Upper Eocene and Oligocene volcaniclastic sedimentary stratigraphy of the Quemado-Escondido Mountain area, Catron County, New Mexico

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UPPER EOCENE AND OLIGOCENE VOLCANICLASTIC SEDIMENTARY STRATIGRAPHY OF THE QUEMADO-ESCONDIDO MOUNTAIN AREA, CATRON COUNTY, NEW MEXICO

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Abstract—An upper Eocene to Oligocene (ca. 40-26 Ma) volcaniclastic sedimentary apron derived from the Mogollon-Datil volcanic field can be divided into three mappable lithostratigraphic units in the Quemado-Escondido Mountain area. From oldest to youngest we propose the new names volcaniclastic unit of Largo Creek (VLC), volcaniclastic unit of Cañon del Leon (VCDL), and sandstone of Escondido Mountain (SEM) as informal divisions of the gently south-southeast-dipping Spears Group. A geologic cross section of the area indicates that VLC, VCDL and SEM are approximately 600, 180 and 240 m thick, respectively. Gray, quartz-poor andesitic sandstones and interbedded red mudstones of the main body of the VLC (lower 540 m) conformably overlie the middle to upper Eocene Baca Formation. The main body of the VLC represents the distal fluvial equivalent of andesitic debris-flow deposits of the Dog Springs Formation (ca. 39.6-36.9 Ma), which is well exposed in the Datil region southeast of Quemado. An upward coarsening interval (~60 m) of gray to light brown, quartz-poor to moderately quartz-rich, andesitic conglomeratic sandstones forms a local (unmapped) transition zone in the upper VLC. A unique quartz-microcline-rich basement-derived sandstone near the top of the VLC may be correlative with mixed-clast conglomerates (basement and volcanic derived) recently observed in the middle Spears Group in the Alpine No. 1 Federal Well near Alpine, Arizona. A cliff-forming marker bed composed of light gray tuffaceous sandstones and thin pumiceous mudstones as much as 18 m thick defines the base of the VCDL and conformably overlies the upper VLC. Numerous gray tuffaceous sandstone beds intercalated with brownish gray to bluish-green andesitic conglomeratic sandstones comprise the VCDL at its type section in upper Cañon del Leon. Sanidines from pumice in syneruptive tuffaceous sandstones and plagioclase from a rhyolitic ash bed in the VCDL yield $^{40}Ar/^{39}Ar$ ages that imply aggradation on a distal alluvial apron from approximately 35.3 to 34.2 Ma. Tuffaceous sandstones of the VCDL thicken to the southwest and appear to form part of the andesitic volcaniclastic apron of the Pueblo Creek Formation, which was shed northward from a late Eocene eruptive center near Reserve. Pale yellowish-brown, medium-grained, planar to high-angle cross-bedded, volcaniclastic sandstones of the SEM are locally well exposed where they paraconformably overlie VCDL in uppermost Cañon del Leon. These eolian sandstones of the SEM are discontinuously exposed on the flanks of several ranges capped by Oligocene basaltic andesites, from Alegres Mountain westward to Escudilla Mountain in eastern Arizona. The SEM appears to represent a southeasterly tapering erg that was blown over the north-facing epiclastic apron of the middle Spears Group (e.g. VCDL) by prevailing westerly winds off the Colorado Plateau in Oligocene time (ca. 32-26 Ma).

INTRODUCTION

Reconnaissance geologic mapping of the Quemado 30′x60′ quadrangle (Chamberlin et al., 1994) has shown that a thick interval of volcaniclastic sedimentary rocks, locally well exposed along the drainage areas of Largo Creek and Cañon del Leon between Quemado and Escondido Mountain, can be informally subdivided into three mappable lithostratigraphic units. These informal subdivisions of the Spears Group (Cather et al., this volume) conformably overlie the middle to upper Eocene Baca Formation and are conformably overlain by middle Oligocene basaltic-andesite lavas and ignimbrites of the Mogollon Group (Chamberlin et al., 1994; Cather et al., this volume). Numerous new $^{40}Ar/^{39}Ar$ ages for volcanic and volcaniclastic rocks in the Quemado region (McIntosh and Chamberlin, this volume) provide a geochronologic framework for these volcaniclastic sedimentary units of the Spears Group. A petrographic study of volcaniclastic sandstones in the Quemado-Escondido Mountain area (J. S. Harris, unpubl. report, NMIMT, March 1994) provides most of the compositional data summarized in this article.

As shown on the reconnaissance geologic map of the Quemado-Escondido Mountain area (Fig. 1) we propose to informally name these three divisions of the Spears Group the volcaniclastic unit of Largo Creek, volcaniclastic unit of Cañon del Leon and sandstone of Escondido Mountain. Here we summarize the lithology, compositional variations, age constraints, correlation, thickness and origin for each of these units. Previous reconnaissance geologic maps of the Quemado region (Willard, 1957; Willard and Weber, 1958) grouped these Eocene to Oligocene units and the unconformably overlying Miocene Fence Lake Formation together as the volcanic sediment facies of the Datil Formation.

At this time we purposely choose not to identify these mappable volcaniclastic sedimentary units as formations or members of formations. Additional mapping is necessary to relate properly these informal map units to formally designated formations in the region (e.g. Chapin and Osburn, 1983; Ratté, 1989; Cather et al., this volume; also see stratigraphic nomenclature chart in back of this guidebook). For a description of the regional geologic setting of the Quemado-Escondido Mountain area see McIntosh and Chamberlin (this volume). Descriptions of these Spears Group units near Quemado can also be found in the First- and Second-Day road logs of this guidebook.

Samples of volcaniclastic sandstones were collected at several of the better exposures along the east flank of Largo Creek and upper Cañon del Leon. Petrographic thin sections were prepared from 20 samples from within the study area and six additional samples of correlative units from outside the area (Fig. 1, Table 1). Three samples of pumiceous muddy siltstone and one primary ash bed were collected from the volcaniclastic unit of Cañon del Leon in order to evaluate the age of this unit by $^{40}Ar/Ar^{39}$ geochronology. Plagioclase and sanidine phenocrysts were hand picked from individual pumice clasts, in order to avoid older detrital components. Feldspar separates from these pumice clasts and the ash bed were then dated by $^{40}Ar/^{39}Ar$ geochronologic methods (see McIntosh and Chamberlin, this volume).

