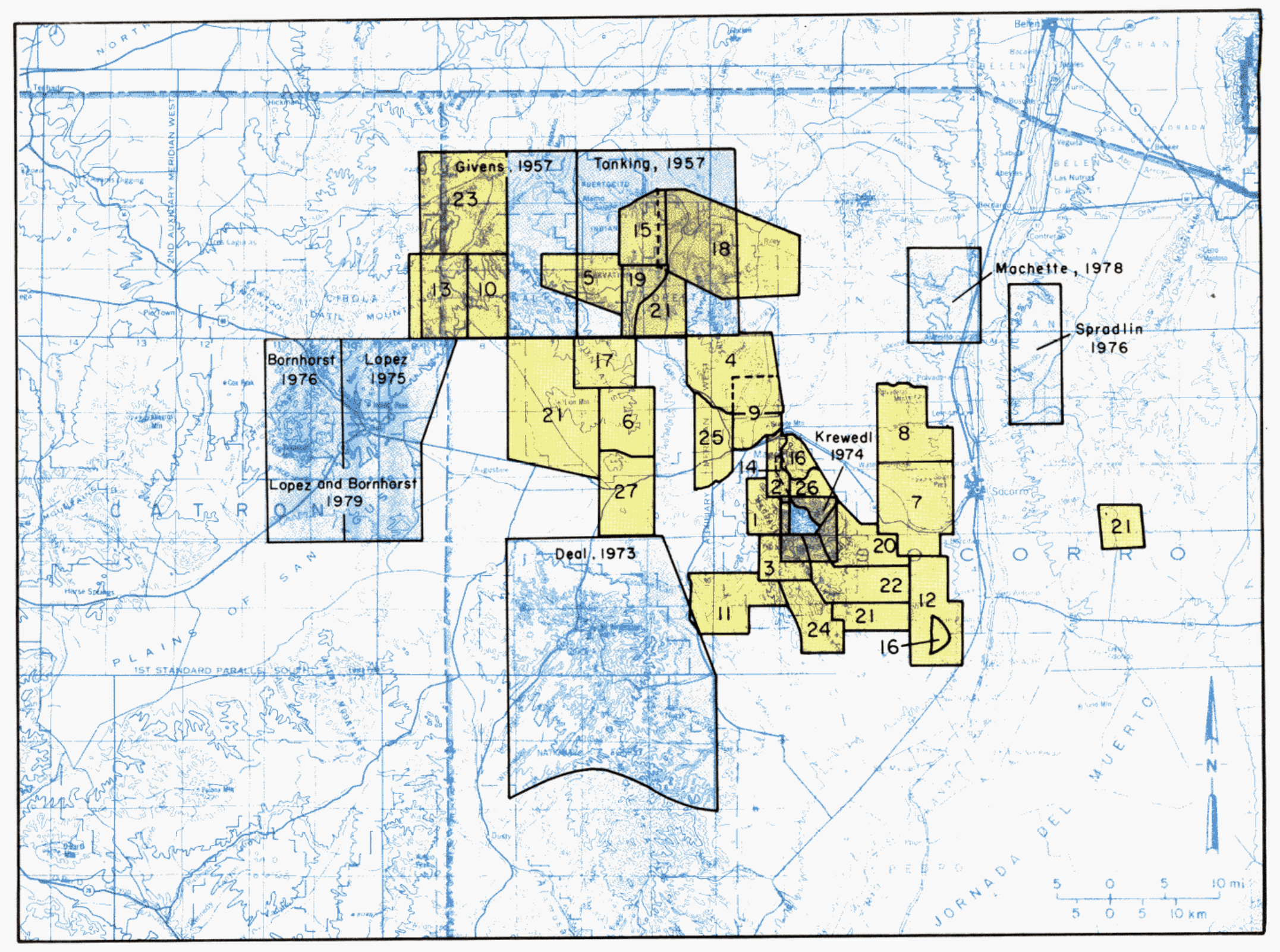


FIGURE 2—LOCATION MAP SHOWING MAJOR GEOLOGIC STUDIES THAT PROVIDE DATA BASE FOR THIS CHART. Areas screened in pale yellow are studies carried out within the New Mexico Bureau of Mines and Mineral Resources Socorro–Magdalena Project. These consist of 23 M.S. thesis projects and five Ph.D. dissertation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

TABLE 1—SOCORRO-MAGDALENA PROJECT STUDIES; NMIMT, New Mexico Institute of Mining and Technology; NMBMMR, New Mexico Bureau of Mines and Mineral Resources.

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

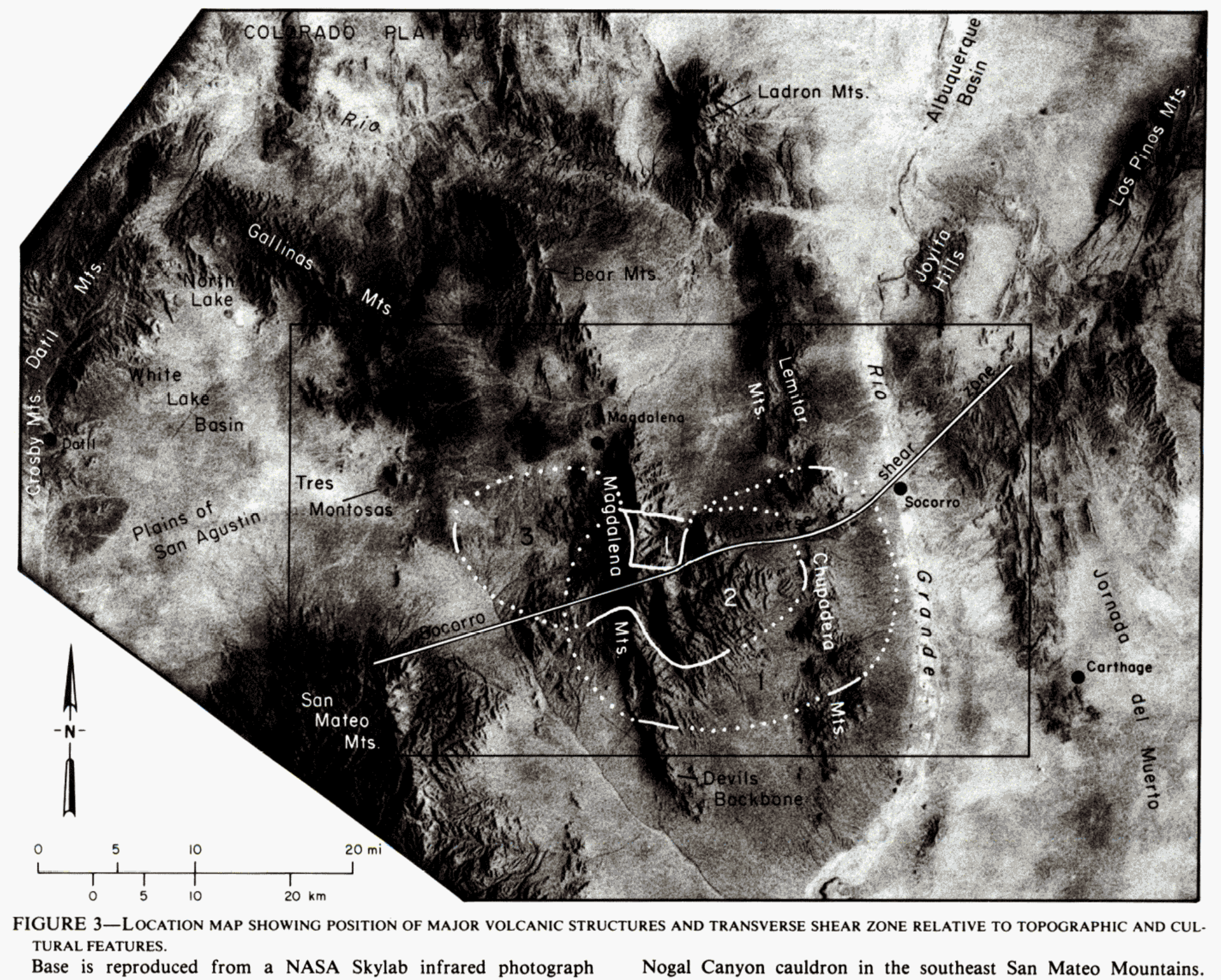
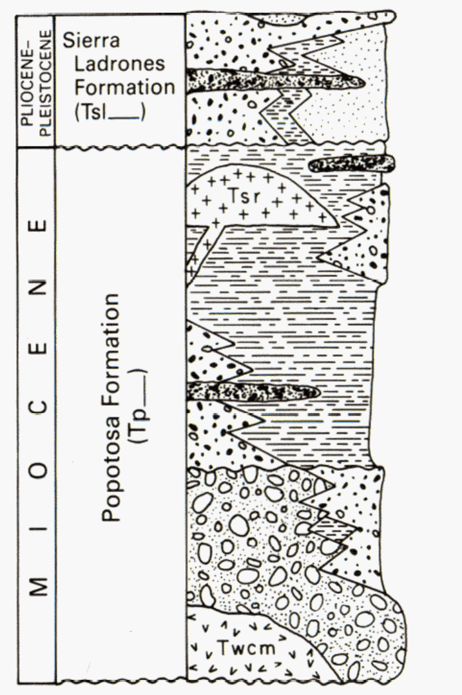


FIGURE 3—LOCATION MAP SHOWING POSITION OF MAJOR VOLCANIC STRUCTURES AND TRANSVERSE SHEAR ZONE RELATIVE TO TOPOGRAPHIC AND CULTURAL FEATURES. Base is reproduced from a NASA Skylab infrared photograph (G30A026195000). Solid lines mark exposed cauldron-wall segments; cauldron-margin intervals inferred beneath younger units are dotted. The Socorro cauldron (1) is the source for the Hells Mesa Tuff, and the composite Sawmill Canyon–Magdalena cauldrons (2 and 3) are thought to be the sources for La Jencia Tuff. The overlying Vicks Peak Tuff of Elston (1976) is thought to have been erupted from the Nogal Canyon cauldron in the southeast San Mateo Mountains. 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 boundary between fields of tilted fault blocks that have undergone rotation in opposite directions (Chapin and others, 1978).

Santa Fe Group

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



Sierra Ladrones Formation [Machette, 1978]—0–1,000 ft (0–300 m); piedmont-slope, river-channel, and floodplain deposits.

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 siltstones. 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 Socorro Canyon. Flows commonly contain sparse olivine and pyroxene phenocrysts and typically have a seriate texture. May be 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 lavas.

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 sandstones.

Bolson deposits interbedded locally with contemporaneous volcanic rocks. Near Socorro the lowermost rocks are usually red, well-indurated 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 flows.

Grayish-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.

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

Rhyodacite to rhyolite lava flows, domes, and minor associated pyroclastic rocks. Domes of this unit make up Strawberry Peak (12.1 ± 0.5 m.y.), Radar Peak (11.5 ± 1.0 m.y.), Signal Flag Hill (10.8 ± 0.4 m.y.), Stonewall Hill (10.6 ± 1.5 m.y.), 6001 Mesa (10.3 ± 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 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 ± 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 (1–3%), biotite (1–3%), and traces of hornblende.

Upper flow—10.8 ± 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 from a different source.

Kelly Ranch, basalt of [Chamberlin, 1980; eastern Lemitar Mountains]—0–165 ft (0–50 m) composite of all flows; basaltic lava flows.

Grayish-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 ± 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 porphyritic. 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 Magdalena Mountains (Bruning, 1973).

Arroyo Montosa, unit of [Simon, 1973; Mulligan Gulch west of Magdalena]—volcanic and sedimentary rocks.

Volcanic facies—25.9 ± 1.2 m.y.; 0–100 ft (0–30 m); lava flows.

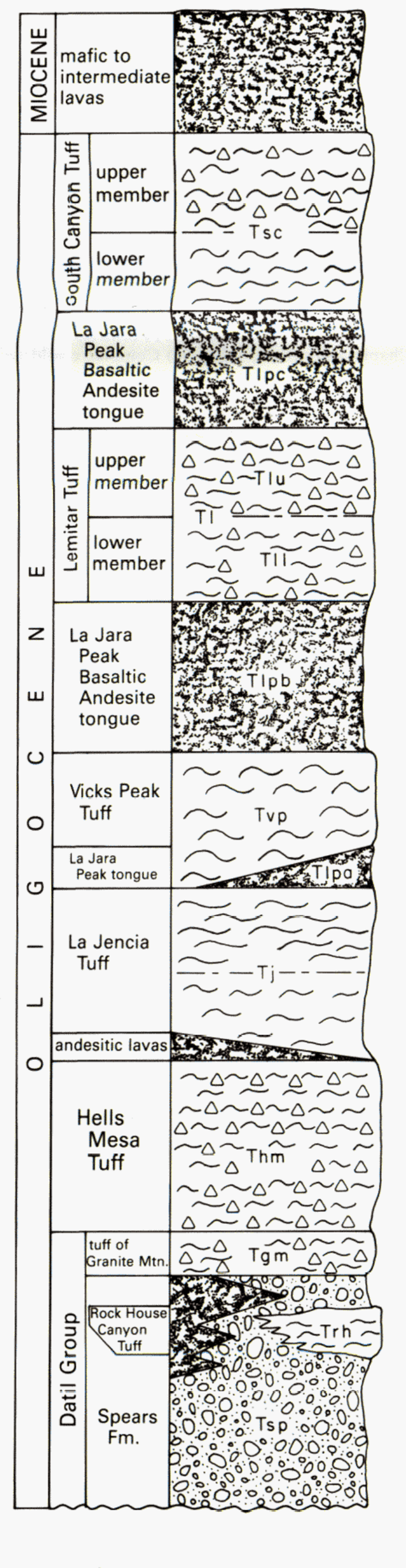
Light-gray to reddish-gray, porphyritic lava flows of intermediate composition. Contain 20–30% phenocrysts of plagioclase, sanidine (2–15%), quartz (1–3%), and traces of highly altered biotite and hornblende. Plagioclase phenocrysts reach 1.5 inches (3.8 cm) in length.

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



Intermediate and mafic lavas.

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

South Canyon Tuff [Osburn, 1978]—26.7 m.y., average of 2 dates; 0–650 ft (0–200 m); ash-flow tuffs.

Simple to compound cooling unit of quartz-rich, one-feldspar rhyolite tuff. Lower member of light-gray to brownish-gray, crystal-poor (1–4%) tuff and an upper member of medium-gray to purple-gray, moderately crystal-rich (15–25%), one-feldspar tuff with abundant chatoyant sanidine and euhedral quartz. The two members are usually mapped together. Source unknown.

La Jara Peak Basaltic Andesite [Tonking, 1957]—0–600 ft (0–180 m); basaltic-andesite lavas.

