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SUMMARY OF THE GEOLOGY OF THE NORTHERN PART OF THE SIERRA CUCHILLO, SOCORRO AND SIERRA COUNTIES, SOUTHWESTERN NEW MEXICO

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Abstract—The northern part of the Sierra Cuchillo is located within the northeastern part of the Mogollon-Datil volcanic field west of the Rio Grande rift in the Basin and Range Province, approximately 50 km northwest of Truth or Consequences in south-central New Mexico. The Sierra Cuchillo is a north-south, elongated horst block composed of Tertiary volcanic and intrusive rocks, sparse outcrops of Lower Permian and Upper Cretaceous rocks, and sediments of the Tertiary-Quaternary Santa Fe Group. The horst is composed mainly of a basal volcanic rock sequence of andesite-latite lava flows and mud-flow breccias with a $^{40}Ar/^{39}Ar$ isotopic age of about 38 Ma. The sequence is locally intruded by numerous dikes and plugs that range in composition from basaltic andesite through rhyolite and granite. The andesite-latite sequence is overlain by ash-flow tuffs and a complex of rhyolitic lava flows and domes. Some of these units are locally derived and some are outflow sheets derived from calderas in the San Mateo Mountains, northeast of the study area. These locally derived units and outflow sheets range in age from 28 to 24 Ma.

INTRODUCTION

The Sierra Cuchillo is an elongated fault-block located west of the Rio Grande rift in the Basin and Range Province, approximately 50 km northwest of Truth or Consequences in south-central New Mexico (Fig. 1). This summary is based on work conducted as part of a Masters thesis at the University of New Mexico (Maldonado, 1974). Other investigations before and since that study include work by Willard (1957), Hillard (1967; 1969), Maldonado (1980), and Lynch (2003). Jahns (1943; 1944; 1955; Jahns and Glass, 1944) mapped the Sierra Cuchillo south of the study area, McGraw (2003) mapped the surficial deposits of the study area, and McLemore (2010) studied and remapped the study area. The study area is located on the northeastern part of the northern Sierra Cuchillo and is composed of sparse outcrops of Lower Permian and Upper Cretaceous rocks, Tertiary volcanic and intrusive rocks, and sediments of the Tertiary-Quaternary Santa Fe Group. The Sierra Cuchillos are located within the northeastern part of the Mogollon-Datil volcanic field and bordered on the west by the Winston graben and the Black Range and on the east by the Monticello graben and the San Mateo Mountains (Fig. 1). The San Mateo Mountains are composed of Precambrian rocks and rhyolitic ash-flow tuffs; eruptions of the San Mateo Mountains resulted in formation of three calderas, the Mt. Withington caldera (Deal, 1973) and Bear Trap caldera (Chapin, et al., 2004) in the northern end of the range and the Nogal Canyon caldera in the southern end of the range (Deal and Rhodes, 1976). The Black Range consists of sedimentary rocks overlain by Tertiary volcanic rocks composed mainly of andesitic and latitic lava flows and interbedded tuffs and breccias that are overlain by rhyolitic flows and tuffs erupted from the Emory caldera (Kuellmer, 1954; Fodor, 1976; Chapin, et al., 2004).

PRE-TERTIARY ROCKS

The oldest exposed rocks in the Sierra Cuchillo are sparse pre-Tertiary rocks exposed only in the southwestern part of study area (Fig. 2) where they consist of the Lower Permian Yeso Formation and San Andres Limestone (combined as map unit **Pys,** Fig. 2) with some Upper Cretaceous rocks. The Yeso Formation is composed of non-marine, reddish-brown, thin- to medium-