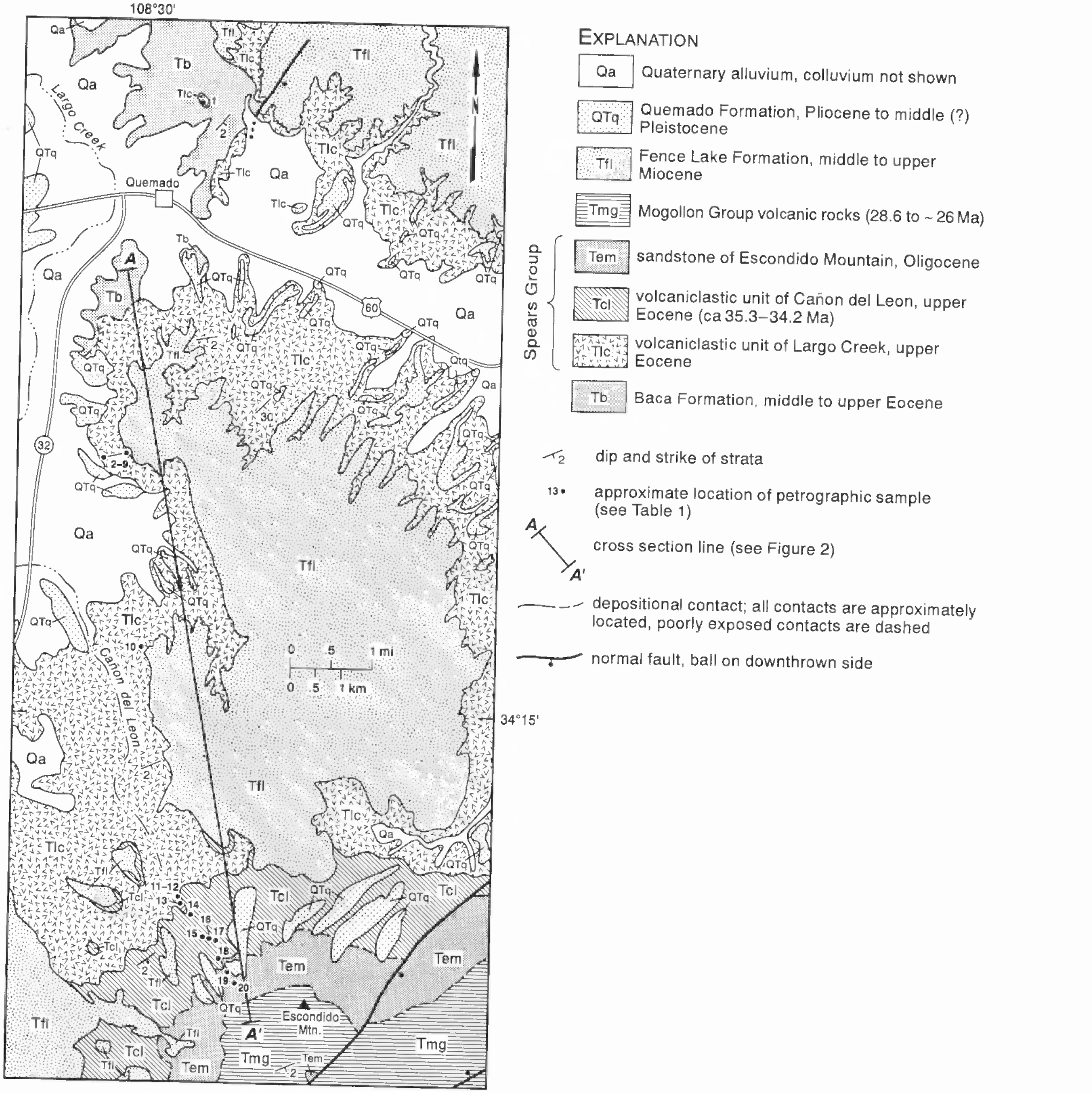

FIGURE 1. Geologic map of the Quemado-Escondido Mountain area, Catron County New Mexico; modified after Chamberlin et al. (1994). Some smaller areas of Quaternary alluvium are not shown.

VOLCANICLASTIC UNIT OF LARGO CREEK

The new informal stratigraphic term "volcaniclastic unit of Largo Creek" (VLC) is proposed here for a thick sequence of mostly gray andesitic sandstones, reddish mudstones, and minor andesitic conglomeratic sandstones that conformably overlie the Baca Formation in the Quemado-Escondido Mountain area (Fig. 1). We designate the eastern side of the valley of Largo Creek from the Quemado Community Cemetery (SW¼ sec. 26, T2N, R16W) southward to the cliffs of upper Cañon del Leon (SW¼ sec. 15, T1S, R16W) as the type area for this unit. It is locally well exposed along the west side of a large mesa capped by middle to upper Miocene Fence Lake Formation (Fig. 1). This mesa defines the upper Miocene piedmont slope that descends northward from its source at Escondido Mountain (Fig. 2). Plio-Pleistocene gravels of the Quemado Formation (Cather and McIntosh, this volume) are locally inset below the Fence Lake Formation.

Contacts and lithology

The basal contact of the VLC is defined by the upsection change from buff quartzofeldspathic sandstones and bright red mudstones of the Baca Formation to the gray andesitic sandstones and dull red mudstones of the VLC. This contact is conformable, gradational and may locally intertongue over an interval of approximately 10-15 m, in the Quemado area (Guilinger, 1981; Chamberlin et al., 1994). We propose the unnamed hill northeast of the Quemado Community Cemetery (NW¼ sec. 35, T2N, R16W) as the basal boundary stratotype for the VLC. The contact is well exposed here at an elevation of approximately 2202 m. The VLC is also locally well exposed in landslide scars below the cliff-forming Fence Lake Formation from Quemado south to Cañon del Leon; each individual exposure typically presents 30 to 60 m of gray slope-forming andesitic sandstones and red mudstones.