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

Lemitar Tuff [Osburn, 1978; Chamberlin, 1980]—28.4 m.y., average of 4 dates; 0–400 ft (0–125 m) outflow; 800–2,000 ft (250–600 m) in Sawmill Canyon–Magdalena cauldrons; ash-flow tuffs.

Simple to compound cooling unit of densely welded tuff showing strong compositional zoning. Usually divided into lower, light-gray to pale-red, crystal-poor (10–15%), rhyolitic member and an upper, medium-red to light-yellowish-gray, crystal-rich member. The upper member is zoned from a lower, plagioclase-rich, quartz-poor, quartz latite at the base to a quartz-rich rhyolite at the top. In general, the lower member is thin and restricted in distribution on the outflow sheet and thick where the unit has puddled in older cauldrons. Source is probably in northern or central San Mateo Mountains.

La Jara Peak Basaltic Andesite—0–100 ft (0–30 m); basaltic-andesite lavas.

This tongue is present in the Lemitar, Gallinas, and Bear Mountains and in the Joyita Hills; absent in Chupadera, Magdalena, and central San Mateo Mountains.

Vicks Peak Tuff [Deal and Rhodes, 1976]—31.3 ± 2.6 m.y.; 0–800 ft (0–250 m) outflow; ash-flow tuffs.

Multiple-flow, simple cooling unit of densely welded, crystal-poor, one-feldspar ash-flow tuff. Lower gray, very densely welded, commonly lithophysal, very crystal poor interval grades upward into a less crystal-poor interval containing abundant large pumice, which often contain euhedral vapor-phase minerals. Upper interval not present in south and central San Mateo Mountains. Equivalent to former upper member A-L Peak Tuff and upper member tuff of Bear Springs.

La Jara Peak Basaltic Andesite—0–100 ft (0–30 m); basaltic-andesite lavas.

This tongue is present in the Lemitar, Bear, and Gallinas Mountains and in the Joyita Hills. Equivalent stratigraphic unit, the basaltic andesite of Deep Well, present in the Datil Mountains.

Sawmill Canyon Formation [Tx_].

Overlies La Jencia Tuff within the Sawmill Canyon–Magdalena cauldrons. See *Cauldron stratigraphy* section.

La Jencia Tuff [new name; formerly lower member A-L Peak Tuff]—30.9 ± 1.5 m.y., date on overlying basaltic andesite of Deep Well; 0–500 ft (0–150 m) outflow; >2,500 ft (>750 m) cauldron facies; ash-flow tuffs.

Multiple-flow, compound cooling unit of densely welded, crystal-poor, often flow-lineated, one-feldspar tuff. Lower pumice-poor interval grades upward into a flow-banded interval that typically has strongly lineated pumice. Unit erupted from interconnected Sawmill Canyon and Magdalena cauldrons. The intracauldron member is well exposed in the Sawmill Canyon cauldron. These two cauldrons were later filled by the Sawmill Canyon Formation. See *Cauldron stratigraphy* section.

Andesite to basaltic-andesite lava flows—0–300 ft (0–90 m).

Unnamed 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; > 3,000 ft (>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 quartz, and traces of pyroxene.

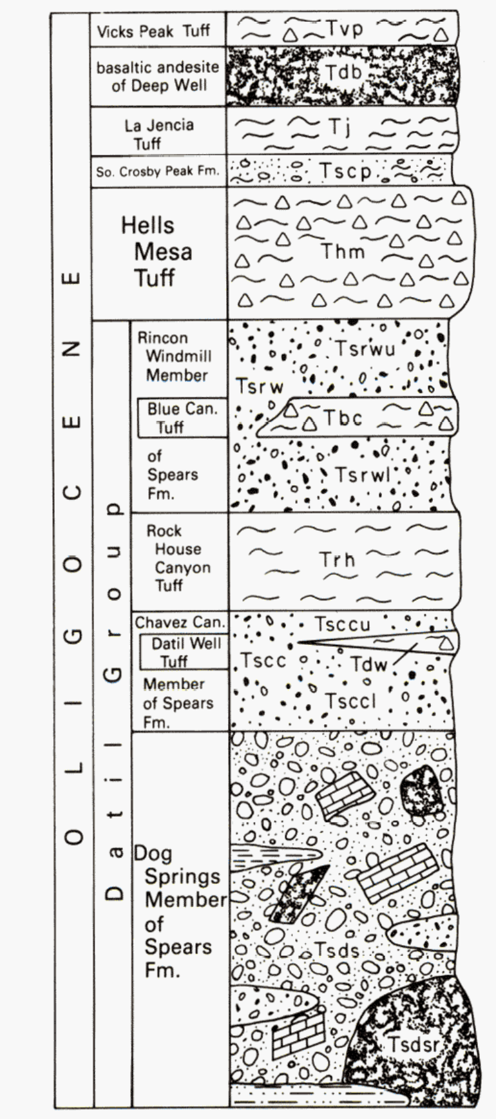
Rock House Canyon Tuff [new name; formerly tuff of Main Canyon, tuff of Nipple Mountain]—0–350 ft (0–107 m); ash-flow tuffs.

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.

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

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 ± 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 hornblende.

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 column.

Datil Group—39.6–33.1 m.y., range of several dates.

Includes Spears Formation and all intercalated ash-flow tuffs.

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-flow tuffs.

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.

Rock House Canyon Tuff [new name; formerly tuff of Main Canyon; tuff of Nipple Mountain]—0–350 ft (0–107 m); ash-flow tuffs.

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 rocks. Transport directions are to the north and northeast.

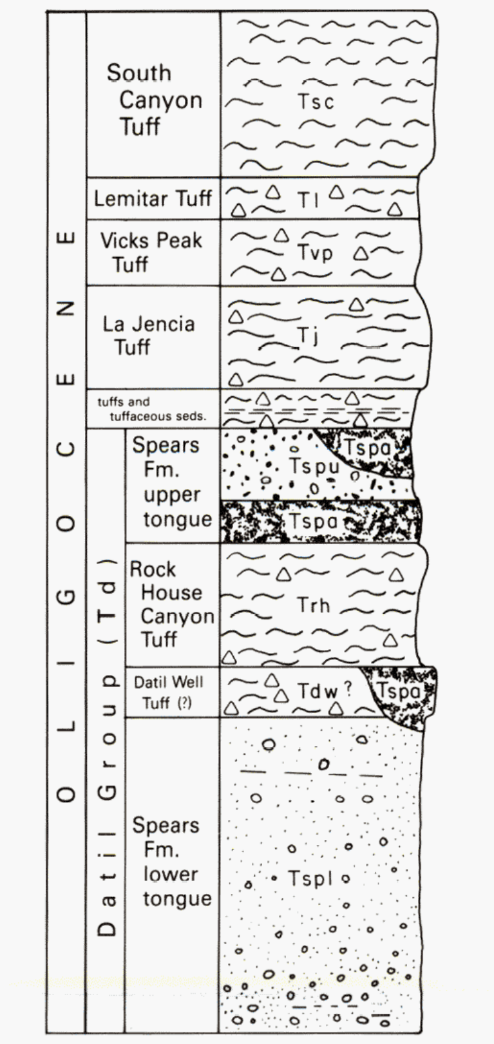
Datil Well Tuff [Lopez, 1975; Lopez and Bornhorst, 1979]—36.7 m.y., average of 2 dates; 0–80 ft (0–25 m); ash-flow tuffs.

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



South Canyon Tuff [Osburn, 1978]—26.7 m.y., average of 2 dates; 0–650 ft (0–200 m); ash-flow tuffs.

Simple cooling unit of quartz-rich, one-feldspar rhyolite tuff. Only the lower member of light-gray to brownish-gray, uniformly crystal poor (1–4%) tuff is found here. The upper member of moderately crystal-rich (15–25%) tuff found in other areas is absent. See first stratigraphic column, *Outflow volcanic units.*

Lemitar Tuff [Osburn, 1978; Chamberlin, 1980]—28.4 m.y., average of 4 dates; 0–200 ft (0–60 m); ash-flow tuffs.

Simple to compound cooling unit of buff to light-brown, poorly to moderately welded tuff. Both members (see first stratigraphic column, *Outflow volcanic units*) are present, but the upper crystal-rich member is thin and restricted in distribution. Thickness of tuff apparently controlled by paleotopography.

Vicks Peak Tuff [Deal and Rhodes, 1976; equivalent to former upper member A-L Peak Tuff]—31.3 ± 2.6 m.y.; 0–350 ft (0–107 m); ash-flow tuffs.

Simple cooling unit of poorly to moderately welded, crystal-poor, one-feldspar tuff. Typically contains large pumice with prominent vapor-phase minerals near top. Thought to have been erupted from Nogal Canyon cauldron in southern San Mateo Mountains.

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 sanidine and quartz.

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 and plagioclase.

Rock House Canyon Tuff [new name; formerly tuff of Main Canyon; tuff of Nipple Mountain]—0–350 ft (0–107 m); ash-flow tuffs.

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.

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 clinopyroxene 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 mudstones.

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

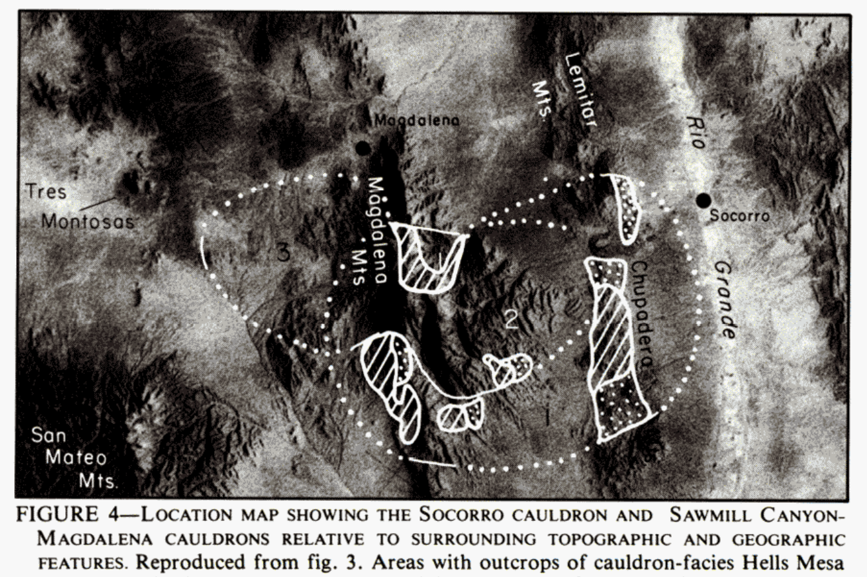


FIGURE 4—LOCATION MAP SHOWING THE SOCORRO CAULDRON AND SAWMILL CANYON-MAGDALENA CAULDRONS RELATIVE TO SURROUNDING TOPOGRAPHIC AND GEOGRAPHIC FEATURES. Reproduced from fig. 3. Areas with outcrops of cauldron-facies Hells Mesa Tuff shown in lined pattern; areas containing outcrops of cauldron-filling Luis Lopez Formation shown in stippled pattern.

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

Tz **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

Tzh 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, crystal-poor interval and an upper, pale-pink, crystal-free interval separated 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. Both lavas contain abundant spherulitic devitrification textures. The spherulites in the lower lava tend to be small, 0.4 inch (1 cm) or less, whereas those in the upper lava are larger, up to 4 inches (10 cm), and often have well-developed rinds (Bowring, 1980).

Tza Andesitic lavas—0–440 ft (0–130 m).

Dark-gray to spotted, aphanitic, andesitic lavas. Occur in one location between the Hells Mesa Tuff and overlying crystal-free, rhyolite lava; other occurrences observed between the two varieties of rhyolite. Correlation between the two outcrop areas is uncertain. Similar to andesites of Luis Lopez Formation in other areas.

Stratigraphic units in northern Chupadera Mountains and on Socorro Peak

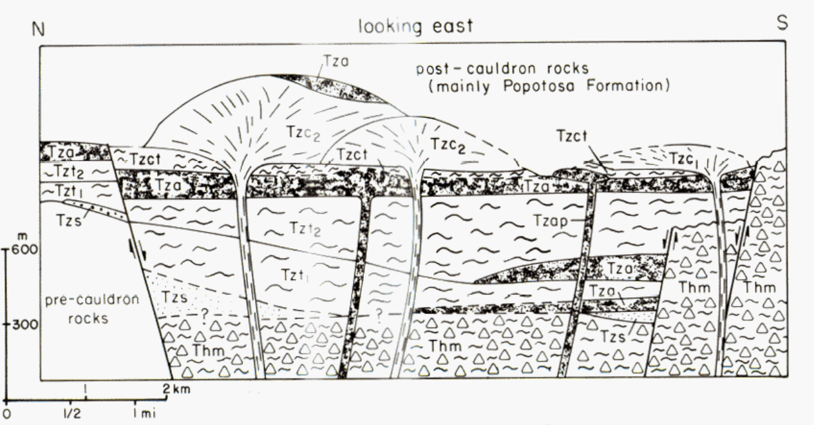


FIGURE 5—STRATIGRAPHIC RELATIONSHIPS OF LUIS LOPEZ FORMATION IN NORTHERN CHUPADERA MOUNTAINS AND SOCORRO PEAK AREA. Data from Chamberlin (1980).

Tzc$_2$ Cook Spring, rhyolitic lavas of, upper member [new name; formerly 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 Socorro Peak between Blue Canyon and the area just northeast of M Mountain.

Tzc$_1$ Cook Spring, rhyolitic lavas of, lower member [new name; formerly rhyolitic lavas of Highway Sixty]—29.4 ± 1.1 m.y.; rhyolitic lavas and tuffs.

Light-gray to pinkish-gray, finely flow banded, crystal-poor rhyolite lavas and thin, associated air-fall and ash-flow tuffs (Tzct) present locally beneath Tzc$_1$. Both the tuffs and lavas contain 2–5% phenocrysts consisting of subequal amounts of sanidine and plagioclase, minor biotite, and traces of quartz.

Tzct Air-fall and ash-flow tuffs similar mineralogically to Tzc$_2$ are present 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.

Tzap Minor volumes of coarsely porphyritic flows and dikes (third interval) of rhyodacite mineralogy exposed along US-60.

Tzt Ash-flow tuffs—0–1,250 ft (0–380 m).

Two intervals of light-brownish-gray to purplish-gray, poorly to moderately welded, pumiceous, lithic-rich rhyolitic ash-flow tuff. The two intervals, which are distinguishable by lithic content, are locally separated by andesite flows. The lower interval [Tzt$_1$] contains abundant andesitic (Spears-type) lithic fragments, whereas the upper interval [Tzt$_2$] is characterized 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-rich tuffs that rest on the Hells Mesa Tuff in the southern Lemitar Mountains have been mapped with La Jencia Tuff.