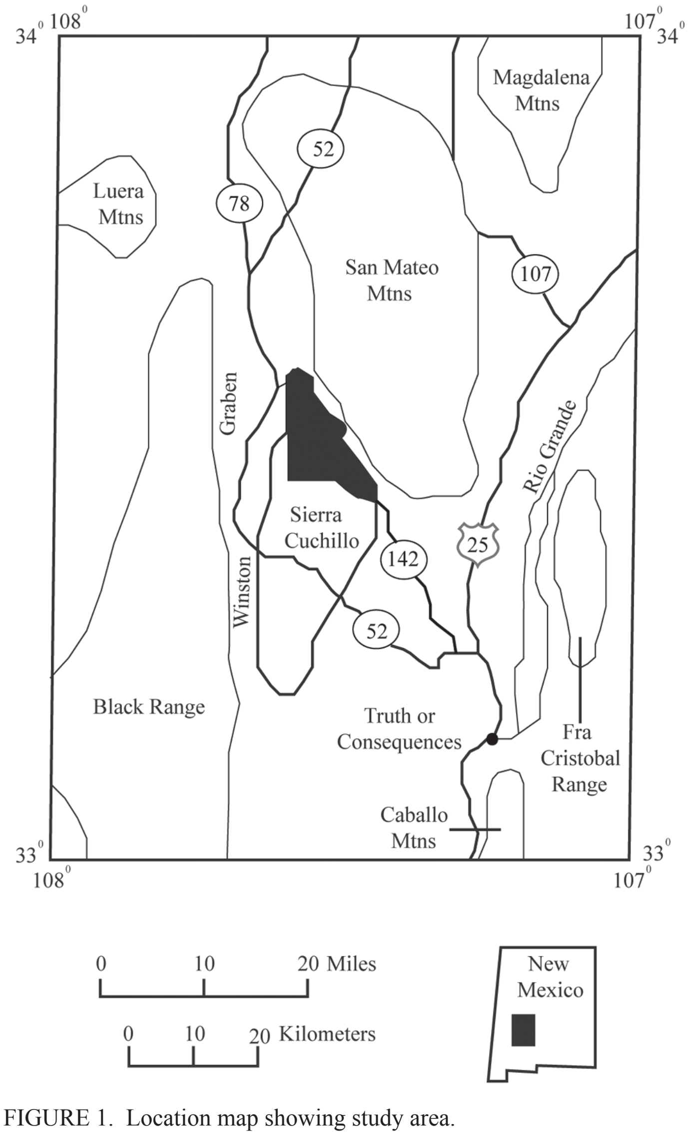


FIGURE 1. Location map showing study area.

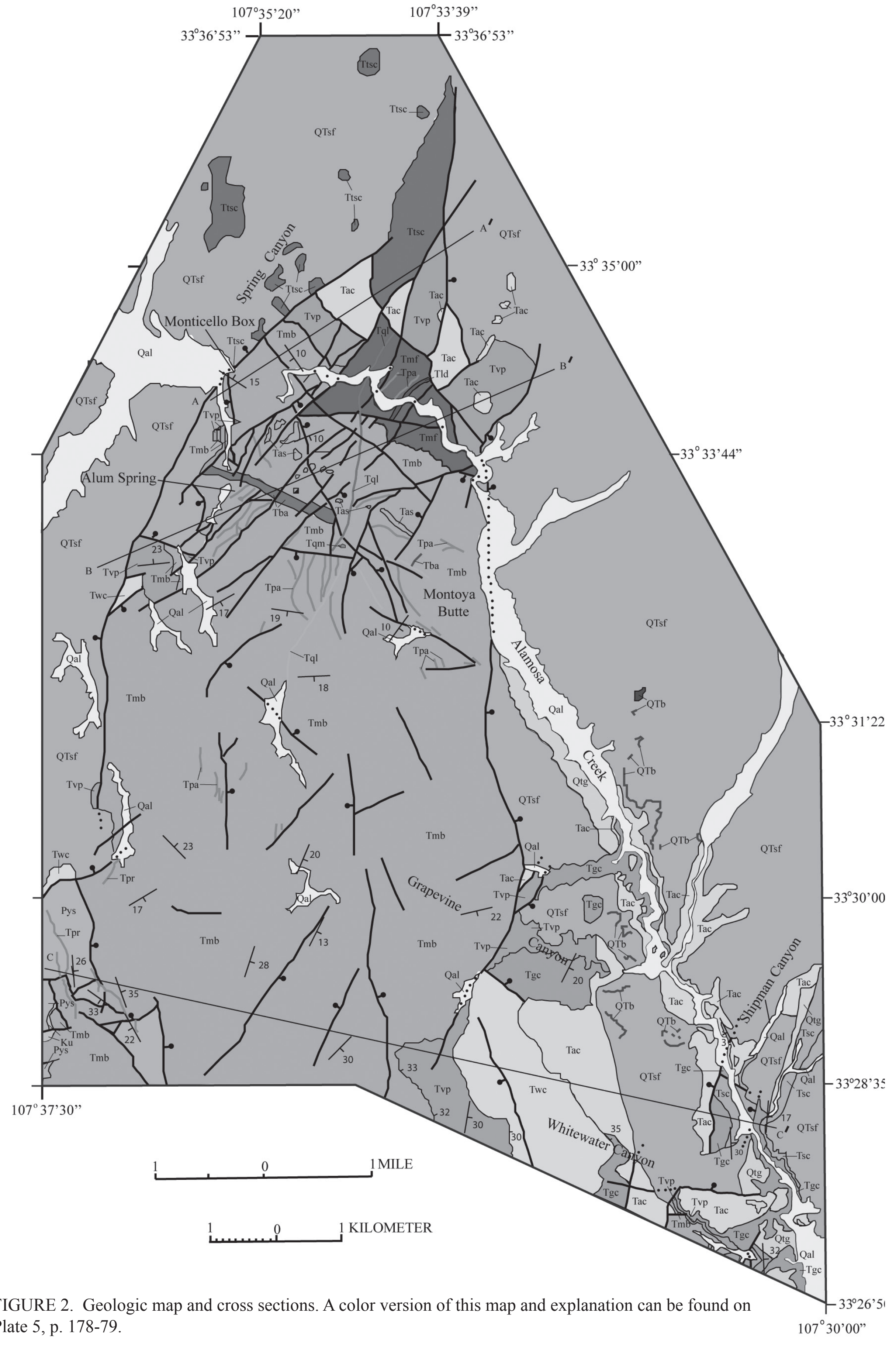
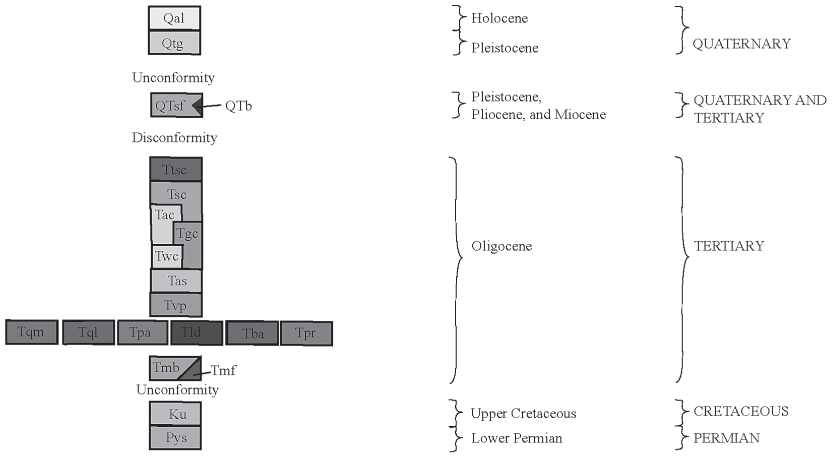