In most VLC exposures, the fine- to medium-grained sandstone beds do not stand out as distinct ledges separated by mudstones, but rather the VLC typically weathers to a soft mud- covered slope. Bedding is commonly planar and horizontal, but trough cross beds occur locally. Upward-fining conglomeratic sandstone beds are locally present. Sandstone beds are generally 0.3 to 3 m thick and reddish mudstones may occur as thin drapes to massive looking beds as much as 5-7 m thick.

The upper part of the VLC, approximately 60 m thick, is formed by light gray to pale brown andesitic sandstones and conglomeratic sandstones that define an upward coarsening sequence. Bluish-green andesitic sandstones and conglomerates are common near the top of the VLC. The bluish-green color is attributed to celadonite cement, which in part may be associated with diagenetic hydration of glass shards in the overlying tuffaceous sandstones. This upper subunit of the VLC appears to be transitional into the overlying volcaniclastic unit of Cañon del Leon, defined below. Rare, thin, pumiceous sandstones, and a general increase in quartz content (from near zero to approximately 30%) also help distinguish the upper transition zone from the main body of the VLC. The vague boundary between the main body of the VLC and upper transition zone has not been mapped. The approximate position of the transition zone (Tlct) is shown only in cross section (Fig. 2), and its regional significance is uncertain.

Petrographic data for the main body and transition zone of the VLC (Table 1; Fig. 3) show that VLC sandstones are predominantly quartz-poor volcanic litharenites of andesitic composition. Large grains of oscillatory zoned plagioclase (phenocryst derived) and microlitic andesite rock fragments comprise most of the framework grains in these sandstones (Fig. 3B). Hornblende, biotite and Fe-Ti oxides commonly form 2-5% of these sandstones; placer-type concentrations of these heavy minerals, however, locally form laminations with 10-20% heavy minerals (Table 1). Quartz is typically sparse to absent in the main body of the VLC.

The most quartz-rich sample (28% quartz; No. 13, Fig. 1, Table 1) in the entire Eocene-Oligocene section was collected about 10 m below the top of the VLC, near the mouth of upper Cañon del Leon. This gray, medium- to coarse-grained sandstone bed is compositionally unique and contains a large component (~80%) of basement-derived grains. Most of the quartz shows undulose extinction; cross-hatched microcline represents at least half of the alkali feldspar grains, and sericitic microgranular felsite is the most common type of rock fragment. These are not typical rhyolitic rock fragments with shard outlines, or banded and spherulitic textures. The sericitic fragments are texturally similar to hydrothermally altered (silicified) lavas, but their association with basement-type quartz and feldspar suggests that these microgranular rock fragments represent basement-derived "metarhyolite". The possible significance of this basement-derived sandstone near the middle of the Spears Group is discussed later.

Age and correlation

The VLC has not been directly dated in the Quemado area. Its age, however, is bracketed by the underlying Baca Formation (ca. 46-40 Ma; Cather et al., 1987) and the overlying volcaniclastic unit of Cañon del Leon (ca. 35.3-34.2 Ma; McIntosh and Chamberlin, this volume). Regional mapping (Chamberlin, et al., 1994) indicates that the VLC is temporally equivalent to andesitic debris-flow deposits of the Dog

TABLE 1. Point count data[1] for volcaniclastic sandstones[2] in the Quemado-Escondido Mountain area and other localities in the Quemado region.

Sample No.[3] or Location	Field Number	Quartz	Plagioclase	Alkali Feldspar	Andesitic Rock Fragments	Rhyolitic Rock Fragments	Fe-Mg Minerals and Opaques	Grain Size ϕ
sandstone of Escondido Mountain (SEM)								
20	CDL-1	2.4	11.8	0.0	82.2	0.0	3.6	2.0
19	CDL-3	16.4	17.6	2.8	2.4	59.2	1.6	2.0
Killion Can.	KC-1	24.5	22.5	14.0[4]	3.2	35.8	0.0	2.0
Killion Can.	KC-2	8.0	10.4	3.6	3.6	74.4	0.0	2.0
volcaniclastic unit of Cañon del Leon (VCDL)								
18	CDL-2	7.3	8.5	0.0	4.0	80.2	0.0	3.0
17	CDL-5	3.6	16.8	2.8	16.8	53.5	6.4	2.5
16	CDL-6	3.2	18.3	4.5	7.1	66.9	0.0	3.5
15	CDL-7	5.6	19.3	15.7	12.0	44.2	3.2	2.5
14	CDL-12	0.7	0.2	0.0	0.0	98.8	0.1	3.5
Castle Rock	CR-1	0.6	0.3	0.3	0.0	97.6	1.2	3.0
volcaniclastic unit of Largo Creek, (upper transition zone, VLCT)								
13	CDL-11A	27.7	8.8	20.0[4]	4.8	37.0[5]	1.6	1.5
12	CDL-10A	4.4	7.8	1.6	74.1	9.4	2.4	1.5
11	CDL-10B	8.0	34.8	4.8	24.4	17.6[5]	10.4	1.5
Castle Rock	CR-2	2.0	4.4	0.0	81.0	11.3	1.2	2.5
volcaniclastic unit of Largo Creek, (main body, VLCM)								
10	WR-9	2.4	51.2	0.0	35.6	0.0	9.6	2.5
9	WR-8	0.0	51.6	0.0	41.2	0.0	5.2	1.0
8	WR-7	6.0	49.6	2.0	38.0	0.0	4.0	3.0
7	WR-6	6.4	38.0	2.0	49.2	0.0	3.6	2.5
6	WR-5	1.6	64.0	0.0	9.2	1.2	23.6	2.0
5	WR-4	0.0	4.0	0.0	74.4	0.0	21.2	0.5
4	WR-3	0.0	7.2	0.0	88.4	0.0	3.6	2.5
3	WR-2	11.6	36.8	8.4	38.0	0.0	4.8	2.5
2	WR-1	4.4	49.6	0.0	43.6	0.0	1.6	1.5
1	QUE-1	4.4	23.3	0.0	62.0	3.2	1.6	2.0
Pie Town	MP-51.8	2.8	74.4	0.0	14.4	0.0	8.8	2.5
Pie Town	MP-62.4	2.6	41.4	0.0	40.8	0.0	15.2	2.5

[1]Point count data by J. S. Harris; percent of total framework grains. Total Count = 250 grains per sample.
[2]Unit correlations from Chamberlin et al. (1994).
[3]Sample No. refers to Fig. 1.
[4]Includes microcline.
[5]Includes minor chert and siltstone.