Tza Intermediate lavas.

Several intervals of purplish, aphanitic to moderately porphyritic lavas separated by rhyolitic lavas and tuffs. Lower two intervals are aphanitic to moderately porphyritic, whereas the third interval from the base is slightly to moderately porphyritic, and the upper interval is moderately porphyritic throughout. Andesitic agglomerates are present locally in all intervals. Several vents for the third interval, commonly associated with agglomerates, are marked by dikes and plugs near Socorro Canyon and at Blue Canyon.

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

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.

Stratigraphic units in the south-central Chupadera Mountains and southeast Magdalena Mountains

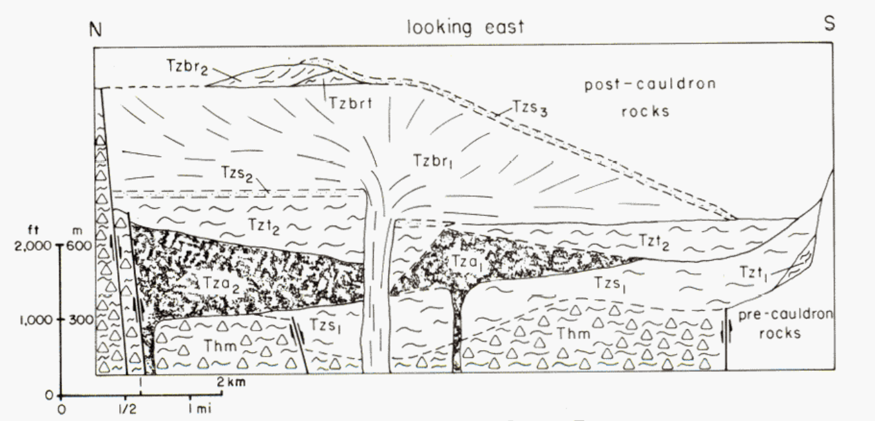


FIGURE 6—STRATIGRAPHIC RELATIONSHIPS OF LUIS LOPEZ FORMATION IN THE SOUTHERN CHUPADERA MOUNTAINS. After Eggleston (1982).

Tzs$_3$ Heterolithic sedimentary rocks—0–50 ft (0–15 m).

Thin, discontinuous, and variable sediment interval containing conglomerates, sandstones, and mudstones. Usually white, buff, or pale red in color and often containing prominent crossbedding.

Tzbr Bianchi Ranch, rhyolite of [Eggleston, 1982]—0–2,000 ft (0–600 m); rhyolite domes and lava flows.

Tzbr$_2$ 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 consisting of plagioclase (2%), sanidine (1%), and a trace of ferromagnesian minerals.

Tzbrt Ash-flow tuffs and tuffaceous sandstones—0–70 ft (0–20 m).

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.

Tzbr$_1$ Lower member—0–1,800 ft (0–550 m).

Brown where fresh but commonly altered to lighter colors; spherulitic, 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.

Tzs$_2$ Heterolithic sedimentary rocks and andesitic lava flows—0–100 ft (0–30 m).

Thin, largely eroded andesitic lava flow, which is underlain and overlain by sedimentary rocks containing abundant andesitic clasts.

Tzt$_2$ 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 sanidine (3%), plagioclase (2%), quartz (1%), and a trace of biotite.

Tza$_2$ Intermediate to mafic lava flows—0–600 ft (0–185 m).

The northern outcrops consist of dark-gray, slightly porphyritic, considerably 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, 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.

Tza$_1$ 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 altered to iddingsite.

Tzs$_1$ 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. 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.

Tzt$_1$ 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 biotite (2%).

Sawmill Canyon–Magdalena cauldrons

The overlapping Sawmill Canyon and Magdalena cauldrons form a dumbbell-shaped complex oriented east-west across the central Magdalena Mountains (fig. 7). These two cauldrons are thought to be the source of La Jencia Tuff (formerly the lower member A-L Peak Tuff and lower member tuff of Bear Springs). The cauldron-facies La Jencia Tuff is well exposed in the Sawmill Canyon cauldron but exposed in only one small area on the northeast rim of the Magdalena cauldron. Cauldron margins are well exposed over large areas near the center of the complex in the central Magdalena Mountains. The eastern and western parts of the complex are covered by younger units, and margins are inferred.

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 Formation shown in stippled pattern.

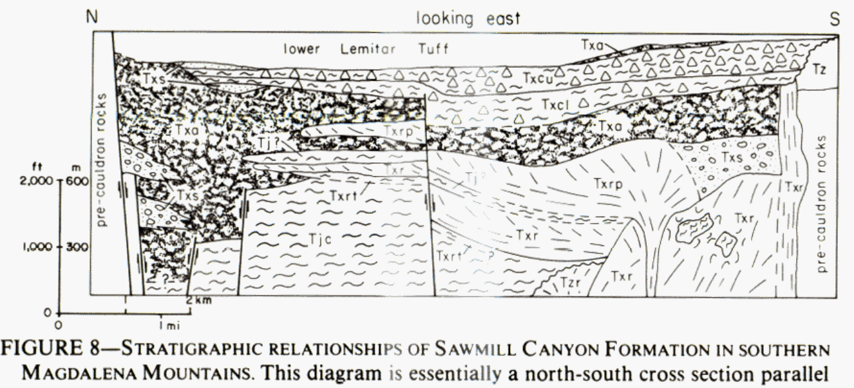


FIGURE 8—STRATIGRAPHIC RELATIONSHIPS OF SAWMILL CANYON FORMATION IN SOUTHERN MAGDALENA MOUNTAINS. This diagram is essentially a north-south cross section parallel to the eastern wall of Sawmill Canyon. Data from Bowring (1980) and Roth (1980).

Tjc **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 well-developed primary flow structures including lineated pumice and flow folding. 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).

Tx **Sawmill Canyon Formation** [new name; formerly unit of Sixmile Canyon]—0–2,500 ft (0–800 m); andesite lavas, rhyolite lavas, ash-flow 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. 8 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 conglomeratic 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 cauldron, only andesitic lavas are exposed. These are called the andesite of Landavaso Reservoir (Simon, 1973) and are described after units from the Sawmill Canyon cauldron.

Txc Caronita Canyon, tuff of [Petty, 1979]—30.2 ± 1.1 m.y.; 0–1,200 ft (0–365 m); ash-flow tuffs.

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 the northwest San Mateo Mountains.

Txcu Upper member.

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 interbed.

Txcl Lower member.

Brown to reddish, moderately crystal-poor, poorly to densely welded ash-flow tuff. Contains 5–20% phenocrysts of plagioclase, biotite, magnetite, and traces of clinopyroxene, quartz, and sanidine. Locally has basal black vitrophyre.

Txrp Porphyritic rhyolite lava—0–1,200 ft (0–365 m); lava flows.

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.

Txr Crystal-poor rhyolitic lavas and domes—0–750 ft (0–230 m).

Fine-grained, pink, gray, or brown, crystal-poor to crystal-free, flow-banded rhyolitic lavas locally overlying minor tuffs of similar lithology [Txrt]. Form several intrusive plugs in Sawmill Canyon (Roth, 1980) and lava flows in both Sawmill and Ryan Hill Canyons.

Txa 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).

Txal 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.

Txs 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 lavas. 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 south.

Editor: Jane Calvert Love
Drafters: Debra Vetterman and Teresa Mueller
Layout artists: Teresa Mueller and Jane Calvert Love

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

(1) Area of occurrence
(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
(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 Magdalena; 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 crystal-rich 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 Jencia Tuff.

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 7½-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.

Baca Formation

(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 Formation. (7) Unknown.

Bear Springs, tuff of [OBSOLETE]

(2) Bear Springs in southern Bear Mountains, approximately 8 mi (13 km) north of Magdalena; sec. 9, 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 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.

Bianchi Ranch, rhyolite of, member of Luis Lopez Formation

(1) Central Chupadera Mountains. (2) Bianchi Ranch along Nogal Canyon, approximately 12 mi (19 km) southwest of Socorro; sec. 6, T. 5 S., R. 1 W., Luis Lopez 7½-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 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., R. 1 W., Socorro 7½-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]

(2) 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.

Blue 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 Canyon; NE¼SE¼ 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, moderately 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 biotite 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 (1979).

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.

Blue Mesa, basalt of

(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 (unsurveyed), 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) southwest of Socorro; secs. 25, 35, 36, T. 4 S., R. 2 W., Molino Peak 7½-min quadrangle. (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 7½-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, Sawmill Canyon Formation.

Cerritos de las Minas, basaltic andesite at, tongue of La Jara Peak Basaltic Andesite

(1) Lemitar Mountains. (2) Cerritos de las Minas (small hills) on east side of Lemitar Mountains, 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 7½-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 Canyon 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; S½ sec. 27, T. 2 N., R. 8 W., unsurveyed, Dog Springs 7½-min quadrangle. (3) Harrison, 1980; and Coffin, 1981. (4) Volcaniclastic 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.

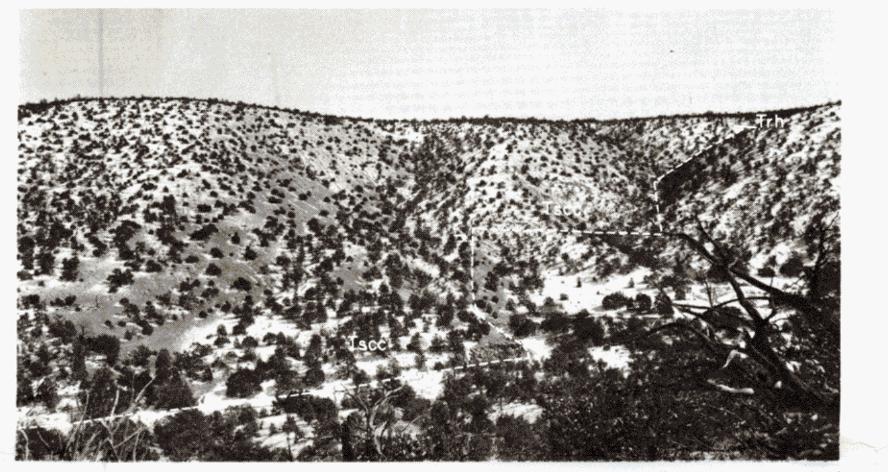


FIGURE 11—TYPE SECTION OF CHAVEZ CANYON MEMBER OF SPEARS FORMATION. Dashed line shows approximate route of section measurement. **Tscc** = Chavez Canyon Member, **Trh** = Rock House Canyon Tuff.

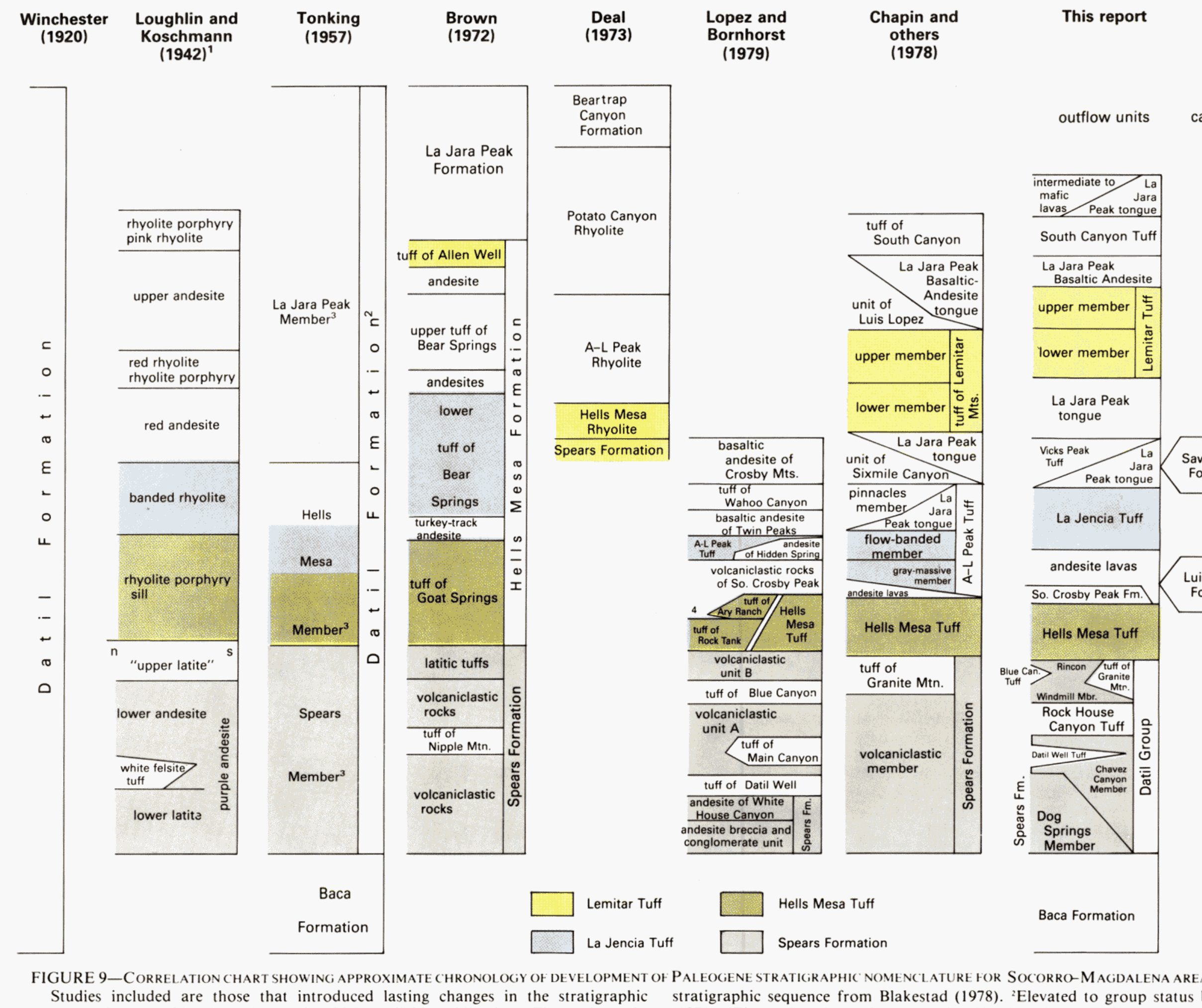


FIGURE 9—CORRELATION CHART SHOWING APPROXIMATE CHRONOLOGY OF DEVELOPMENT OF PALEOGENE STRATIGRAPHIC NOMENCLATURE FOR SOCORRO–MAGDALENA AREA. Studies included are those that introduced lasting changes in the stratigraphic nomenclature and/or those that are in widely available publications. The reader seeking detailed correlations of individual units should see either the appropriate stratigraphic column or the glossary. ¹Nomenclature from Loughlin and Koschmann; stratigraphic sequence from Blakestad (1978). ²Elevated to group status by Weber (1971). ³Elevated to formation status by Chapin (1971). ⁴Tuffs of Ary Ranch and Rock Tank are both Hells Mesa Tuff; the volcaniclastic rocks of South Crosby Peak can nowhere be demonstrated to have this interfingering relationship.