FIGURE 2. Geologic map and cross sections. A color version of this map and explanation can be found on Plate 5, p. 178-79.



MAP UNITS

- Qal — Alluvium (Holocene)
- Qtg — Terrace gravel (Pleistocene)
- QTb — Olivine basalt (Pleistocene, Pliocene, and Miocene)
- QTsf — Santa Fe Group (Pleistocene, Pliocene, and Miocene)
- Ttsc — Tuff of Spring Canyon (Oligocene)
- Tsc — Tuff of Shipman Canyon (Oligocene)
- Tac — Rhyolite of Alamosa Creek (Oligocene)
- Tgc — Latite of Grapevine Canyon (Oligocene)
- Twc — Quartz latite porphyry of Whitewater Canyon (Oligocene)
- Tas — Rhyolite of Alum Spring (Oligocene)
- Tvp — Vicks Peak Rhyolite (Oligocene)
- Tqm — Quartz monzonite plug (Oligocene)
- Tql — Quartz latite dikes (Oligocene)
- Tpa — Porphyritic andesite dikes (Oligocene)
- Tld — Latite dikes (Oligocene)
- Tba — Basaltic andesite dikes (Oligocene)
- Tpr — Porphyritic rhyolite dikes (Oligocene)
- Tmb — Andesite-latite of Montoya Butte (Oligocene)
- Tmf — Basal mudflow breccia of andesite-latite of Montoya Butte (Oligocene)
- Ku — Upper Cretaceous rocks, undivided (Cretaceous)
- Pys — San Andres Limestone and Yeso Formation, undivided (Lower Permian)

SYMBOLS

- Contact
- Fault, bar and bell on downthrown side; dotted where concealed
- 28 Strike and dip of bedding and foliation of pumice
- Shaft