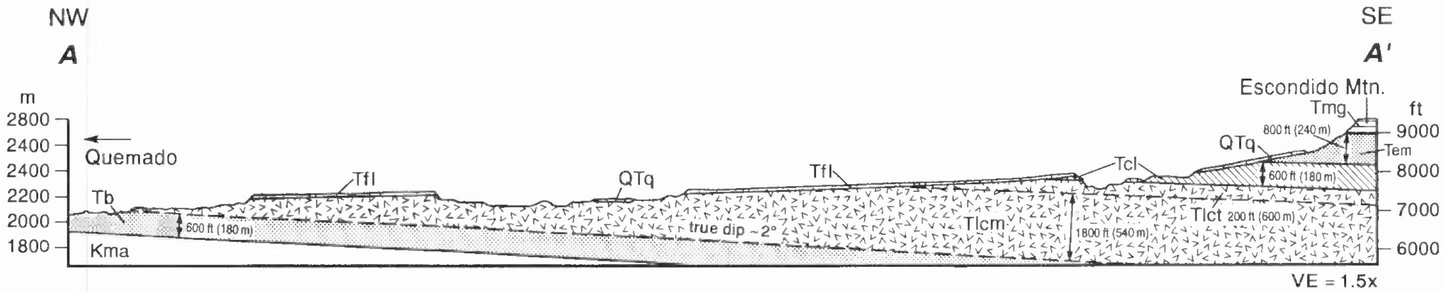

FIGURE 2. Geologic cross section of the Quemado-Escondido Mountain area; original cross section used to estimate thickness of units was drawn to true scale at 1:24,000. See Figure 1 for explanation of symbols. Tlcm=main body of the volcaniclastic unit of Largo Creek. Tlct=upper transition zone of the volcaniclastic unit of Largo Creek. Kma=Cretaceous Moreno Hill-Atarque Formations. Thickness of Baca Formation from Guilinger (1981).

Springs Formation exposed in the Datil region southeast of Quemado. Isotopic ages of Dog Springs volcaniclastic rocks range from 39.6 ± 1.5 Ma (Osburn and Chapin, 1983; Cather et al., 1987) to 36.94 ± 0.07 Ma (McIntosh and Chamberlin, this volume). The above age constraints support the correlation of the volcaniclastic unit of Largo Creek at Quemado with the Dog Springs Formation at Datil. The VLC at Quemado is here considered to be of late Eocene age (ca. 40-35 Ma).

Thickness and origin

The thickness of the VLC south of Quemado was estimated by constructing a geologic cross section (at true scale) along the regional south-southeast dip. This cross section is vertically exaggerated here for clarity (Fig. 2). Assuming a uniform 2° dip, this yields a 600 m thickness for the VLC. This estimate is a maximum, since the VLC is locally folded and faulted (see First-Day road log, mile 149.7-151.4). Intercepts and surface observations at the Hunt No. 1-16 State Well, 43 km southeast of Quemado (Broadhead and Chamberlin, this volume) indicate a total thickness of 462 m for the quartz-poor andesitic lower Spears Group (VLC equivalent). Quartz-poor, gray, andesitic sandstones similar to the VLC at Quemado were intersected in the Alpine No. 1 Federal Well (62 km SW of Quemado) between 480 m and 625 m, a total intercept of 145 m. These sandstones overlie 363 m of basement-derived Eagar Formation and lie below 66 m of pumiceous sandstones and 97 m of mixed-clast conglomerate, the latter derived from both volcanic and basement terranes. We suggest that the basement-derived sandstone bed near the top of the VLC may be in part correlative with the mixed-clast conglomerate interval of the Alpine No. 1 Federal Well. The above observations suggest that the actual thickness of the VLC near Quemado is approximately 300 to 400 m.

The dominance of fine- to medium-grained, well-sorted, andesitic sandstones and interbedded mudstones, with minor pebbly sandstones, suggest that the main body of the VLC in the Quemado area is a distal basin-floor fluvial deposit. These fluvial andesitic sandstones appear to grade easterly or southeasterly into argillaceous andesitic sandstones (also assigned to the VLC, Chamberlin et al., 1994) in the Pie Town area. These better-indurated argillaceous sandstones may primarily represent hyperconcentrated flood deposits derived from downstream dilution of andesitic debris-flow deposits in the Datil-Crosby Mountains area. These volcanogenic facies transitions or transformations (Fisher and Smith, 1991) are consistent with a source for the VLC (main body) somewhere under the south-central San Agustin plains (see First-Day road log, mile 71.4 and 101.4).

A few observations of pebble imbrications in the upper transitional VLC suggest northeasterly paleoflow. In conjunction with the quartz-rich, basement-derived sandstone observed in this zone, the available data suggest that the upper VLC represents a northeast prograding alluvial apron derived from an andesitic volcanic center in the Reserve area. This younger volcanic center is presumably the same one documented by Ratté (1989) as the source area for volcaniclastic alluvial deposits of the Pueblo Creek Formation and the andesite of Dry Leggett Canyon.