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 7½-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 7½-min quadrangle. (3) Chamberlin, 1974; and Wilkinson, 1976. (4) Basalt and basaltic-andesite lava 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) None.

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 SE¼ sec. 2, T. 2 S., R. 11 W. and SE¼ 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 separation.

Datil Group [REDEFINED]

(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 Winchester'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 10 m.y., the Datil Group of Weber (1971) became untenable. For several years a gentleman'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 underlying Baca Formation and the overlying Hells Mesa Tuff are present throughout 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 stratigraphically 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 formational names and type localities. (4) Volcaniclastic rocks (Spears Formation), lava flows, and ash-flow tuffs (Datil Well Tuff, Rock House Canyon Tuff, Blue Canyon Tuff, 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) 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.

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; NW¼SW¼ sec. 2, T. 2 S., R. 10 W., Datil 7½-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) Unknown. (8) Petrographically similar to, and possibly correlative with, a tuff in the northern Jornada del Muerto. See appropriate stratigraphic column.

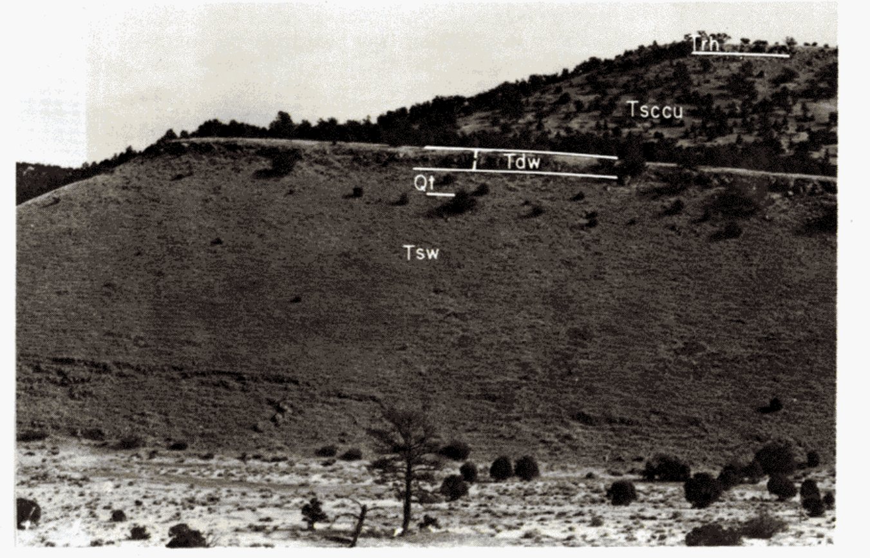


FIGURE 12—TYPE SECTION OF DATIL WELL TUFF. Route of section measurement was up cliff along dashed line, then across wide bench parallel to strike. **Tsw** = andesite of White House Canyon (informal member of Spears Formation), **Qt** = talus, **Tdw** = Datil Well Tuff, **Tsccu** = upper part of Chavez Canyon Member of Spears Formation, **Trh** = Rock House Canyon 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, volcaniclastic 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 7½-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; SE¼ 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) Crystal-rich, 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 7½-min quadrangle. (3) Wilkinson, 1976. (9) Name abandoned in this report because most of unit is now correlated with lower member Lemitar Tuff.

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 Formation.

Hells Mesa Tuff

(1) Present throughout northeast Mogollon–Datil volcanic field except southern Chupadera 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 7½-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.y., 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 Tdh₇]. 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.

FIGURE 13—TYPE SECTION OF HELLS MESA TUFF. Dashed line shows route of section measurement. **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 SE¼ 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 7½-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 lavas 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 Canyon 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 ± 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 7½-min quadrangle. (3) Simon, 1973. (9) Abandoned in this report because outcrops were found to be Lemitar Tuff.

La Jencia Tuff

(1) 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; NW¼ sec. 22, T. 1 S., R. 4 W., Magdalena NW 7½-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 Hells 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 or 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 for this stratigraphic interval.

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.

Lemitar Tuff

(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; NW¼SE¼SE¼ sec. 12, T. 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 lower 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.

Luis Lopez Formation

(1) Socorro Peak and Chupadera and Magdalena Mountains. (2) Luis Lopez manganese district, 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 7½-min quadrangle. (3) Chapin and others, 1978; Chamberlin, 1980, 1981; and Eggleston, 1982. (4) Cauldron-fill unit of Socorro cauldron; includes rhyolite domes and flows, local ash-flow tuffs, volcaniclastic rocks, breccias, andesite flows, and intrusives; very thick but restricted to Socorro cauldron and immediate vicinity. (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.

Magdalena Peak Rhyolite of the Santa Fe Group

(1) West flank of Magdalena Range. (2) Magdalena Peak, approximately 1.25–5 mi (2–8 km) 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 7½-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 7½-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 [OBSOLETE]

(2) Nipple Mountain, approximately 4 mi (6 km) northeast of Magdalena; sec. 1, T. 2 S., R. 4 W., Magdalena NW 7½-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 lavas; 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 7½-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 7½-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 7½-min 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 ± 0.5 m.y. K-Ar biotite date; upper flow, 10.8 ± 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 NW¼NW¼ sec. 18, T. 1 N., R. 8 W., unsurveyed, Dog Springs 7½-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 Canyon 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 sedimentary unit A and volcaniclastic sedimentary unit B of Lopez and Bornhorst (1979), middle sedimentary unit of Harrison (1980), and middle volcaniclastic rocks of Coffin (1981).

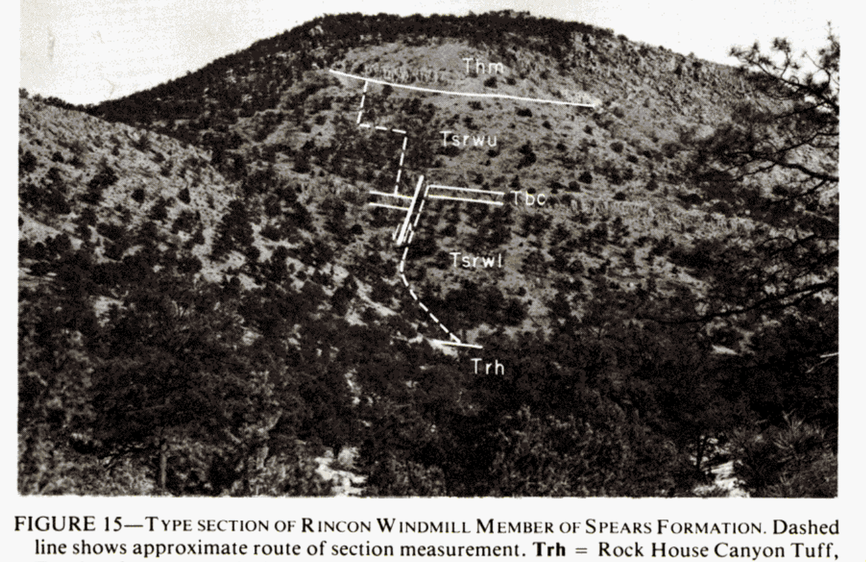


FIGURE 15—TYPE SECTION OF RINCON WINDMILL MEMBER OF SPEARS FORMATION. Dashed line shows approximate route of section measurement. **Trh** = Rock House Canyon Tuff, **Tsrwl** = lower part of Rincon Windmill Member, **Tbc** = Blue Canyon Tuff, **Tsrwu** = upper part of Rincon Windmill Member, **Thm** = Hells Mesa Tuff.

Rock House Canyon Tuff of the Datil Group

(1) Datil, Gallinas, Crosby, and Magdalena Mountains and Tres Montosas–Magdalena area. (2) Rock House Canyon in northwest Gallinas Mountains, approximately 15 mi (24 km) northeast of Datil; type section at junction of Rock House Canyon and Long Canyon; SW¼ sec. 13, T. 1 N., R. 8 W., unsurveyed, Dog Springs 7½-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.

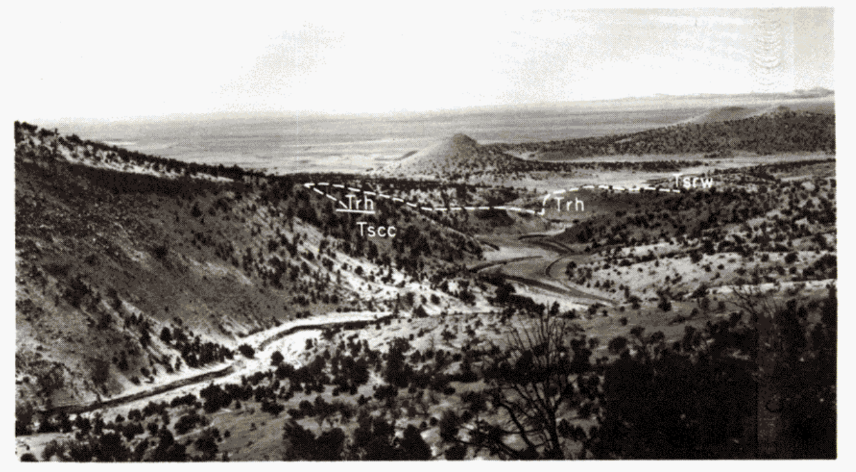


FIGURE 16—TYPE SECTION OF ROCK HOUSE CANYON TUFF. Dashed line shows approximate route of section measurement. **Tscc** = Chavez Canyon Member of Spears Formation, **Trh** = Rock House Canyon Tuff, **Tsrw** = Rincon Windmill Member of Spears Formation. Plains of San Agustin in distance.

FIGURE 17—CLIFFS OF ROCK HOUSE CANYON TUFF AT JUNCTION OF ROCK HOUSE CANYON AND LONG CANYON (FOREGROUND).

Rock Tank, tuff of [OBSOLETE]

(2) Rock tank in the Crosby Mountains, approximately 7 mi (11 km) southwest of Datil; secs. 35, 36, T. 2 S., R. 11 W.; secs. 1, 2, T. 3 S., R. 11 W., Sugarloaf Mountain 7½-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 Canyon, 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 not known.

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 7½-min quadrangle. (3) Machette, 1978. (4) Basaltic flows, thin and local. (5) 4.6 ± 0.1 m.y. K-Ar whole-rock date (Bachman and Mehnert, 1978). (6) Interbedded in lowest exposed part of piedmont-slope and alluvial-flat deposits of the Sierra Ladrones Formation. (7) Feeder dike exposed at southwest corner 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 been studied.

Sawmill Canyon Formation

(1) Magdalena Mountains. (2) Exposures along Sawmill Canyon in the southern Magdalena Mountains, approximately 16 mi (26 km) southeast of Magdalena; secs. 3, 4, 9, 10, 11, 14, 15, T. 5 S., R. 3 W., South Baldy 7½-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 report.

Sawmill Canyon, unit of [OBSOLETE]

(2) Sawmill Canyon in the southern Magdalena Mountains, approximately 18 mi (29 km) south of Magdalena; secs. 30, 31, 32, T. 4 S., R. 3 W.; sec. 5, T. 5 S., R. 3 W., South 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 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) Basalt 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 7½-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 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 Formation.

Sixmile Canyon, unit of [OBSOLETE]

(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 report in favor of Sawmill Canyon Formation because of better exposures and a more representative cross section of the cauldron-fill stratigraphy in the Sawmill Canyon cauldron and because the name has been preempted by prior use elsewhere.

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

(1) Socorro Peak area. (2) Socorro Canyon, approximately 6 mi (10 km) southwest of Socorro; secs. 27, 30, T. 3 S., R. 1 W., Socorro 7½-min quadrangle. (3) Previously called basalt of Sedillo Hill (Chapin and others, 1978; and Chamberlin, 1980, 1981) or "basalt flow, Black Mountain, Socorro Canyon" (Bachman and Mehnert, 1978). (4) Basalt flows, thin and local. (5) 4.1 ± 0.3 m.y. K-Ar whole-rock date (Bachman and Mehnert, 1978). (6) Above playa claystone facies of Popotosa Formation; above axial-stream deposits (ancestral Rio Grande) of Sierra Ladrones Formation; below piedmont gravels of Sierra Ladrones Formation. (7) Unknown; source previously thought to be vents at Sedillo Hill, but this correlation is uncertain. (8) Basalt of Sedillo Hill(?).

Socorro Peak Rhyolite of the Santa Fe Group

(1) Socorro Peak and vicinity. (2) Socorro Peak, approximately 3 mi (5 km) west and southwest of Socorro; secs. 5, 8, 16, 17, 21, 28, T. 3 S., R. 1 W., Socorro 7½-min quadrangle. (3) Chapin and others, 1978; and Chamberlin, 1980, 1981. (4) Rhyodacite to rhyolite domes and flows with minor pyroclastic rocks, thick but local. (5) About 12–7 m.y. as evidenced by several K-Ar dates. (6) Above Popotosa fanglomerate and playa deposits; interbedded with upper Popotosa playa mudstones. Includes rhyolite of Pound Ranch. (7) Numerous vents in Socorro Peak area. (8) Similar petrographically but slightly younger than Magdalena Peak Rhyolite.

South Baldy Peak andesite [OBSOLETE]

(2) South Baldy, the highest peak in the Magdalena Range, approximately 10 mi (16 km) south of Magdalena; sec. 6, T. 4 S., R. 3 W., South Baldy 7½-min quadrangle. (3) Krewedl, 1974. (9) Name abandoned in this report because unit as defined included andesites of the Sawmill Canyon Formation (eastern two thirds of outcrop area) and andesites above South Canyon Tuff, which are probably correlative with tongue d of La Jara Peak Basaltic Andesite (western one third of area).