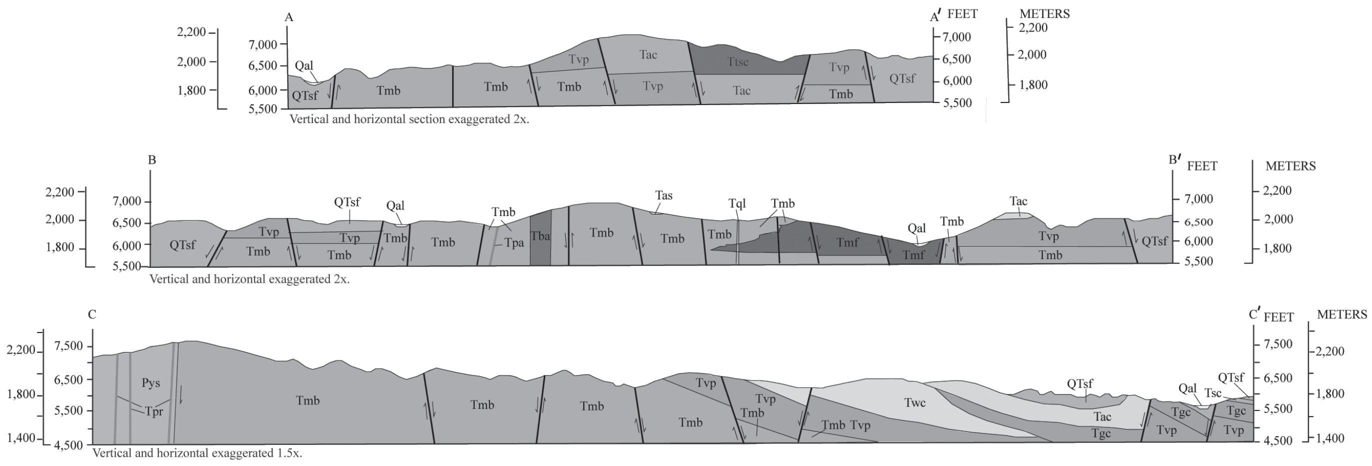


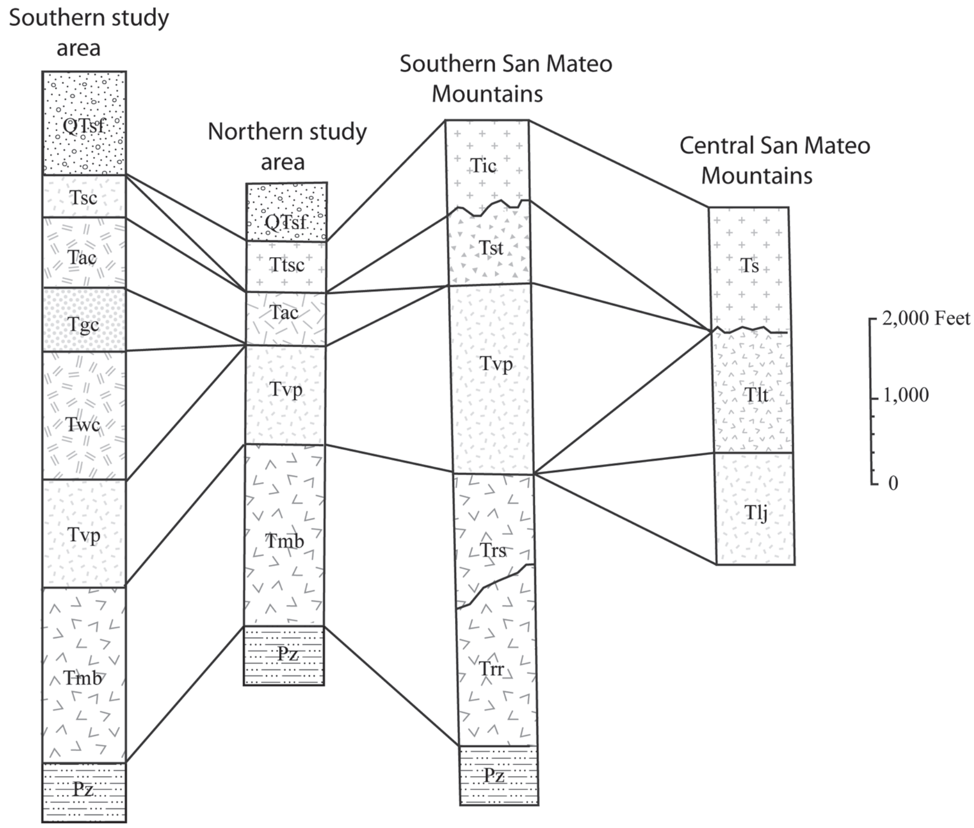
FIGURE 2. Cont.

bedded sandstone and siltstone with abundant medium- to dark-gray limestone. The San Andres Limestone is mostly marine, fine-grained, medium- to dark-gray, limestone with subordinate interbedded silty limestone and reddish siltstone and sandstone. Total thickness for these formations in the region is about 640 m (Jahns, 1955). Units are intruded by porphyritic rhyolite dikes (**Tpr**). The Upper Cretaceous rocks are composed of interbedded shale, conglomerate, and sandstone with a thickness of approximately 10 m.

TERTIARY VOLCANIC ROCKS

The Tertiary volcanic rocks are of Oligocene age and composed of a basal sequence of andesite to latite lava flows, with a basal tuff-breccia, and interbedded tuff-breccia (mudflow breccia) referred to as andesite-latite of Montoya Butte (unit **Tmb** of this report) by Maldonado (1974, 1980). These Oligocene rocks are the oldest exposed volcanic rocks in the study area and are intruded by a quartz monzonite plug (**Tqm**) and numerous dikes (**Tql, Tpa, Tld**, **Tba**, **Tpr**) that range in composition from basaltic andesite through rhyolite which will be described in the intrusive rocks section below. The rocks of Montoya Butte are overlain, unconformably, by Vicks Peak Rhyolite (**Tvp**) and the rhyolite of Alum Spring (**Tas**) and successively younger extrusive rocks that include the quartz latite porphyry of Whitewater Canyon (**Twc**), latite of Grapevine Canyon (**Tgc**), rhyolite of Alamosa Creek (**Tac**), tuff of Shipman Canyon (**Tsc**), and tuff of Spring Canyon (**Ttsc**). The geochemistry of these rocks has been described by McLemore (2010).