VOLCANICLASTIC UNIT OF CAÑON DEL LEON

We propose the new informal name "volcaniclastic unit of Cañon del Leon" for approximately 180 m of interbedded rhyolitic tuffaceous sandstones and andesitic to rhyolitic conglomeratic sandstones that conformably overlie the VLC in upper Cañon del Leon (Figs. 1, 2). We designate the eastern side of upper Cañon del Leon from the SE¼SE¼ sec. 15, T1S, R16W to the SE¼NW¼ sec. 23, T1S, R16W as the type section. Access to this type section within the Apache National Forest may be gained by Forest Service roads along Escondido Creek. The most advantageous entry to upper Cañon del Leon, which avoids large cliffs, lies approximately 1.7 km south-southwest of Escondido Tank (SE¼ sec. 11, T1S, R16W, Escondido Mountain 7.5′ quadrangle).

Contacts and lithology

The basal contact of the volcaniclastic unit of Cañon del Leon (VCDL) is well exposed at the type section on the east wall of Cañon del Leon (Fig. 4). The basal stratotype here consists of a thin bedded, cliff-forming, light gray, angular-jointed tuffaceous sandstone and pumiceous mudstone that conformably overlies medium-bedded, bluish-green to brownish-gray and rare reddish-brown conglomeratic sandstone of the upper VLC. The base of this cliff-forming marker bed (basal VCDL) is present at an approximate elevation of 2378 m (34.212°N, 108.487°W, Escondido Mountain 7.5′ quadrangle). An alternative, more accessible, boundary stratotype is at the east end of Castle Rock at an elevation of 2430 m in the Largo Mesa 7.5′ quadrangle (34.158°N, 108.548°W). The latter locality is described in the First-Day road log of this guidebook (see mile 156.5). The top of the VCDL is locally exposed in upper Cañon del Leon (east fork) at an elevation of 2500 m, where it appears to be paraconformably overlain by well-sorted sandstone of the sandstone of Escondido Mountain (new name), as described in a following section.

The basal VCDL is a cliff-forming marker bed, as much as 18 m thick, that is composed of light gray tuffaceous sandstones, 0.1-1 m thick, with thin (~ 1 cm) pale red muddy siltstone beds. The thin siltstone beds appear to be slackwater drape deposits and preferentially contain larger (0.5-2 cm) clasts of white fibrous pumice. Pumice at the type section and Castle Rock consists of a moderately phenocryst-rich (biotite, sanidine, plagioclase and quartz) pumice, and a phenocryst-poor pumice with dominantly plagioclase crystals. The former is distinctly rhyolitic and the latter may be of andesitic to dacitic composition. Sandstones in the basal cliff-forming marker bed consists almost entirely of rhyolitic glass shards mixed with minor reworked phenocrysts of quartz, plagioclase and sanidine (Table 1, CR-1 and CDL-12). A 5-cm-thick white rhyolitic ash-bed occurs in the narrow box of upper Cañon del Leon within the cliff-forming marker bed. This ash bed contains approximately 2% of phenocrystic quartz and plagioclase, 10% small angular devitrified felsite clasts and about 88% flattened pumice clasts and shards (McIntosh and Chamberlin, this volume, sample CDL-10/2-9B).

Interbedded andesitic conglomeratic sandstone and thin tuffaceous to pumiceous sandstone comprise most of the VCDL at the type section. Andesitic sandstones consist of upward fining, coarse- to medium-

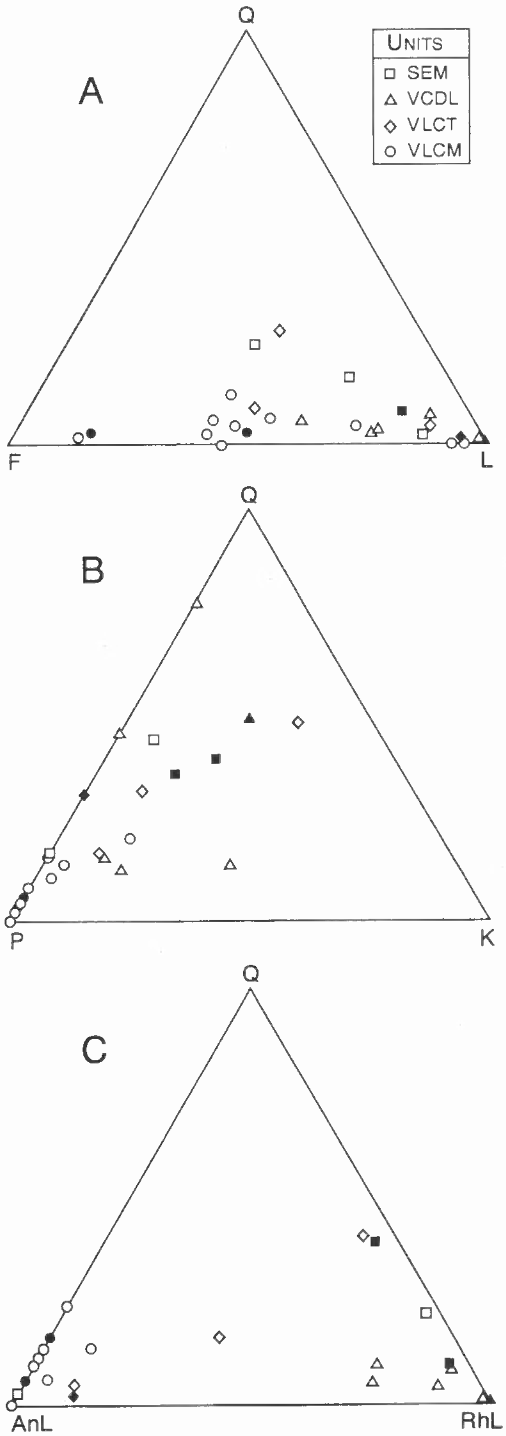

FIGURE 3. Ternary diagrams showing compositional variations in the main body of the volcaniclastic unit of Largo Creek (VLCM), in the upper transition zone of the volcaniclastic unit of Largo Creek (VLCT), in the volcaniclastic unit of Cañon del Leon (VCDL), and in the sandstone of Escondido Mountain (SEM). All data are from Table 1; open symbols represent samples from the Quemado-Escondido Mountain area (Fig. 1). Solid symbols represent samples collected outside the Quemado-Escondido Mountain area (Table 1). 3A, variation in total quartz, Q; total feldspar, F and total lithic fragments, L. 3B, variation in total quartz, Q; total plagioclase feldspar, P; and total alkali feldspar, K. 3C, variation in total quartz, Q; andesitic lithic fragments, AnL; and rhyolitic lithic fragments, RhL.