South Canyon Tuff

(1) Present throughout the northeast Mogollon–Datil volcanic field except in the Datil area, the northern Gallinas Mountains, and the Bear Mountains. (2) Mouth of South Canyon in the eastern Magdalena Mountains, approximately 12 mi (19 km) southwest of Socorro; type section at SW¼ sec. 30, T. 3 S., R. 2 W., Magdalena SE 7½-min quadrangle. (3) Osburn, 1978; and Chapin and others, 1978. (4) Rhyolite ash-flow tuffs, crystal poor to moderately crystal rich, thick and continuous. (5) 26.7 m.y., average of two K-Ar dates on biotite. (6) Above Lemitar Tuff and tongue c of La Jara Peak Basaltic Andesite; youngest major ash-flow sheet of the northeast Mogollon–Datil volcanic field; below Popotosa Formation, unit of Arroyo Montosa, and basalt of Madera Canyon. (7) Unknown but probably in northern San Mateo Mountains. (8) Part of upper tuffs of Simon (1973); part of Potato Canyon Tuff of Deal (1973), Deal and Rhodes (1976), Chapin and Seager (1975), Spradlin (1976), and Wilkinson (1976); part of A-L Peak Tuff of Chamberlin (1974).

South Crosby Peak Formation

(1) Crosby and Datil Mountains; thin deposits of similar material present as far east as the northern Jornada del Muerto. (2) South Crosby Peak, approximately 4.3 mi (7 km) southwest of Datil; type section approximately 1.8 mi (3 km) northeast of South Crosby Peak; NE¼ sec. 19, T. 2 S., R. 10 W., Sugarloaf Mountain 7½-min quadrangle. (3) Lopez, 1975; Bornhorst, 1976; Lopez and Bornhorst, 1979; Harrison, 1980; and Coffin, 1981. (4) Interbedded volcaniclastic sedimentary rocks and air-fall and reworked tuffs; poorly welded, lithic-rich rhyodacite to rhyolite ash-flow tuffs; thick in Crosby Mountains but thins rapidly northeastward in Datil Mountains; present as thin, discontinuous lenses at base of La Jencia Tuff in Magdalena area and northern Jornada del Muerto. (5) Not dated. (6) Above Hells Mesa Tuff; below La Jencia Tuff. Lower part of unit miscorrelated by Lopez and Bornhorst (1979) with upper part of Spears Formation. The tuff of Ary Ranch (Hells Mesa Tuff) is not interbedded with the South Crosby Peak Formation as described by these authors. (7) Unknown. (8) Tuff of Crosby Mountain (Lopez, 1975); volcaniclastic rocks of South Crosby Peak (Lopez and Bornhorst, 1979).

FIGURE 18—TYPE SECTION OF SOUTH CROSBY PEAK FORMATION. Dashed line shows approximate route of section measurement. **Tscp** = South Crosby Peak Formation, **Tdb** = basaltic andesite of Deep Well.

Spears Formation of the Datil Group

(1) Present throughout northeast Mogollon–Datil volcanic field. (2) Spears Ranch on 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]

(2) Twin Peaks, approximately 2 mi (3 km) southeast of Datil; secs. 18, 19, T. 2 S., R. 9 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 correlative with the basaltic andesite of Crosby Mountains. Type section moved to better constrained locality near Deep Well windmill approximately 10 mi (16 km) to the northeast. Unit renamed basaltic andesite of Deep Well.

Vicks Peak Tuff

(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 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 (S½ sec. 22, T. 1 S., R. 4 W., Magdalena NW 7½-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 7½-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.

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

(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 7½-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 deposits of Popotosa Formation. Basal contact overlies an unconformity cut as deep as the upper Lemitar Tuff. (7) Unknown but local. (8) Water Canyon Mesa lavas (Osburn, 1978).

White House Canyon, andesite of, member of the Spears Formation

(1) Datil Mountains. (2) White House Canyon between 1 and 5 mi (1.6–8 km) northwest of Datil; secs. 29, 32, T. 1 S., R. 10 W., Crosby Springs 7½-min quadrangle. (3) Lopez, 1975; Bornhorst, 1976; and Lopez and Bornhorst, 1979. (4) Porphyritic basaltic-andesite flows with large plagioclase and clinopyroxene phenocrysts, thick but local. (5) Not dated. (6) Above volcaniclastic rocks of Spears Formation; below Datil Well Tuff. (7) Unknown but local. (8) Informal member of Spears Formation.

References

Allen, P., 1979, Geology of the west flank of the Magdalena Mountains, south of the Kelly mining district, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 153 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 119, 161 pp.

Bachman, G. O., and Mehnert, H. H., 1978, New K-Ar dates and the late Pliocene to Holocene geomorphic history of the central Rio Grande region, New Mexico: Geological Society of America, Bulletin, v. 89, no. 2, pp. 283–292.

Baldwin, B., 1963, Part 2—Geology; *in* Spiegel, Z., and Baldwin, B., Geology and Water Resources of the Santa Fe area, New Mexico: U.S. Geological Survey, Water-Supply Paper 1525, pp. 21–89.

Blakestad, R. B., Jr., 1978, Geology of the Kelly mining district, Socorro County, New Mexico: M.S. thesis, University of Colorado, 174 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 43, 139 pp.

Bobrow, D. J., 1983, Geochemistry and petrology of Miocene silicic lavas in the Socorro–Magdalena area, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, in preparation.

Bobrow, D. J., Kyle, P. R., and Osburn, G. R., 1983, Miocene rhyolitic volcanism in the Socorro area of New Mexico: New Mexico Geological Society, Guidebook to 34th field conference, in press.

Bornhorst, T. J., 1976, Volcanic geology of the Crosby Mountains and vicinity, Catron County, New Mexico: M.S. thesis, University of New Mexico, 113 pp.

Bornhorst, T. J., Jones, D. P., Elston, W. E., Damon, P. E., and Shafiqullah, M., 1982, New radiometric ages on volcanic rocks from the Mogollon–Datil volcanic field, southwestern New Mexico: Isochron/West, no. 35, pp. 13–15.

Bowring, S. A., 1980, The geology of the west-central Magdalena Mountains, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 127 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 120, 135 pp.

Brown, D. M., 1972, Geology of the southern Bear Mountains, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 110 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 42, 110 pp.

Bruning, J. E., 1973, Origin of the Popotosa Formation, north-central Socorro County, New Mexico: Ph.D. dissertation, New Mexico Institute of Mining and Technology, 131 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 38, 142 pp.

Bryan, K., 1938, Geology and ground-water conditions of the Rio Grande depression in Colorado and New Mexico; *in* Joint Investigations in the Upper Rio Grande Basin in Colorado, New Mexico, and Texas: Washington, National Resources Commission, Regional Planning, pt. 6, pp. 196–225.

Cather, S. M., 1980, Petrology, diagenesis, and genetic stratigraphy of the Eocene Baca Formation, Alamo Navajo Reservation and vicinity, Socorro County, New Mexico: M.S. thesis, University of Texas (Austin), 243 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 125, 263 pp.

Chamberlin, R. M., 1974, Geology of the Council Rock district, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 134 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 40, 143 pp.

———, 1980, Cenozoic stratigraphy and structure of the Socorro Peak volcanic center, central New Mexico: D.Sc. dissertation, Colorado School of Mines, 495 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 118, 532 pp.

———, 1981, Cenozoic stratigraphy and structure of the Socorro Peak volcanic center, central New Mexico—a summary: New Mexico Geology, v. 3, no. 2, pp. 22–24.

———, 1982, Geologic map, cross sections, and map units of the Lemitar Mountains, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 169, 3 pls.

Chapin, C. E., 1971, K-Ar age of the La Jara Peak Andesite and its possible significance to mineral exploration in the Magdalena mining district, New Mexico: Isochron/West, no. 2, pp. 43–44.

Chapin, C. E., Chamberlin, R. M., Osburn, G. R., White, D. W., and Sanford, A. R., 1978, Exploration framework of the Socorro geothermal area, New Mexico; *in* Chapin, C. E., and Elston, W. E. (eds.), Field Guide to Selected Cauldrons and Mining Districts of the Datil–Mogollon Volcanic Field, New Mexico: New Mexico Geological Society, Special Publication 7, pp. 115–129.

Chapin, C. E., and Deal, E. G., 1976, The A-L Peak Tuff, New Mexico—a composite ash-flow sheet (abs.): Geological Society of America, Abstracts with Programs, v. 8, no. 5, p. 575.

Chapin, C. E., Osburn, G. R., Hook, S. C., Massingill, G. L., and Frost, S. J., 1979, Coal, uranium, oil and gas potential of the Riley–Puertecito area, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 103, 35 pp., 4 sheets; New Mexico Energy Institute, Technical Report ERB 77-3302, 33 pp.

Chapin, C. E., and Seager, W. R., 1975, Evolution of the Rio Grande rift in the Socorro and Las Cruces areas: New Mexico Geological Society, Guidebook to 26th field conference, pp. 297–321.

Coffin, G. C., 1981, Geology of the northwestern Gallinas Mountains, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 202 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 159, 214 pp.

Dalrymple, G. B., 1979, Critical tables for conversion of K-Ar ages from old to new constants: Geology, v. 7, pp. 558–560.

D'Andrea, J. F., 1981, Chemical changes associated with potassium metasomatism of ash-flow tuffs near Socorro, New Mexico: M.S. thesis, Florida State University, 243 pp.

Deal, E. G., 1973, Geology of the northern part of the San Mateo Mountains, Socorro County, New Mexico—a study of a rhyolite ash-flow tuff cauldron and the role of laminar flow in ash-flow tuffs: Ph.D. dissertation, University of New Mexico, 136 pp.

———, 1978, Geology of San Mateo Mountains; *in* Hawley, J. W. (compiler), Guidebook to Rio Grande Rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources, Circular 163, pp. 97–98.

Deal, E. G., and Rhodes, R. C., 1976, Volcano-tectonic structures in the San Mateo Mountains, Socorro County, New Mexico; *in* Elston, W. E., and Northrop, S. A. (eds.), Cenozoic Volcanism in Southwestern New Mexico: New Mexico Geological Society, Special Publication 5, pp. 51–56.

DeBrine, B., Spiegel, Z., and Williams, D., 1963, Cenozoic sedimentary rocks in Socorro Valley, New Mexico: New Mexico Geological Society, Guidebook to 14th field conference, pp. 123–131.

Denny, C. S., 1940, Tertiary geology of the San Acacia area, New Mexico: Journal of Geology, v. 48, no. 1, pp. 73–106.

Donze, M. A., 1980, Geology of the Squaw Peak area, Magdalena Mountains, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 120 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 123, 131 pp.

Eggleston, T. L., 1982, Geology of the central Chupadera Mountains, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 161 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 141, 162 pp.

Elston, W. E., 1976, Glossary of stratigraphic terms of the Mogollon–Datil volcanic province, New Mexico; *in* Elston, W. E., and Northrop, S. A. (eds.), Cenozoic Volcanism in Southwestern New Mexico: New Mexico Geological Society, Special Publication 5, pp. 131–144.

Farkas, S. E., 1969, Geology of the southern San Mateo Mountains, Socorro and Sierra Counties, New Mexico: Ph.D. dissertation, University of New Mexico, 137 pp.

Fodor, R. V., 1976, Volcanic geology of the northern Black Range, New Mexico; *in* Elston, W. E., and Northrop, S. A. (eds.), Cenozoic Volcanism in Southwestern New Mexico: New Mexico Geological Society, Special Publication 5, pp. 68–70.

Furlow, J. W., 1965, Geology of the San Mateo Peak area, Socorro County, New Mexico: M.S. thesis, University of New Mexico, 83 pp.

Galusha, T., and Blick, J. C., 1971, Stratigraphy of the Santa Fe Group, New Mexico: American Museum of Natural History, Bulletin, v. 144, art. 1, 127 pp.

Givens, D. B., 1957, Geology of Dog Springs quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 58, 37 pp.

Harrison, R. W., 1980, Geology of the northeastern Datil Mountains, Socorro and Catron Counties, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 137 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 136, 146 pp.

Hawley, J. W., 1978, Guidebook to Rio Grande rift in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources, Circular 163, 241 pp.

Hawley, J. W., Kottlowski, F. E., Seager, W. R., King, W. E., Strain, W. S., and LeMone, D. V., 1969, The Santa Fe Group in the south-central New Mexico border region; *in* Kottlowski, F. E., and LeMone, D. V. (eds.), Border Stratigraphy Symposium: New Mexico Bureau of Mines and Mineral Resources, Circular 104, pp. 52–76.

Hayden, F. V., 1869, Preliminary field report of the United States Geological Survey of Colorado and New Mexico: Washington, Government Printing Office, pp. 1–99.

Iovenitti, J., 1977, A reconnaissance study of jasperoid in the Kelly Limestone, Kelly mining district, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 200 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 85, 224 pp.

Jackson, R. A., 1979, Geology of the Puertecito–La Cruz Peak area, Socorro County, New Mexico; *in* Chapin, C. E., Osburn, G. R., Hook, S. C., Massingill, G. L., and Frost, S. J., Coal, Uranium, Oil and Gas Potential of the Riley-Puertecito Area, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 103, 38 pp, 4 sheets.

Johnson, B. D., 1978, Genetic stratigraphy and provenance of the Baca Formation, New Mexico, and Eagar Formation, Arizona: M.A. thesis, University of Texas (Austin), 150 pp.

Kent, S. C., 1982, Precambrian geologic maps of rocks in the Magdalena and Chupadera Mountains, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 170, 3 sheets, scale 1:12,000.

Krewedl, D. A., 1974, Geology of the central Magdalena Mountains, Socorro County, New Mexico: Ph.D. dissertation, University of Arizona, 128 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 44, 142 pp.

Laroche, T. M., 1981, Geology of the Gallinas Peak area, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 145 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 128, 154 pp.

Lindley, J. I., 1979, Chemical changes associated with the propylitic alteration of two ash-flow tuffs, Datil–Mogollon volcanic field, New Mexico: M.S. thesis, University of North Carolina (Chapel Hill), 197 pp.

Lopez, D. A., 1975, Geology of the Datil area, Catron County, New Mexico: M.S. thesis, University of New Mexico, 72 pp.

Lopez, D. A., and Bornhorst, T. J., 1979, Geologic map of the Datil area, Catron County, New Mexico: U.S. Geological Survey, Miscellaneous Geologic Investigation Map I-1098, scale 1:50,000.

Loughlin, G. F., and Koschmann, A. H., 1942, Geology and ore deposits of the Magdalena mining district, New Mexico: U.S. Geological Survey, Professional Paper 200, 168 pp.

Machette, M. N., 1978, Geologic map of the San Acacia quadrangle, Socorro County, New Mexico: U.S. Geological Survey, Geologic Quadrangle Map GQ-1415, scale 1:24,000.

Massingill, G. R., 1979, Geology of Riley–Puertecito area, southeastern margin of the Colorado Plateau, Socorro County, New Mexico: D.G.S. thesis, University of Texas (El Paso), 301 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 107, 316 pp.

Mayerson, D. L., 1979, Geology of the Corkscrew Canyon–Abbe Spring area, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 125 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 112, 133 pp.