The andesite-latite of Montoya Butte (**Tmb)** are mostly lava flows that form the main rock unit exposed in the study area with the best exposure at Montoya Butte located in the east-central part of study area, west of Alamosa Creek (Fig. 2). The lowest exposed part of this unit is composed of a thick tuff-breccia deposit mapped locally as **Tmf** that is approximately 200 m thick and is interpreted as a mudflow breccia. The best exposure of this unit is found in Monticello Box in the northwestern part of study area (Fig. 2). The mudflow breccia is poorly sorted, greenish to purplish-gray with a latitic matrix that contains andesitic and latitic clasts as large as 2 m long**.** The mudflow breccia resembles



QTsf Santa Fe Group
Ttsc Tuff of Spring Canyon
Tsc Tuff of Shipman Canyon
Tac Rhyolite of Alamosa Creek
Tgc Latite of Grapevine Canyon
Twc Quartz latite porphyry of White Water Canyon
Tvp Vicks Peak Rhyolite
Tmb Andesite-latite of Montoya Butte
Tic Indian Creek Rhyolite
Tst Springtime Canyon Quartz Latite
Trs Rock Spring Formation
Trr Red Rock Ranch Formation
Ts South Canyon Tuff
Tlt Lemitar Tuff (Potatoe Canyon Rhyolite of Deal (1973)
Tlj La Jencia Tuff (A-L Peak Rhyolite of Deal (1973)
Pz Paleozoic rocks undivided

FIGURE 3. Correlation chart of rock units, northern part of the Sierra Cuchillo and central and southern San Mateo Mountains, southwestern New Mexico.

deposits described by Jahns and Glass (1944) at Iron Mountain, located southwest of the study area, where these deposits overlie Paleozoic sedimentary rocks. A sequence of andesite-latite lava flows and interbedded tuff-breccias (**Tmb**) overlie the tuff-breccia deposits that may be as much as 600 m thick; however, Jahns (1955) estimated a thickness of about 900 m south of the study area. The andesite-latite lava flows usually form steep cliffs and the latite lava flows are light gray, flow banded, and porphyritic. The andesite lava flows are propylitized and range in color from purplish, gray, and greenish to light or dark brown, and white where extremely altered. Texture is aphanitic to coarsely porphyritic with scattered xenoliths of coarse- to fine-grained granite and gneissic rocks up to 20 m across (Hillard, 1969). The andesite-latite of Montoya Butte is probably regionally equivalent to Willard's (1957) Lower volcanic group, Tonking's (1957) Spears Member of the Datil Formation, and Jahns (1955) and Hillard's