grained beds generally 0.3 to 2 m thick, with common clasts of dark gray to reddish-brown andesite porphyry and rare clasts of light gray rhyolite. The conglomeratic sandstone beds are mostly light brownish

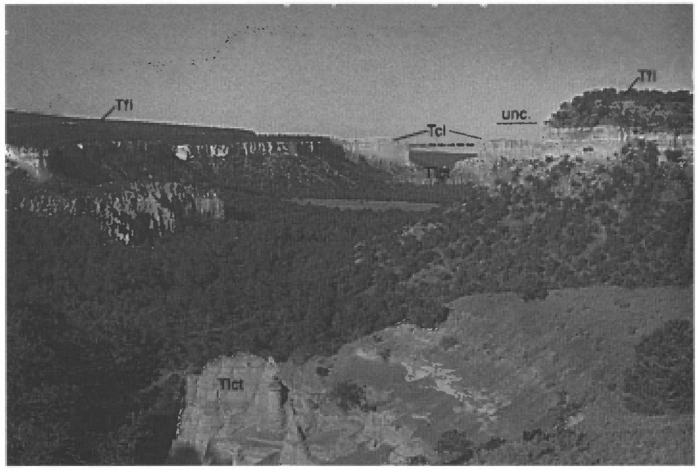

FIGURE 4. View to west-southwest of upper Cañon del Leon. Basal contact of volcaniclastic unit of Cañon del Leon (Tcl) is indicated by dashed line. Unconformity (unc.) at base of Fence Lake Formation (Tfl) is indicated by solid line. Basal 18 m of the volcaniclastic unit of Cañon de Leon is a cliff-forming tuffaceous sandstone and pumiceous mudstone marker bed, just above white tuffaceous sandstone bed. Transitional sandstones and conglomeratic sandstones of upper part of the volcaniclastic unit of Largo Creek (Tlct) locally form badlands topography.

gray and moderately indurated. A few bluish-green conglomeratic sandstones, presumably cemented with celadonite, are also present. Tuffaceous sandstones are mostly light gray, thin bedded (0.1-1 m) and are commonly associated with pale red pumiceous mudstone.

Preliminary petrographic study of the VCDL sandstones (Table 1, Fig. 3) indicate that they generally represent a mixture of rhyolitic and andesitic detritus similar to the underlying transition zone in the upper VLC and much more variable than the andesitic main body of the VLC (Fig. 3). In thin section (Table 1, Fig. 3) sandstones of the VCDL are classified as volcanic lithic arenites of rhyolitic to andesitic composition (Fig. 3C). Relatively iron-rich microlitic grains (with finely disseminated opaques) and plagioclase porphyry clasts are the most common types of andesitic lithic fragments. Glass shards, sand-sized pumice fragments and minor microgranular felsites (iron poor) are the most common type of rhyolitic rock fragments. Rare siliceous siltstone clasts and chert were counted with rhyolitic fragments in some VCDL sandstones. Low birefringent clay minerals or zeolites are the most common cement; sparry calcite may be present in some conglomeratic sandstones. Bluish-green sandstones are apparently cemented with fibrous, moderately birefringent celadonite. Sparse grains of embayed quartz and sanidine form a minor rhyolitic component of VCDL sandstones; these were not observed in the main body of the VLC.

Age and correlation

A rhyolitic ash bed in the lower VCDL, approximately 12 m above the base at the type section, yielded an imprecise $^{40}Ar/^{39}Ar$ depositional age of 35.19 ± 0.42 Ma (McIntosh and Chamberlin, this volume). Sanidine phenocrysts hand-picked from pumice clasts at the base of VCDL at Castle Rock produced a precise $^{40}Ar/^{39}Ar$ age of 35.33 ± 0.06 Ma (McIntosh and Chamberlin, this volume). Also, a single sanidine crystal from pumice at the top of the VCDL at the type section, apparently derived from the Rock House Canyon Tuff, yielded an $^{40}Ar/^{39}Ar$ age of 34.17 ± 0.13 Ma (McIntosh and Chamberlin, this volume). One additional plagioclase separate from pumice at the base of the type section gave an imprecise $^{40}Ar/^{39}Ar$ age of 35.48 ± 0.42 Ma (McIntosh and Chamberlin, this volume), which is within analytical error of the more precise age determination at Castle Rock.

The above ages from pumice clasts would normally be interpreted as maximum ages of deposition. However, the field characteristics of these pumice samples, and the fact that their maximum ages are in agreement with the stratigraphic sequence suggest that these pumice-clast ages are also the approximate age of deposition of the host beds. We interpret the VCDL at the type section to range in age from approximately 35.3 to 34.2 Ma. This age range includes several regional igimbrites, including the 35.0-Ma Datil Well Tuff, the 34.9-Ma tuff of Bishop Peak, the 34.9-Ma Kneeling Nun Tuff, and the 34.2-Ma Rock House Canyon Tuff (McIntosh et al., 1991; McIntosh and Chamberlin, this volume). Older pumice clasts near the base of the VCDL and the rhyolitic ash bed may have been derived from smaller pyroclastic eruptions associated with silicic or intermediate lava domes, although such lava domes have not been recognized in the Quemado region.

The tuffaceous cliff-forming marker bed at the base of the VCDL can be traced across the north flank of Escondido Mountain westward to Castle Rock and the northern toe of Agua Fria Mountain. West of Agua Fria Mountain the marker bed is locally truncated by a splay of the Spur Lake fault, but it reappears to the west at Cañon Blanco (SW¼ sec. 25, T2S, R18W) and Steel Canyon (SW¼ sec. 8, T3S, R18W), where it underlies the upper Eocene andesite of Dry Leggett Canyon. Light brown andesitic conglomeratic sandstone beds that overlie the andesite of Dry Leggett Canyon west of Agua Fria Mountain also contain the 33.4-Ma tuff of Luna (McIntosh and Chamberlin, this volume), which is apparently absent at the type section in Cañon del Leon. These map relationships (Chamberlin et al., 1994) suggest a local unconformity may be present at the top of VCDL at the type section.