Osburn, G. R., 1978, Geology of the eastern Magdalena Mountains, Water Canyon to Pound Ranch, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 150 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 113, 160 pp.

———, 1982, Geologic map of the Monica Saddle quadrangle, San Mateo Mountains, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 139c, scale 1:24,000.

Osburn, G. R., and Laroche, T. M., 1982, Geology of the Lion Mountain quadrangle, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 139b, scale 1:24,000.

Osburn, G. R., Petty, D. M., and Chapin, C. E., 1981, Geology of the Molino Peak quadrangle: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 139a, scale 1:24,000.

Petty, D. M., 1979, Geology of the southeastern Magdalena Mountains, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 163 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 106, 174 pp.

Robinson, B. R., 1981, Geology of the D Cross Mountain quadrangle, Socorro and Catron Counties, New Mexico: D.G.S. dissertation, University of Texas (El Paso), 212 pp.

Roth, S. J., 1980, Geology of the Sawmill Canyon area, Magdalena Mountains, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 88 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 129, 96 pp.

Siemers, W. T., 1973, Stratigraphy and petrology of Mississippian, Pennsylvanian, and Permian rocks in the Magdalena area, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 133 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 54, 141 pp.

———, 1978, The stratigraphy, petrology, and paleoenvironments of the Pennsylvanian system of the Socorro region, west-central New Mexico: Ph.D. dissertation, New Mexico Institute of Mining and Technology, 165 pp.

Simon, D. B., 1973, Geology of the Silver Hill area, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 101 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 41, 110 pp.

Snyder, D. O., 1971, Stratigraphic analysis of the Baca Formation, west-central New Mexico: Ph.D. dissertation, University of New Mexico, 160 pp.

Spradlin, E. J., 1976, Stratigraphy of Tertiary volcanic rocks, Joyita Hills area, Socorro County, New Mexico: M.S. thesis, University of New Mexico, 73 pp.

Sumner, W., 1980, Geology of the Water Canyon–Jordan Canyon area, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 143 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 135, 152 pp.

Tonking, W. H., 1957, Geology of Puertecito quadrangle, Socorro County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 41, 67 pp.

Weber, R. H., 1971, K-Ar ages of Tertiary igneous rocks in central and western New Mexico: Isochron/West, no. 1, pp. 33–45.

Wilkinson, W. H., Jr., 1976, Geology of the Tres Montosas–Cat Mountain area, Socorro County, New Mexico: M.S. thesis, New Mexico Institute of Mining and Technology, 158 pp.; New Mexico Bureau of Mines and Mineral Resources, Open-file Report 39, 169 pp.

Willard, M. E., 1959, Tertiary stratigraphy of northern Catron County, New Mexico: New Mexico Geological Society, Guidebook to 10th field conference, pp. 92–99.

Wilpolt, R. H., McAlpin, A. J., Bates, R. L., and Vorbe, G., 1946, Geologic map and stratigraphic sections of Paleozoic rocks of the Joyita Hills, Los Pinos Mountains, and northern Chupadera Mesa, Valencia, Torrance, and Socorro Counties, New Mexico: U.S. Geological Survey, Oil and Gas Investigations, Preliminary Map 61, scale 1:62,500.

Winchester, D. E., 1920, Geology of Alamosa Creek Valley, Socorro County, New Mexico: U.S. Geological Survey, Bulletin 716-A, pp. 1–15.

Stratigraphic Chart 1
1983

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

by Glenn R. Osburn and Charles E. Chapin

Type sections–reference section–type areas

Tables 2–8 describe type sections measured by the authors for Blue Canyon Tuff, Chavez Canyon Member of the Spears Formation, Datil Well Tuff, Hells Mesa Tuff, Rincon Windmill Member of the Spears Formation, Rock House Canyon Tuff, and South Crosby Peak Formation. The measured type section of Hells Mesa Tuff (table 5) is a redefinition of that unit. Tonking's (1957, p. 56) type section included the Hells Mesa Tuff of this report plus La Jencia and Vicks Peak Tuffs. Also, Tonking's measured section contains a major error in the thickness of the Hells Mesa portion. Because of restrictions in space, type sections for La Jencia, Lemitar, and South Canyon Tuffs and a reference section for Vicks Peak Tuff, all previously described in theses, are listed with location and reference but not redescribed here. Type areas are described for units whose great thickness and/or variability make measurement of a type section impractical. These are the Dog Springs Member of the Spears Formation, Luis Lopez Formation, Magdalena Peak Rhyolite, Sawmill Canyon Formation, and Socorro Peak Rhyolite.

All theses cited in this section for descriptions of measured sections or type areas are available as open-file reports at the New Mexico Bureau of Mines and Mineral Resources. Photocopies of the texts and blue-line copies of the maps may be purchased from the Publications Office.

TABLE 2—TYPE SECTION FOR BLUE CANYON TUFF IS LOCATED IN THE DATIL MOUNTAINS. Location is approximately 7 mi (11 km) north of Datil and 1.1 mi (1.8 km) northeast of the junction of Cibola National Forest road 14 and the road up Blue Canyon, approximately 300 ft (90 m) north of the southern boundary of the Cal Ship Mesa 7½-min quadrangle; NE¼ SE¼ sec. 1, T. 1 S., R. 10 W.; measured up the northwest side of Main Canyon. Access is by forest roads 100 and 14 from US-60 northwest of Datil. The section was measured in January 1982 by C. E. Chapin and G. R. Osburn using a Brunton compass and tape.

Unit	Lithology	Thickness (equivalents) ft	(*m*)
	Datil Group (Oligocene). The type area for the Datil Group is located in the Datil Mountains and northwest Gallinas Mountains. See glossary for a discussion of the evolution of the term "Datil" and its new definition.		
	Overlying unit is Rincon Windmill Member of Spears Formation (Oligocene); not measured at this location. Volcaniclastic sandstone, light-brownish-gray (light-brown-weathering), coarse to granule; pebbly, noncalcareous cement; well stratified and well indurated; forms 2-ft (0.6-m) ledge then grassy slope with scattered piñon-juniper growth that rises gently northwestward for approximately 300 ft (90 m) to where a down-to-the-east normal fault juxtaposes Blue Canyon Tuff against the Rincon Windmill Member.		
	Blue Canyon Tuff		
3	Covered interval.	9	(*2.7*)
2	Ash-flow tuff, light-brownish-gray to light-purplish-gray (light-brown-weathering), unwelded to poorly welded, moderately crystal rich; phenocrysts mainly sanidine and biotite with traces of plagioclase and quartz; abundant black to bronze biotite; sparsely to moderately abundant andesitic lithic fragments; pumice poor but weathering of widely spaced large pumice imparts a crude eutaxitic foliation. The Blue Canyon Tuff forms a light-brown, massive cliff with crude columnar joints that stands out as a distinctive ledge between slope-forming volcaniclastic rocks above and below. The unit dips approximately 5° to the southwest.	31	(*9.4*)
	Total thickness of *Blue Canyon Tuff.*	40	(*12.1*)
1	Covered interval.	7	(*2.1*)
	Underlying unit is Rincon Windmill Member of Spears Formation (Oligocene); not measured at this location. Volcaniclastic sandstone, light-greenish-gray (light-brownish-gray-weathering), medium to very coarse, conglomeratic; contains thin lenses of pebble to small-boulder volcanic conglomerate; noncalcareous cement; well stratified and well indurated; planar bedding and low-angle crossbedding; weathers to steep, rounded slopes. A prominent monolith of these volcaniclastic rocks is present near the base of the slope.		

TABLE 3—TYPE SECTION FOR CHAVEZ CANYON MEMBER OF SPEARS FORMATION IS LOCATED IN THE NORTHWEST GALLINAS MOUNTAINS. Location is approximately 17 mi (27 km) northeast of Datil and 0.6 mi (1 km) north of Chavez well; S½ sec. 27, T. 2 N., R. 8 W., unsurveyed, Dog Springs 7½-min quadrangle; measured southward along the bottom of Chavez Canyon, thence southeastward up a steep tributary gully; 5° dip obtained from geologic map and from sighting across canyon; dips on outcrops vary from 5° to 20° because of low-angle cross-stratification. Access is by private roads from Long Canyon on the J. Taylor Ranch (permission required). The section was measured in February 1982 by C. E. Chapin and G. R. Osburn using a Brunton compass and Jacob's staff.

Unit	Lithology	Thickness (equivalents) ft	(*m*)
	Spears Formation of the Datil Group (Oligocene)		
	Overlying unit is Rock House Canyon Tuff of the Datil Group (Oligocene); not measured at		

Unit	Lithology	Thickness (equivalents) ft	(*m*)
	this location. Ash-flow tuff, light-gray (light-orange-tan-weathering), poorly welded, crystal-poor; phenocrysts mainly sanidine with traces of plagioclase, biotite, and quartz; moderately pumiceous; forms prominent ledge at head of gully.		
	Chavez Canyon Member		
14	Talus from overlying Rock House Canyon Tuff.	15	(*4.5*)
13	Volcaniclastic sandstone, light-brown (brown-weathering), medium to very coarse, conglomeratic; contains thin lenses of pebbly sand and pebble to cobble conglomerate; consists mainly of varicolored tan, red-brown, purple, and gray andesitic clasts.	15	(*4.5*)
12	Covered interval.	13	(*4.0*)
11	Volcaniclastic conglomerate, reddish-brown (same-weathering); pebble to small-boulder conglomerate; matrix of coarse sand and small pebbles; subrounded to well-rounded clasts; west-northwest transport indicated by imbricated clasts; consists mainly of varicolored tan, red-brown, purple, and gray clasts of various andesites including a plagioclase porphyritic turkey-track type.	12	(*3.6*)
10	Volcaniclastic sandstones and conglomerates; thin sedimentation units of varying grain size, light-gray (same-weathering), medium to very coarse; conglomeratic sandstones containing thin lenses of pebble to cobble (to 6 inches, 15 cm) conglomerate, pebbly sandstone, and pebble conglomerate; intermittent exposures along gully bottom.	18	(*5.5*)
9	Covered interval.	21	(*6.4*)
8	Volcaniclastic sandstone, light-gray (same-weathering), medium to very coarse, well-indurated; noncalcareous cement; abundant small balls of tightly cemented sand.	10	(*3.0*)
7	Covered interval.	25	(*7.6*)
6	Volcaniclastic sandstone, light-gray (light-brownish-gray-weathering), medium to granule; abundant pebbles to 2¾ inches (7 cm); occasional matrix-supported cobble or small boulder; well indurated; noncalcareous cement; some balls of tightly cemented sand; ledgy outcrops; beds from 8 inches (20 cm) to 4 ft (1.2 m) thick; includes a few thin beds of clean sandstones similar to underlying unit; north-northwest transport indicated by imbricated clasts; normal fault with 6.5 ft (2 m) of down-to-the-north displacement cuts this unit.	22	(*6.7*)
5	Covered interval.	20	(*6.1*)
4	Volcaniclastic sandstone, light-gray (light-brownish-gray-weathering); salt-and-pepper texture formed by very abundant grains of biotite and hornblende and other dark minerals; dark minerals also concentrated on laminae; moderately well sorted beds of fine to medium, medium to coarse, and granule sand; induration varies from poor to very good with a noncalcareous to slightly calcareous cement; beds range from laminae to 5 ft (1.5 m) thick and average approximately 3 ft (1 m); bedding varies from planar to low-angle trough crossbedding; occasional matrix-supported, isolated cobble or small boulder to 2 ft (0.6 m); unit is distinctive because of its moderately good sorting, light-gray color, and general lack of either mud drapes or coarse clasts. Abundant fracture-controlled caliche approximately 20 ft (6 m) below top.	165	(*50.0*)
3	Volcaniclastic sandstone, light-gray (light-brownish-gray-weathering), medium to very coarse, conglomeratic, becoming finer and better sorted upward; interbedded thin lenses of pebble conglomerate; bedding thickens upward to maximum of 5 ft (1.5 m); moderately well indurated with noncalcareous cement; partly covered but with intermittent exposures in small gullies.	75	(*23.0*)
2	Volcaniclastic sandstone, light-gray (light-brownish-gray-weathering); salt-and-pepper texture due to abundant biotite and hornblende grains; medium to very coarse, conglomeratic; contains thin lenses of pebble conglomerate with some cobbles and boulders to 14 inches (36 cm); outcrop approximately 65% sandstone and 35% conglomerate; moderately well indurated with noncalcareous cement; well stratified; planar bedding and low-angle crossbedding; moderately thin bedding from 6 inches (15 cm) to 2 ft (0.6 m) with frequent variation in grain size; some shallow cut-and-fill structures; transport direction N. 10°–20° W. as indicated by clast imbrication and channel axes; large outcrop at right-angle bend in stream bed.	5	(*1.5*)
	Total thickness of *Chavez Canyon Member.*	416	(*126.4*)
1	Covered interval (a few isolated exposures of the Dog Springs Member are present in small gullies along the east side of Chavez Canyon). The base of the Chavez Canyon Member is near the top of the covered interval.	65	(*20.0*)
	Underlying unit is Dog Springs Member of Spears Formation (Oligocene); not measured. Mudflow deposit, buff (same-weathering), heterolithic, epiclastic; approximately 75% matrix of unsorted sand, silt, and clay; abundant black biotite and hornblende grains in matrix; angular clasts range from small pebbles to boulders 18 inches (46 cm) across; clast lithologies are various intermediate rock types ranging from tan to gray, greenish gray, and reddish brown; some clasts contain mainly pyroxene phenocrysts, others mainly hornblende; some large boulders (to 10 ft, 3 m) of light-greenish-gray to reddish-brown monolithic breccias (section measured southward up stream bed in Chavez Canyon from the good outcrop of mudflow breccia described above).		