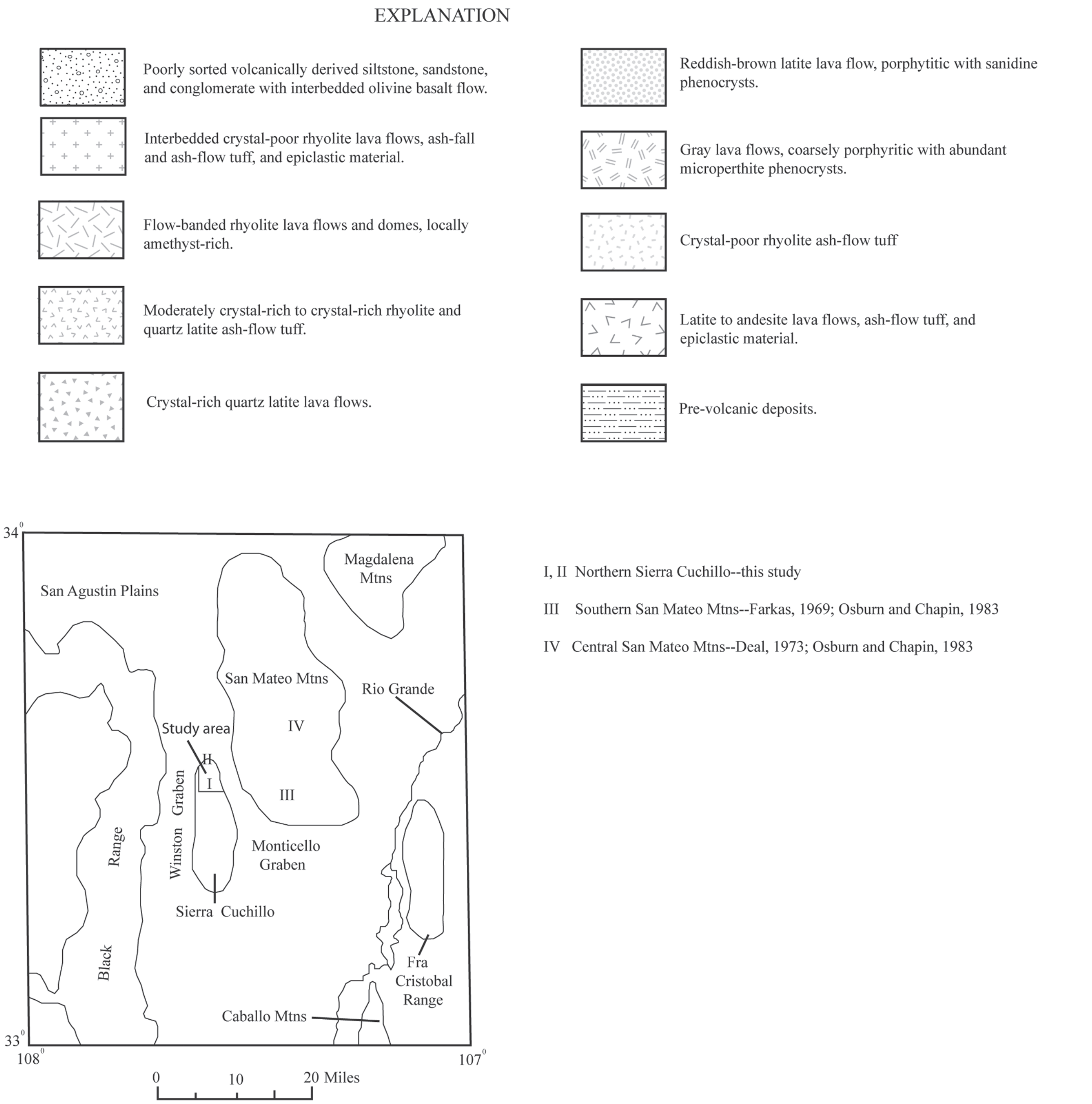


FIGURE 3. Cont.

(1969) Andesite-latite sequence, to Jahns' et al., (2006) latite-andesite sequence, and to McLemore's (2010) andesite of Monticello Box and Latite of Montoya Butte. The andesite-latite lava flows probably correlate with the Red Rock Ranch Formation and part of the Rock Spring Formation in the southern San Mateo Mountains (Farkas, 1969) (Fig. 3). The latite of andesite-latite of Montoya Butte has been dated at 37.5 Ma ($^{40}Ar/^{39}Ar$, McLemore, 2010) from the study area.

The Vicks Peak Rhyolite (**Tvp**) was first used by Farkas (1969) in a dissertation for exposures in the southern San Mateo Mountains located northeast of study area. The source of the tuff is the Nogal Canyon caldron (Deal and Rhodes, 1976; Chapin, et. al., 2004) located in the southern part of the San Mateo Mountains. The tuff is rhyolitic and contains 1-8% phenocrysts of sanidine and quartz, is approximately 2-370 m thick and exposed in the northeastern and southeastern part of study area, where it probably represents outflow sheets. The tuff is densely welded and varies in color from pink, brownish red, to grayish white and it locally contains walnut-size spherulites. A thin ash-fall tuff (approximately 6 m) locally forms the base of unit. To the south, in the study area, the rhyolite overlies the lavas of Montoya Butte and lies below the latite of Grapevine Canyon (**Tgc**) or the quartz latite porphyry of Whitewater Canyon (**Twc**). To the north, it is overlain by the rhyolite of Alamosa Creek (**Tac**). The tuff has been dated at about 28.4 Ma ($^{40}Ar/^{39}Ar$, Lynch, 2003).

The rhyolite of Alum Spring (**Tas**) is named for lava flows exposed at Alum Spring, located in the northwest part of study area south of Monticello Box (Fig. 2). The unit contains approximately 27% phenocrysts of sanidine, quartz, and trace amounts of apatite. The rhyolite occurs as tabular lava flows about 8-12 m (Hillard, 1969) thick with crude columnar joints. The flows typically overlie the andesite-latite of Montoya Butte, but locally, overlie a Tertiary sedimentary sequence that in turn overlies the lavas of Montoya Butte. Beryllium mineralization is present in the study area near Alum Spring (Fig. 2a) and just south of the entrance to Monticello Box in the northwest corner of the study area (Fig. 2a). This beryllium mineralization has been described by McLemore (2010, this guidebook) and Hillard (1969).

The quartz latite porphyry of Whitewater Canyon (**Twc**) is exposed in Whitewater Canyon located in the southeastern part of study area (Fig. 2). The unit contains crystal rich lava flows, about 30% phenocrysts of sanidine (microperthite), quartz, pyroxene, and traces of plagioclase, biotite, olivine, apatite, and chlorite. The rocks are flow-banded, gray, approximately 470 m thick and contain flow folds with amplitudes up to 2 m. An aphanitic matrix consists mainly of spherulitites and scattered patches of granophyric quartz-feldspar intergrowths and euhedral microperthite phenocrysts up to 1 cm long.