Pumiceous sandstones and bluish-green andesitic sandstones, similar to the VCDL, are known to underlie the andesite of Dry Leggett Canyon at Deep Canyon (30 km to the SW of the type section, see Third-Day road log, mile 65.95). Pumiceous sandstones also occur in the middle Spears Group of the Alpine Federal No. 1 Well (Witcher et al., this volume, fig. 4), and above the Rock House Canyon Tuff at Saulsberry Ranch (see First-Day road log, mile 84.1). The VCDL is in part correlative with the upper Eocene Chavez Canyon Formation and the Rincon Windmill Formation (Osburn and Chapin, 1983; Cather et al., this volume) as mapped in the Datil region. Also, the VCDL appears to be in part correlative with the Pueblo Creek Formation as mapped in the Reserve area (e.g., Ratté, 1989).

Thickness and origin

At its type section the VCDL is approximately 180 m thick, as determined in cross section (Fig. 2). This unit may thicken to the southwest where 250 m of pumiceous and tuffaceous sandstones have been observed at Deep Canyon (Third-Day road log, mile 65.95). Only 20 m of pumiceous sandstones are present in the roughly equivalent stratigraphic interval at Saulsberry Ranch (First-Day road log, mile 84.1). A few observations of pebble imbrications in andesitic conglomeratic sandstones at the type section suggest northeasterly paleoflow for the fluvial system that delivered both the andesitic sandstones and the rhyolitic tuffaceous sandstones. The thin-bedded character of tuffaceous sandstones and preferential concentration of pumice in thin, muddy siltstones (drape deposits) suggest that this stream system was periodically oversaturated with pyroclastic debris. These clogged stream systems then formed rapidly-aggraded, sheet-like, tuffaceous deposits shortly after the explosive eruptions. The cliff-forming basal marker bed and similar tuffaceous sandstones higher in the VCDL are classified as syneruptive volcaniclastic sedimentary rocks (Smith, 1991). Andesitic conglomeratic sandstones within the VCDL probably represent medial to distal alluvial-apron deposits derived from a late Eocene volcanic center, to the south near Reserve (e.g. Ratté, 1989).

SANDSTONE OF ESCONDIDO MOUNTAIN

The new and informal name "sandstone of Escondido Mountain" is here proposed for well-sorted, fine- to medium-grained sandstone, as much as 240 m thick (Fig. 2) that paraconformably overlies the VCDL at Cañon del Leon. The base of this pale yellowish-brown sandstone is locally well exposed in the upper reach of Cañon del Leon at an elevation of approximately 2500 m (SE¼ NW¼ sec. 23, T1S, R16W). The sandstone of Escondido Mountain (SEM) is commonly but discontinuously exposed on the upper flanks of Escondido Mountain, for which it is named. The base of the SEM locally exposed on the east rim of Cañon del Leon (cited above) is proposed as the boundary stratotype. Here the well-sorted sandstone is planar bedded, but approximately 150 m up-canyon the medial SEM shows large high-angle cross beds more typical of the main body of this unit. The upper third of the SEM in Cañon del Leon is covered with colluvial blocks of andesite porphyry derived from overlying cliffs of 28.4-Ma Squirrel Springs Canyon Andesite (Chamberlin, et al., 1994; McIntosh and Chamberlin, this volume). The base of these cliff-forming lavas on the north face of Escondido Mountain at an elevation of about 2737 m is mapped as the approximately located top of the SEM (Fig. 1). We suggest the lower north flank of El Caso Peak (sec. 18, T2S, R16W), upper Cañon del Macho (sec. 27, T1S, R15W) and the east flank of Canon del Lolo (sec. 32, T1S, R15W) as partial reference sections for the SEM. All proposed reference sections are on the flanks of Escondido Mountain, which is suggested as the type area for the SEM. Cross-bedded SEM is also locally well exposed in roadcuts of Forest Road 13, NE of Quemado Lake.

Contacts and lithology

Regional mapping suggests that the base of the SEM at Cañon del Leon is a paraconformity. However, regional mapping also implies that the SEM once intertongued with or graded into epiclastic conglomeratic sandstones of the South Crosby Peak Formation between Alegres Mountain and the Crosby Mountains. The base of the SEM is typically poorly exposed and thus its regional character is not well known. Southwest of Escondido Mountain the SEM is generally in fault contact with the middle Spears Group and Datil Group along the Spur Lake fault zone (Chamberlin et al., 1994). The upper contact of the SEM is also poorly exposed in most areas and is generally defined by mafic lavas of the Oligocene Mogollon Group. including the 28.4-Ma Squirrel Springs Canyon Andesite and the 26.1-Ma Bearwallow Mountain Andesite (McIntosh and Chamberlin, this guidebook).

Where well exposed, the SEM typically consists of well-sorted, pale yellowish-brown, planar to high-angle cross-bedded, medium-grained, volcaniclastic sandstone. Pebbles and mudstones typical of underlying fluviatile deposits are normally absent. Cross bed sets as much as 10 m high have locally been observed. The steepest cross beds (25-30°) most commonly face to the east (from northeast to southeast). Weathered outcrops are often littered with small (~1 cm) yellowish-brown sandstone concretions.

Limited petrographic study (Table 1) indicates that SEM sandstones are primarily volcaniclastic, and composed of a mixture of andesitic to rhyolitic lithic fragments and associated phenocryst-derived minerals (plagioclase, sanidine and quartz). Assuming samples from Killion Canyon (Table 1; NE¼ sec. 3, T3S, R14W) are representative of the main body of SEM, the unit generally appears to contain more quartz than the underlying Eocene volcaniclastic units. Minor amounts of recycled or basement-derived microcline are also present in the samples from Killion Canyon. A very low birefringent zeolite (possibly heulandite) appears to be the most common type of cement. Diagenetic calcite may also be present.