TABLE 4—TYPE SECTION FOR DATIL WELL TUFF IS LOCATED IN THE DATIL MOUNTAINS. Location is on the northeast side of White House Canyon 1.2 mi (1.9 km) northwest of junction of US-60–US-12 in town of Datil; NW¼SW¼ sec. 2, T. 2 S., R. 10 W., Datil 7½-min quadrangle. Measured from small outcrop of andesite of White House Canyon poorly exposed on steep talus-covered slope approximately 200 ft (60 m) southeast of west corner of mesa and just northwest of large juniper tree, thence N. 70° E., parallel to strike, up steep slope and low cliff of Datil Well Tuff and across wide bench to first exposure of overlying volcaniclastic sandstones. The section was measured in February 1982 by C. E. Chapin and L. A. Brouillard using direct measurement on the cliffy outcrop and eye-height method parallel to strike in crossing the wide bench. *Because the changes in the Datil Well Tuff are gradational, the section is described at a series of points whose elevations above the base are given instead of the usual thickness of beds.*

Unit	Lithology	Elevation (above base) ft	(*m*)
	Datil Group (Oligocene). The type area for the Datil Group is located in the Datil Mountains and northwest Gallinas Mountains. See glossary for a discussion of the evolution of the term "Datil" and its new definition.		
	Overlying unit is upper part of Chavez Canyon Member of Spears Formation (Oligocene); not measured at this location. Volcaniclastic sandstone, red-brown, poorly sorted; coarse sand and granules with abundant pebbles (interbedded lenses of pebble to cobble volcaniclastic conglomerate inferred from float); well indurated; angular to subrounded clasts; contact with Datil Well Tuff not exposed but inferred to be near change in slope on northeast side of wide bench formed by Datil Well Tuff; top of mesa is capped by Rock House Canyon Tuff.		
	Datil Well Tuff		
7	First exposure of volcaniclastic sandstones near change in slope at northeast side of soil-covered bench.	31.5 (above base)	(*9.5*)
6	Southwest edge of 400-ft (120-m) wide, soil-covered bench held up by Datil Well Tuff.	19.5 (above base)	(*5.9*)
5	Ash-flow tuff, pink and purple, very streaky and flaggy, densely welded, moderately crystal rich.	15.8 (above base)	(*4.8*)
4	Ash-flow tuff, pink and purple, mottled and streaky (flow-banded?), densely welded, moderately crystal rich; phenocryst mineralogy as below; moderately abundant green pyroxene phenocrysts; sparse very small andesitic lithic fragments; sparse white pumice.	10.9 (above base)	(*3.3*)
3	Ash-flow tuff, light-pinkish-gray, faintly streaky, densely welded, moderately crystal rich; phenocryst mineralogy as below; moderately abundant small red and gray andesitic lithic fragments; very pumice poor; transition between massive and flaggy zones.	8.2 (above base)	(*2.5*)
2	Ash-flow tuff, light-purple-gray (light-brown-weathering), massive, densely welded, moderately crystal rich; phenocrysts mainly sanidine with approximately 1% each of biotite and a green, considerably altered pyroxene; traces of plagioclase and quartz; moderately abundant small andesitic lithic fragments and a few pebble-size fragments of the underlying andesite of White House Canyon; very pumice poor.	3.5 (above base)	(*1.1*)
	Total thickness of *Datil Well Tuff.*	31.5	(*9.5*)
1	Covered interval. Measurement reflects thickness of interval in feet and meters.	24	(*7.3*)
	Underlying unit is andesite of White House Canyon, an informal member of Spears Formation (Oligocene). Basaltic-andesite flow, purplish-gray (same-weathering), coarsely porphyritic with abundant large (⅜ inch, 1 cm) laths of plagioclase and abundant greenish-black pyroxene phenocrysts in a purplish matrix, crystal-rich; scattered amygdules of quartz and calcite; small (10 ft long by 5 ft high [3 m long by 1.5 m high]) outcrop on northwest side of large juniper tree 55 ft (16.7 m) downslope from base of Datil Well cliff.		

The type area for the *Dog Springs Member* of the Spears Formation is located in the northwest Gallinas Mountains. The location is approximately 20 mi (32 km) northeast of Datil in Dog Springs Canyon and its major tributaries, Chavez Canyon and Old Canyon; S½, T. 2 N., R. 8 W. and north edge of T. 1 N., R. 8 W., D Cross and Dog Springs 7½-min quadrangles. Access is by driving up Dog Springs Canyon from the Martin Ranch (permission required). For descriptions of the Dog Springs Member in its type area see Coffin (1981, p. 17–87, pl. 1), Harrison (1980, p. 15–43, pl. 1), and Robinson (1981, p. 92–98, pl. 1).

TABLE 5—TYPE SECTION FOR HELLS MESA TUFF IS LOCATED AT NORTH END OF BEAR MOUNTAINS. Location is approximately 17 mi (27 km) north-northwest of Magdalena, approximately 3.6 mi (5.7 km) northwest of Hells Mesa, and approximately 0.3 mi (0.4 km) southwest of Bluff Spring; center of side common to sec. 36, T. 2 N., R. 5 W. and sec. 31, T. 2 N., R. 4 W., Mesa Cencerro 7½-min quadrangle. Measured southwest up sharp ridge on south side of Cañon del Alamito; ridge is at east end of prominent cliff. Base of Hells Mesa Tuff is near brass quarter-section monument and approximately 80 ft (24 m) above canyon bottom. A jeep trail up Cañon del Alamito provides access to near Bluff Spring. Tonking (1957, p. 56) apparently measured the type section of his Hells Mesa Member of the Datil Formation in this vicinity; however, his Hells Mesa Member included the Hells Mesa Tuff plus La Jencia and Vicks Peak Tuffs of this report. The thickness reported for the Hells Mesa portion by Tonking is only approximately half the thickness as measured in March 1982 by the authors, C. E. Chapin and G. R. Osburn, using a Brunton compass and tape. The authors, therefore, redefine the section as described below. *Because the changes in the Hells Mesa Tuff are gradational, the section is described at a series of points whose elevations above the base are given instead of the usual thickness of beds.*

Unit	Lithology	Elevation (above base) ft	(*m*)
	Overlying unit is La Jencia Tuff; not measured. Ash-flow tuff, 2 ft (0.6 m) of lavender-gray (brown-weathering), densely welded, crystal-poor; pumice-poor tuff grading abruptly upward in welded transition to orange-brown (brown-weathering), densely welded, crystal-poor, very pumiceous tuff that forms a 30-ft (9.1-m) cliff. La Jencia Tuff is crystal poor with sanidine being the dominant phenocryst followed by approximately 0.5% quartz and traces of plagioclase and biotite.		
	Hells Mesa Tuff		
10	Contact of Hells Mesa Tuff and La Jencia Tuff.	233 (above base)	(*70.5*)
9	Ash-flow tuff, pale-pinkish-white (very light brown weathering), poorly welded, very crystal rich, very quartz rich; other phenocrysts are sanidine, plagioclase, and biotite; sparse gray and red-brown andesitic lithic fragments; sparse cream-colored, crystal-rich pumice to 3 inches (8 cm); forms rounded, light-colored ledge approximately 8 ft (2.4 m) high.	223 (above base)	(*67.5*)
8	Ash-flow tuff, light-pinkish-gray (light-brown-weathering), moderately welded, crystal-rich with very bronzy biotite; other phenocrysts as below; pumice less abundant; forms bench of smooth, spheroidally weathering slabs.	199 (above base)	(*60.3*)
7	Ash-flow tuff, pale-pink (brown-weathering), moderately welded, crystal-rich but less than below; mineralogy same as below; bronzy biotite; moderately abundant, small, highly flattened, red-brown pumice with spherulitic texture.	175 (above base)	(*53.0*)

Unit	Lithology	Elevation (above base) ft	(*m*)
6	Ash-flow tuff, brownish-pink (brown-weathering), densely welded, crystal-rich; mineralogy same as below except more quartz and bronzy biotite; almost no pumice.	135 (above base)	(*41.0*)
5	Ash-flow tuff, brownish-pink (brown-weathering), densely welded, crystal-rich; abundant quartz and bronzy biotite; sanidine and plagioclase approximately equal; fewer lithic fragments and pumice than below.	73 (above base)	(*22.1*)
4	Ash-flow tuff, light-lavender (brown-weathering), densely welded, crystal-rich, two-feldspar; abundant black biotite; sparse large quartz grains; sparse small brown and gray aphanitic lithic fragments; abundant small (0.5–1.5 cm) light-colored pumice.	19 (above base)	(*5.8*)
3	Base of densely welded zone.	12 (above base)	(*3.6*)
2	Brass monument marking quarter section.	11 (above base)	(*3.3*)
1	Ash-flow tuff, pink, poorly welded, crystal-rich, two-feldspar; abundant black biotite; minor quartz; abundant red, gray, and purple andesitic lithic fragments; abundant small (0.5–1.5 cm) light-colored pumice; weathers with platy fracture and forms slope that is often covered by talus from more resistant tuff above; good exposure of Spears–Hells Mesa contact and much thicker basal zone in gully approximately 100 ft (30 m) east of section.	6 (above base)	(*1.8*)
	Total thickness of *Hells Mesa Tuff.*	233	(*70.5*)
	Underlying unit is Spears Formation of the Datil Group (Oligocene). Volcaniclastic sandstone, light-brown to red-brown (same-weathering), poorly sorted; medium to very coarse sand with abundant pebbles; some thin lenses of pebble conglomerate; well indurated; noncalcareous cement; planar bedding from 2 inches (5 cm) to 3 ft (1 m) thick; minor cut-and-fill structure.		

The type section for *La Jencia Tuff* is located in the southern Bear Mountains. The location is on the west side of La Jencia Basin approximately 6.5 mi (10.5 km) north of Magdalena and 1.8 mi (2.9 km) southeast of Bear Springs on the east slope of a west-dipping hogback just south of Cibola National Forest road 506; NW¼ sec. 22, T. 1 S., R. 4 W., Magdalena NW 7½-min quadrangle. Access is by forest roads 354 and 506 from Magdalena. La Jencia Tuff is the lower cooling unit of Brown's (1972) tuff of Bear Springs. For a description of the type section of La Jencia Tuff see Brown (1972, p. 31–42, pl. 1). Brown measured 507 ft (155 m) of La Jencia Tuff and reported modal mineralogy for 23 samples collected along the line of section.

The type section for the *Lemitar Tuff* is located in the Lemitar Mountains. The location is approximately 8 mi (13 km) northwest of Socorro in a tributary canyon on the north side of Cañoncito del Puertecito del Lemitar (Corkscrew Canyon); NW¼SE¼SE¼ sec. 12, T. 2 S., R. 2 W., Lemitar 7½-min quadrangle. Access is by jeep trail up Corkscrew Canyon through the J. B. Kelly Ranch (permission required). For a description of the type section of the Lemitar Tuff see Chamberlin (1980, p. 92–97, fig. 13, tables 3 and 4, and appendix A, p. 481–490). Chamberlin measured 126 ft (38 m) of Lemitar Tuff and reported modal mineralogy for five samples and chemical compositions for eight samples collected along the line of section.

The type area for the *Luis Lopez Formation* is located in the central Chupadera Mountains. The location is at the south end of the Luis Lopez manganese district approximately 11 mi (18 km) southwest of Socorro and 7 mi (11 km) southwest of the village of Luis Lopez. Here, the Luis Lopez Formation is well exposed along the east side of the Chupadera Range from approximately 2.5 mi (4 km) north of Nogal Canyon to 3.3 mi (5.3 km) south of Nogal Canyon; 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 7½-min quadrangle. Access is via a road that leads westward up Nogal Canyon from I-25 at the San Antonio interchange (4-wheel-drive vehicle advised) and by the Red Canyon (M.C.A.) mine road. Chamberlin (1980) named the Luis Lopez Formation for exposures at the north end of the Chupadera Range; however, stratigraphic relationships are better demonstrated in the Nogal Canyon area, herein designated the type area. For descriptions of the Luis Lopez Formation in its type area see Eggleston (1981, p. 41–62, fig. 9, pl. 1).

The type area for *Magdalena Peak Rhyolite* is located on and south of Magdalena Peak. The location is approximately 1.25–5 mi (2–8 km) south of the village of Magdalena on Magdalena Peak and along Hop and Agua Frio Canyons; sec. 34, T. 2 S., R. 4 W. and secs. 2, 3, 10, 11, 14, 15, T. 3 S., R. 4 W., Magdalena SW 7½-min quadrangle. Access is from Magdalena via the Hop Canyon Road (Cibola National Forest road 101) or NM-107. For descriptions of the Magdalena Peak Rhyolite in its type area see Allen (1979, p. 71–89, pl. 1) and Bobrow (1983).

TABLE 6—TYPE SECTION FOR RINCON WINDMILL MEMBER OF SPEARS FORMATION IS LOCATED IN THE NORTHEAST DATIL MOUNTAINS. Location is approximately 14 mi (22.5 km) northeast of Datil and 1.25 mi (2 km) north-northwest of Rincon windmill; NW¼NW¼ sec. 18, T. 1 N., R. 8 W., unsurveyed, Dog Springs 7½-min quadrangle; measured northeastward up a steep gully on the southwest corner of mesa 8390; 7° dip taken from geologic map; dips on outcrops are variable because of low-angle cross-stratification. Access is by private roads leading to either Rincon windmill or John Henry windmill on the J. Taylor Ranch (permission required). The section was measured in February 1982 by C. E. Chapin and L. A. Brouillard using a Brunton compass and Jacob's staff.