TABLE 1. Trace-element analyses for rhyolite lava of Alamosa Creek, Shipman Canyon area, in ppm.

	Sn	W	Ti	B	Be	Mo
Amethyst-rich vesicular phase	<20	1.1	1200	0.7	0.5	<8
Amethyst-poor vesicular phase	<20	2.2	1300	2.3	1.4	<8
Lower limit of sensitivity	20	0.5	50	0.25	0.25	8

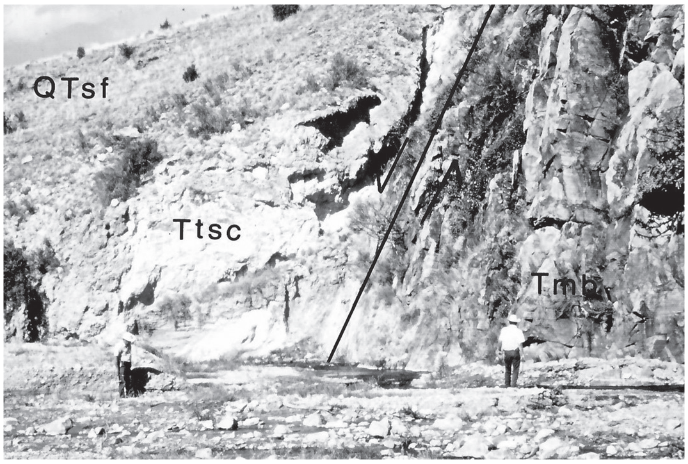


FIGURE 4. Photo showing northwest entrance to Monticello Box with high-angle fault and spring. Wolfgang Elston (retired University of New Mexico professor) on left part of photograph and Ed Deal (Montana State Geologist) on right. QTsf, Santa Fe Group; Ttsc, tuff of Spring Canyon; Tmb, andesite-latite of Montoya Butte.

The latite of Grapevine Canyon (**Tgc**) is a reddish-brown porphyritic rock exposed in Grapevine Canyon in the southeastern part of study area (Fig. 2) and may correlate with the Springtime Canyon Quartz Latite of Farkas (1969) exposed in the San Mateo Mountains. The unit is massive to flow banded lavas and contains 2-4% phenocrysts of sanidine, quartz, and pyroxene and is 6 m to about 200 m. Locally, an ash-fall tuff about 60 cm thick is at the contact between the latite of Grapevine Canyon and quartz latite porphyry of Whitewater Canyon.

The rhyolite of Alamosa Creek (**Tac**) is exposed in the Alamosa Creek area (Fig. 2) in the southeastern part of study area and is as much as 200 m thick. The rhyolite forms lava flows and local domes and varies from an amethyst-rich to an amethyst-poor non-vesicular phase and contains 9-12% phenocrysts of sanidine (microperthite), quartz, and traces of biotite and hornblende. In Shipman Canyon (Fig. 2), the rhyolite forms a dome and typically contains numerous vesicles filled with abundant amethyst crystals and lesser amounts of magnetite, anorthoclase, and pseudobrookite. The amethyst crystals range up to 2 mm in length and make up to about 7% by volume in some samples. The rhyolite overlies the latite of Grapevine Canyon in the southeastern part of study area where it fills in paleotopographic low areas in the latite. In the northeastern part of study area where the latite of Grapevine Canyon is missing the rhyolite overlies Vicks Peak Rhyolite. The Taylor Creek Rhyolite, dated at about 27.9 Ma ($^{40}Ar/^{39}Ar$, Dalrymple and Duffield, 1988; Duffield and Dalrymple, 1990), is similar to the rhyolite of Alamosa Creek as described by Fries (1940), Fries et. al., (1942), and Lufkin (1974) in the Black Range west of study area (Fig. 1). The rhyolite has been dated at 28.4 Ma ($^{40}Ar/^{39}Ar$, Lynch, 2003; McLemore, 2010). A trace element analysis of the amethyst-rich and amethyst-poor non-vesicular phase was conducted with the results shown in Table 1. Analysis indicates anomalous amounts of tin, titanium, and beryllium. McLemore (2010) indicated that the rhyolite of Alamosa Creek has similar chemical composition to Vicks Peak Rhyolite and the granite of Kelly Canyon and is slightly peralkaline.