Unit	Lithology	Thickness (equivalents) ft	(*m*)
	Spears Formation of the Datil Group (Oligocene)		
	Overlying unit is Hells Mesa Tuff; not measured at this location. Ash-flow tuff, white (light-brownish-gray-weathering), unwelded, crystal-rich; phenocrysts of sanidine, plagioclase, quartz, and biotite; abundant pumice lapilli; forms prominent light-colored cliff, the lower part of which shows some internal stratification.		
	Rincon Windmill Member		
8	Volcaniclastic sandstone, aeolian, brown, fine to medium, very well sorted, poorly consolidated, laminated and crossbedded, poorly exposed in gully just north of traverse.	35	(*10.6*)

		Thickness (equivalents)	
Unit	Lithology	ft	(*m*)
7	Volcaniclastic sandstone, light-brownish-gray (light-brown-weathering), fine to medium, clean and well-sorted with no pebbles, moderately indurated, very porous; concretionary cementation common; planar bedding and low-angle crossbedding; beds from laminae to 2 ft (0.6 m) thick; approximately 2 ft (0.6 m) of relief on base of unit with the lows filled with structureless bimodal sand (coarse sand and granules and a few pebbles floating in matrix of fine to medium sand); uppermost 8 ft (2.4 m) of unit is less well sorted, fine to coarse sandstone, very poorly indurated with spectacular low-angle crossbedding and concretionary cementation.	50	(*15.2*)
6	Volcaniclastic sandstone, light-brownish-gray (light-brown-weathering); medium to granule sand with sparse andesitic (gray, red-brown, purple) small pebbles and an occasional cobble; well indurated; noncalcareous cement; well stratified; planar bedding and low-angle crossbedding; beds average 1–2 ft (0.3–0.6 m) thick but range from laminae marked by concentrations of heavy minerals to beds 6 ft (2 m) thick; occasional thin lenses of pebble conglomerate or pebbly sandstone; N. 10° E. transport direction from imbricated pebbles.	97	(*29.4*)
5	Blue Canyon Tuff, light-gray (light-brown-weathering), unwelded, moderately crystal rich; phenocrysts mainly sanidine and biotite with traces of plagioclase and quartz; abundant black biotite; moderately abundant small andesitic lithic fragments (gray, red-brown, purple) and a few pebbles from underlying sediments; sparse moderately large (⅜–2 inches [1–5 cm]) light-brown pumice, which weathers out and imparts a crude foliation to the cliffy outcrop; soft, clayey, altered zones at base (1–5 ft [0.3–1.5 m] thick) and top (4 ft [1.2 m] thick) of unit.	23	(*7.0*)
	Note: line of section offset 50 ft (15.2 m) to north along base of Blue Canyon Tuff to avoid a minor fault.		
4	Volcaniclastic sandstones and conglomerates, light-brownish-gray (same-weathering); coarse to granule sandstones with thin (3–18 inches [7–46 cm]) lenses of pebble to cobble conglomerate that contain a few small boulders; planar bedding and low-angle crossbedding; moderately well indurated; forming ledgy outcrops; north-northeast transport direction based on pebble imbrications; granule to 1 inch (2.5 cm) pumice abundant in sandstones; distinctive 7.5 ft (2.3 m) bed of light-cream, fine to medium tuffaceous sandstone containing abundant biotite and sparse pumice lapilli occurs 110 ft above base of interval.	171	(*52.0*)
3	Covered interval.	25	(*7.6*)
2	Volcaniclastic sandstone, light-brownish-gray (same-weathering); poorly sorted; very coarse to granule sand with sparse small pebbles and occasional cobbles; moderately well indurated but very porous (minor noncalcareous cement); well stratified; low-angle crossbedding; abundant yellow and tan granules of pumice; lithic grains are tan, gray, red-brown, and purple andesitic rock fragments.	5	(*1.5*)
1	Covered interval.	5	(*1.5*)
	Total thickness of *Rincon Windmill Member.*	411	(*124.8*)
	Underlying unit is Rock House Canyon Tuff; not measured at this location. Ash-flow tuff, light-gray (very light brown weathering), unwelded, crystal-poor; phenocrysts mainly sanidine with traces of plagioclase, biotite, and quartz; moderately abundant pumice; unit forms light-gray, smooth, rounded surfaces and low cliffs along arroyos.		

TABLE 7—TYPE SECTION FOR ROCK HOUSE CANYON TUFF IS LOCATED IN THE NORTHWEST GALLINAS MOUNTAINS. Location is approximately 15 mi (24 km) northeast of Datil and 3 mi (4.8 km) north of North Lake at the junction of Rock House Canyon and Long Canyon; SW¼ sec. 13, T. 1 N., R. 8 W., unsurveyed, Dog Springs 7½-min quadrangle. Measured from near the head of a steep gully on the south side of Long Canyon where the base of the unit is exposed, thence southwestward down a dip slope and across to the north side of Long Canyon at the east end of the box, thence southwestward to just beyond the junction of Long Canyon with Rock House Canyon. Access is by private road up Long Canyon on the J. Taylor Ranch (permission required). The section was measured in February 1982 by C. E. Chapin and G. R. Osburn using an Abbe level and Jacob's staff. *Because the changes in the Rock House Canyon Tuff are gradational, the section is described at a series of points whose elevations above the base are given instead of the usual thickness of beds.*

		Elevation (above base)	
Unit	Lithology	ft	(*m*)
	Datil Group (Oligocene). The type area for the Datil Group is located in the Datil Mountains and northwest Gallinas Mountains. See glossary for a discussion of the evolution of the term "Datil" and its new definition.		
	Overlying unit is Rincon Windmill Member of Spears Formation (Oligocene); not measured at this location. Volcaniclastic conglomerate, variegated, poorly sorted; pebble to boulder (to 2 ft, 0.6 m) conglomerate with light-tan, medium to very coarse sandy matrix and a few thin sandy strata, well-rounded boulders, and some calcite cement; moderately well indurated; clast supported; N. 55° E. transport direction from clast imbrication; description from exposures along north bank of arroyo approximately 650 ft (200 m) west of the uppermost exposure of Rock House Canyon Tuff.		
8	Covered interval. Measurement reflects thickness of interval in feet and meters.	36	(*11.0*)
	Rock House Canyon Tuff		
7	Ash-flow tuff, light-creamy-white (light-brown-weathering), unwelded, soft, crystal-poor; sparse sanidine phenocrysts; sparse small gray lithic fragments; abundant elliptical pumice to 1½ inches (4 cm) across. (Additional Rock House Canyon Tuff, as described above, is exposed approximately 500 ft [150 m] west of the end of the measured section in the north bank of the arroyo; however, because of an apparent flattening of the dip and possible faulting beneath the intervening covered interval, this material was not included in the measured section.)	225	(*68.6*) (above base)

Unit	Lithology	Elevation (above base) ft	(*m*)
6	Ash-flow tuff, very light gray (light-brown-weathering), unwelded, crystal-poor; sparse small gray and red andesitic lithic fragments; top of cliff on north side of box canyon.	175 (above base)	(*53.0*)
5	Ash-flow tuff, very light tan (light-brown-weathering), slightly welded, crystal-poor; sparse small gray and red andesitic lithic fragments; pumice cellular and uncompacted; at east end of box canyon approximately 100 ft (30 m) north of box.	135 (above base)	(*41.0*)
4	Ash-flow tuff, light-gray (light-brown-weathering), moderately welded, crystal-poor; phenocrysts mainly sanidine with traces of hornblende and quartz; grainy matrix; 10 ft (3 m) below top of ridge, traverse turns southwestward down dip slope and crosses to north side of Long Canyon at east end of box canyon.	65 (above base)	(*19.7*)
3	Ash-flow tuff, light-purplish-gray (purple-gray-weathering), moderately welded, crystal-poor; phenocrysts mainly sanidine but with noticeable quartz and sparse black hornblende(?); gradational increase in pumice content and degree of welding up from base; pumice well compacted and no longer spherulitic; shard structure in matrix still noticeable.	30 (above base)	(*9.1*)
2	Ash-flow tuff, light-pinkish-gray (weathers to gray platy grus); poorly welded but well indurated; crystal poor; phenocrysts mainly sanidine but with noticeable quartz (0.5%) and traces of biotite and a black ferromagnesian mineral that may be hornblende; sparse small gray andesitic lithic fragments; sparse uncompacted pink pumice and light-tan spherulitically devitrified pumice, shard structure conspicuous in matrix.	1 (above base)	(*0.3*)
	Total thickness of *Rock House Canyon Tuff.*	225	(*68.6*)
1	Covered interval. Measurement reflects thickness of interval in feet and meters.	10	(*3.0*)
	Underlying unit is Chavez Canyon Member of Spears Formation (Oligocene); not measured at this location. Volcaniclastic conglomerate, light-brownish-gray (very light brown weathering), poorly sorted; coarse sand to granules and pebbles with some cobbles; moderately well indurated; noncalcareous cement; abundant bronzy biotite; exposed in steep gully on south side of Long Canyon (first conspicuous gully east of the last outcrop of Rock House Canyon Tuff in bottom of canyon).		

The type area for the *Sawmill Canyon Formation* is located in Sawmill Canyon. The location is approximately 16 mi (26 km) southeast of Magdalena along both sides of Sawmill Canyon; secs. 3, 4, 9, 10, 11, 14, 15, T. 5 S., R. 3 W., South Baldy 7½-min quadrangle. Access is via Cibola National Forest road 472 and trail 19. For descriptions of the Sawmill Canyon Formation in its type area see Roth (1980, p. 36–46, pl. 1) and Bowring (1980, p. 28–41, pl. 1). The Sawmill Canyon Formation is Roth and Bowring's unit of Sixmile Canyon.

The type area for the *Socorro Peak Rhyolite* is located on and south of Socorro Peak. The location is approximately 3 mi (5 km) west and southwest of Socorro in a belt extending from the summit of Socorro Peak southward to the Grefco perlite mine; secs. 5, 8, 16, 17, 21, 28, T. 3 S., R. 1 W., Socorro 7½-min quadrangle. Access is via Blue Canyon Road through the campus of New Mexico Institute of Mining and Technology (permission required) and by roads to Socorro Spring and the Grefco mine. For descriptions of the Socorro Peak Rhyolite in its type area see Chamberlin (1980, p. 283–339, pls. 1, 2).

The type section for the *South Canyon Tuff* is located at the mouth of South Canyon. The location is approximately 12 mi (19 km) southwest of Socorro on the northwest side of the mouth of South Canyon; SW¼ sec. 30, T. 3 S., R. 2 W., Magdalena SE 7½-min quadrangle. Access is via US-60 southwest from Socorro then by Cibola National Forest road 37. For a description of the type section of the South Canyon Tuff see Osburn (1978, p. 49–58, fig. 14, pl. 1). Osburn measured 620 ft (189 m) of South Canyon Tuff and reported modal mineralogy for 11 samples collected along the line of section.

TABLE 8—TYPE SECTION FOR SOUTH CROSBY PEAK FORMATION IS LOCATED IN THE EASTERN CROSBY MOUNTAINS. Location is approximately 4.3 mi (7 km) southwest of Datil and 1.8 mi (3 km) northeast of South Crosby Peak; NE¼ sec. 19, T. 2 S., R. 10 W., Sugarloaf Mountain 7½-min quadrangle. Forest roads 66, 196, and 510 to near Rock Cliff tank (Crosby Springs 7½-min quadrangle) provide the nearest access. Section begins approximately 25 ft (8 m) lower in elevation and approximately 75 ft (23 m) N. 30° E. of a rounded knob of Hells Mesa Tuff. The basal South Crosby Peak Formation occurs at lower elevations than the top of the Hells Mesa Tuff due to deposition in channels cut into the tuff. Because of this irregular contact and lack of exposure, the section was started at the lowest exposed sandstone and measured N. 20° W. directly upslope using a N. 75° E. strike for the beds and a 4° dip to the southeast. The section was measured in March 1982 by G. R. Osburn and D. J. Bobrow using a hand level and Jacob's staff.

Unit	Lithology	Thickness (equivalents) ft	(*m*)
	Overlying unit is basaltic andesite of Deep Well; not measured. Basaltic andesite, black (olive-gray-weathering) with abundant light-brown specks of oxidized ferromagnesian minerals (to 2 mm); moderately abundant plagioclase laths (to 5 mm); abundant amygdules of calcite and silica; prominent rubble zone at base of flow. The basaltic andesite of Deep Well consists of three flows separated by thin (13 ft [4 m] and 45 ft [13.6 m]) intervals of volcaniclastic conglomerate and conglomeratic sandstone and is overlain by the Vicks Peak Tuff.		
	South Crosby Peak Formation		
4	Volcaniclastic conglomerates and interbedded tuffaceous sandstones, grayish-pink (brownish-pink-weathering); dark andesitic clasts impart darker colors to cobble-rich intervals; sandstones medium to granule with variable subangular to subrounded pebbles and cobbles; maximum clast size in conglomerates approximately 8 inches (20 cm); lithic grains are varicolored, tan, reddish-brown, purple, and light-green, aphanitic, intermediate to felsic volcanic rocks; all beds are tuffaceous with abundant light-colored pumice lapilli and ash; the conglomerate/sandstone ratio increases upward in the section; the lower beds are the most tuffaceous apparently because of reworking of		

Unit	Lithology	Thickness (equivalents) ft	(*m*)
	underlying ash-flow tuff; moderately to well indurated; noncalcareous; well stratified; planar bedding from 3 inches (7 cm) to 1 ft (30 cm); minor low-angle crossbedding and small cut-and-fill structures; transport direction from pebble imbrications from N. 30° W. to N. 60° W.	451	(*137.0*)
3	Ash-flow tuff, pale-pink (brownish-pink-weathering), unwelded to poorly welded, crystal-poor; abundant lithic fragments of red, brown, purple, and light-green, aphanitic, intermediate to felsic volcanic rocks; abundant light-colored pumice to ⅝ inch (1.5 cm); weak eutaxitic foliation; lithic content varies both vertically and laterally from approximately 5% to more than 50%; unit forms moderately massive cliffs and steep slopes; the unit extends for several miles to the west and southwest but is missing immediately east of this section.	37	(*11.2*)
	Section offset 300 ft (90 m) to west along base of ash-flow tuff.		
2	Volcaniclastic sandstones and conglomeratic sandstones, tuffaceous, grayish-pink (grayish-orange-pink-weathering); medium to granule sand with some layers containing granules and pebbles to 1 inch (2.5 cm); abundant small light-colored pumice; abundant biotite; angular to subrounded clasts; moderately indurated; noncalcareous cement; well stratified; planar bedding; beds from 5 inches (10 cm) to 3 ft (1 m) thick; white pumice-rich layers along bedding planes.	22	(*6.7*)
1	Volcaniclastic sandstone, tuffaceous, grayish-orange-pink (same-weathering), medium to coarse, well-sorted; occasional pebbles; moderately to well indurated; noncalcareous cement; indistinct planar bedding; beds from a few inches to 1 ft (30 cm) thick; unit uniform from top to bottom and forms massive, gently sloping outcrops.	85	(*25.8*)
	Total thickness of *South Crosby Peak Formation.*	595	(*180.7*)
	Underlying unit is Hells Mesa Tuff; not measured at this location. Ash-flow tuff, pinkish-gray (grayish-orange-weathering), poorly welded, crystal-rich, quartz-rich; subequal sanidine and plagioclase; abundant bronzy biotite; sparse andesitic lithic fragments; moderately abundant pumice; weak foliation; forms large rounded knobs and boulders.		

A reference section for the *Vicks Peak Tuff* is located in the southern Bear Mountains. The location is approximately 6 mi (9.7 km) north of Magdalena and 2.5 mi (4 km) southeast of Bear Springs on the west slope of a west-dipping hogback 0.8 mi (1.3 km) south of Cibola National Forest road 506; S½ sec. 22, T. 1 S., R. 4 W., Magdalena NW 7½-min quadrangle. Access is via forest roads 354 and 506 from Magdalena. The Vicks Peak Tuff was named by Farkas (1969) and redefined by Deal and Rhodes (1976), but a type section was not measured nor was the type locality, Vicks Peak, mapped in detail. Since the name is established in the literature and the Vicks Peak Tuff was erupted from the Nogal Canyon cauldron in the Vicks Peak area, we accept the name but herein define a reference section in an area that has been mapped in detail (1:24,000) and where the stratigraphic relationships are well exposed. For a description of the reference section of the Vicks Peak Tuff see Brown (1972, p. 42–46, table 3, fig. 12, pl. 1). The Vicks Peak Tuff is the upper cooling unit of Brown's tuff of Bear Springs. Brown measured 280 ft (85 m) of Vicks Peak Tuff and reported modal mineralogy for 15 samples collected along the line of section.