The tuff of Shipman Canyon (**Tsc**) is exposed in Shipman Canyon (Fig. 2) along the southern Alamosa Creek area in the southeastern part of study area, but a fault sliver of the unit occurs at the entrance of Monticello Box. The unit is a cliff-forming, light-brown to gray, multiple-flow cooling unit of welded rhyolitic ash-flow tuff about 180 m thick, and contains 4-11% phenocrysts of sanidine (microperthite) and quartz. The unit is unusual because it consists of hundreds of individual flows ranging in thickness from 5 cm to 60 cm. The flows may be related to the domes of the rhyolite of Alamosa Creek because they overlie the rhyolite of Alamosa Creek in an angular unconformity.

The tuff of Spring Canyon (**Ttsc**) is exposed north of Monticello Box, in the Spring Canyon area, in the northwestern part of study area (Fig. 2). It is also exposed as a fault sliver at the entrance to Monticello Box (Figs. 2, 4). The unit is a pink and white to red-brown, crystal-rich, welded rhyolitic ash-flow tuff at least 75 m thick. The tuff contains approximately 6-11% phenocrysts of sanidine (microperthite), plagioclase, quartz, and trace of biotite and apatite. The unit consists of two zones, one rich in plagioclase and biotite and the other with only traces of plagioclase and biotite. Locally, this unit contains interbedded, thin andesitic lava flows, mud-flow breccias, and siltstone beds and it is been correlated to the South Canyon Tuff in the San Mateo Mountains and is equivalent to McLemore's (2010) Turkey Springs Tuff derived from the Bear Trap caldera located in the northern part of the San Mateo Mountains (McLemore, 2010) (Fig. 1). The tuff has been dated at 24.4 Ma ($^{40}Ar/^{39}Ar$, Lynch, 2003; McLemore, 2010).

TERTIARY INTRUSIVE ROCKS

Numerous dikes (**Tql, Tpa, Tld**, **Tba**, **Tpr**) which range in composition from basaltic andesite through rhyolite, and a quartz monzonite plug (**Tqm**) are found in the northern part of the study area where they intrude the andesite-latite of Montoya Butte but no younger units. The dikes appear to have no particular sequence of intrusion but they may be controlled by fractures and faults and may be feeders for the rocks of Montoya Butte.

FIGURE 5. Photo showing pillow-like structures in basaltic lava flow interbedded with the Santa Fe Group.

The quartz latite dikes (**Tql**) are up to 20 m in width and contain plagioclase phenocrysts up to 20 mm long in a fine-grained groundmass. The latite dikes (**Tld**) are 3 m to 130 m in width and contain plagioclase phenocrysts up to 6 mm long in a fine-grained light-brown groundmass. The porphyritic andesite dikes (**Tpa**) range in width from 0.3 m to about 6 m and consist of plagioclase phenocrysts 8 mm long in a dark-gray fine-grained groundmass. These dikes are the most common dikes in the area and, locally, intrude the latite dikes (**Tld**). The basaltic andesite dikes (**Tba**) are usually thin but in the southern half of the study area they are about 60 m wide. The dikes are fine-grained and vary in color from greenish to dark gray and black. The porphyritic rhyolite dikes (**Tpr**) are restricted to the southwestern part of study area where they intrude Permian rocks and andesite-latite of Montoya Butte. The dikes are reddish brown and fine grained with phenocrysts of plagioclase, sanidine, and quartz. A quartz monzonite plug (**Tqm**) is found in the northern part of the study area. The plug is fine grained with plagioclase, sanidine, and quartz phenocrysts, and may be related to the porphyritic rhyolite dikes (**Tpr**).

SANTA FE GROUP

The Santa Fe Group (Miocene to Pleistocene) (**QTsf**) consists of poorly sorted siltstone and conglomerate with clasts derived mainly from local volcanic rocks, and this unit correlates with the Winston beds of Jahns (1955). The unit is about 360 m thick in the study area with the lower contact exposed in the southern Alamosa Creek area where it overlies the rhyolite of Alamosa Creek (**Tac**) and in the northern study area where it overlies the tuff of Spring Canyon (**Ttsc**). Locally, in the southeastern part of study area, olivine basaltic lava flows (**QTb**) are interbedded with the sediments of the Santa Fe Group and locally characterized by pillow-like structures (Fig. 5). McLemore (2010) suggests that these flows may be 2-6 m.y. old based on similarities of dated flows in the general area.

SUMMARY

The Sierra Cuchillo is an elongated, north-south horst block composed of Tertiary volcanic and intrusive rocks, sparse outcrops of Lower Permian and Upper Cretaceous rocks, and sediments of the Tertiary-Quaternary Santa Fe Group. In most of the study area, the volcanic rocks are underlain by Permian and Upper Cretaceous rocks at depth. Most of the volcanic rocks erupted from calderas in the San Mateo Mountains to the northeast of study area and some erupted locally. Beryllium mineralization is associated with some of these local eruptions. Ages for these rocks range from about 38 Ma to 24 Ma. Uplift of the Sierra Cuchillo was post 24 Ma and pre 6 Ma based on ages of rocks in the study area.

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