Age and correlation

The age of the SEM is established by thin distal ignimbrites that are intercalated with this unit in the Quemado region (Chamberlin et al., 1994; McIntosh and Chamberlin, this volume). The upper SEM is locally interbedded with the 28.1-Ma Bloodgood Canyon Tuff near the head of Cañon del Macho (sec. 27, T1S, R15W) and with the 28.6-Ma Vicks Peak Tuff at Killion Canyon. The lower SEM also contains the 31.6-Ma Caballo Blanco Tuff in the conical hills east of Mangas (sec. 35, T1S, R14W). A possible correlative high-angle, cross-bedded, volcaniclastic sandstone is reported to underlie the 32.1-Ma Hells Mesa Tuff on Sugarloaf Mountain, 14 km southwest of Datil (Lopez and Bornhorst, 1979; Osburn and Chapin, 1983). The Hells Mesa Tuff is the oldest volcanic unit known to overlie cross-bedded SEM-type sandstone; the youngest volcanic unit that typically caps the SEM in the Quemado-Datil region is the Bearwallow Mountain Andesite, which has yielded an $^{40}Ar/^{39}Ar$ isochron age of 26.1 ± 0.1 Ma from a basal lava flow (McIntosh and Chamberlin, this volume). Available age data indicate the SEM is of Oligocene age and ranges from about 32 to 26 Ma.

Epiclastic conglomeratic sandstones in the South Crosby Peak Formation, southwest of Datil are known to occupy the same age range (ca. 32-27 Ma; McIntosh and Chamberlin, this volume) as the SEM near Quemado. Presumably these northwesterly transported (Osburn and Chapin, 1983) South Crosby Peak conglomerates once intertongued with the SEM in the erosional gap between the Crosby Mountains and Alegres Mountain. Jones (1980) mapped correlative eolian sandstones in the upper part of his "sandstone of Alegros Mountain". High-angle, cross-bedded, volcaniclastic sandstones in the Alpine, Arizona region mapped by Wrucke (1961) as the "upper sedimentary formation" are probably correlative to the SEM. Similar cross-bedded sandstones in the upper Rincon Windmill Formation (Osburn and Chapin, 1983) are also probably correlative with the SEM.

Thickness and origin

Based on cross section (Fig. 2), the estimated thickness of the SEM on the north face of Escondido Mountain is 240 m. Wrucke (1961) reported that a high-angle cross-bedded sandstone of probable eolian origin in the Alpine, Arizona area is as much as 360 m thick. Other regional observations suggest that SEM thins to the south (James C. Ratté, oral commun., 1994) and to the east (Lopez and Bornhorst, 1979; Osburn and Chapin, 1983; Chamberlin et al., 1994). The SEM is approximately 120-180 m thick in the Alegres Mountain-Mangas area (Chamberlin et al., 1994).

The common occurrence of east-facing high-angle cross beds, uniform fine- to medium-grain size and absence of fluviatile features (e.g. pebbles) indicates that the SEM is primarily an eolian deposit derived from the distal alluvial apron of the Mogollon-Datil volcanic pile. This volcaniclastic sandstone was probably blown in from the west and northwest off the Colorado Plateau. It generally overlapped the toe of epiclastic alluvial-apron deposits derived from volcanic highlands to the south. The SEM presumably formed as a widespread southeast tapering wedge of dune sands, and most likely represents a dry climatic period on the Colorado Plateau in Oligocene time.

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REFERENCES

Broadhead, R. F. and Chamberlin, R. M., 1994, Hunt Oil Co. No. 1-16 State Well, wireline log responses, Tertiary and Cretaceous sections: New Mexico Geological Society, Guidebook 45.

Cather, S. M. and Johnson, B. D., 1984, Eocene tectonics and depositional setting of west-central New Mexico and eastern Arizona: New Mexico Bureau of Mines and Mineral Resources, Circular 192, 33 p.

Cather, S. M. and McIntosh, W. C., 1994, The Plio-Pleistocene Quemado Formation of west-central New Mexico: New Mexico Geological Society, Guidebook 45.

Cather, S. M., Chamberlin, R. M. and Ratté, J. C., 1994, Tertiary stratigraphy and nomenclature for western New Mexico and eastern Arizona: New Mexico Geological Society, Guidebook 45.

Cather, S. M., McIntosh, W. C. and Chapin, C. E., 1987, Stratigraphy, age and rates of deposition of the Datil Group (Upper Eocene-lower Oligocene), west-central New Mexico: New Mexico Geology, v. 9, p. 50-54.

Chamberlin, R. M., Cather, S. M., Anderson, O. J. and Jones, G. E., 1994, Reconnaissance geologic map of the Quemado 30´x60´ quadrangle, Catron County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 406, scale 1:100,000.

Fisher, R. V. and Smith, G. A., 1991, Volcanism, tectonics and sedimentation: SEPM Special Publication no. 45, p. 1-5.

Guilinger, D. R., 1982, Geology and uranium potential of the Tejana Mesa-Hubbell Draw area, Catron County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Open-file Report 176, 137 p.

Jones, D. P., 1980, Volcanic geology of the Alegros Mountain area, Catron County, New Mexico [M.S. thesis]: Albuquerque, University of New Mexico, 76 p.

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

McIntosh, W. C. and Chamberlin, R. M., 1994, $^{40}Ar/^{39}Ar$ geochronology of middle to late Cenozoic ignimbrites, mafic lavas, and volcaniclastic rocks in the Quemado-Datil region, New Mexico: New Mexico Geological Society, Guidebook 45.

Osburn, G. R. and Chapin, C. E., 1983, Nomenclature for Cenozoic rocks of the northeast Mogollon-Datil volcanic field, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Stratigraphic Chart 1.

Ratté, J. C., 1989, Geologic map of the Bull Basin quadrangle, Catron County, New Mexico: U.S. Geological Survey, Geologic Quadrangle Map GQ-1651, scale 1:24,000.

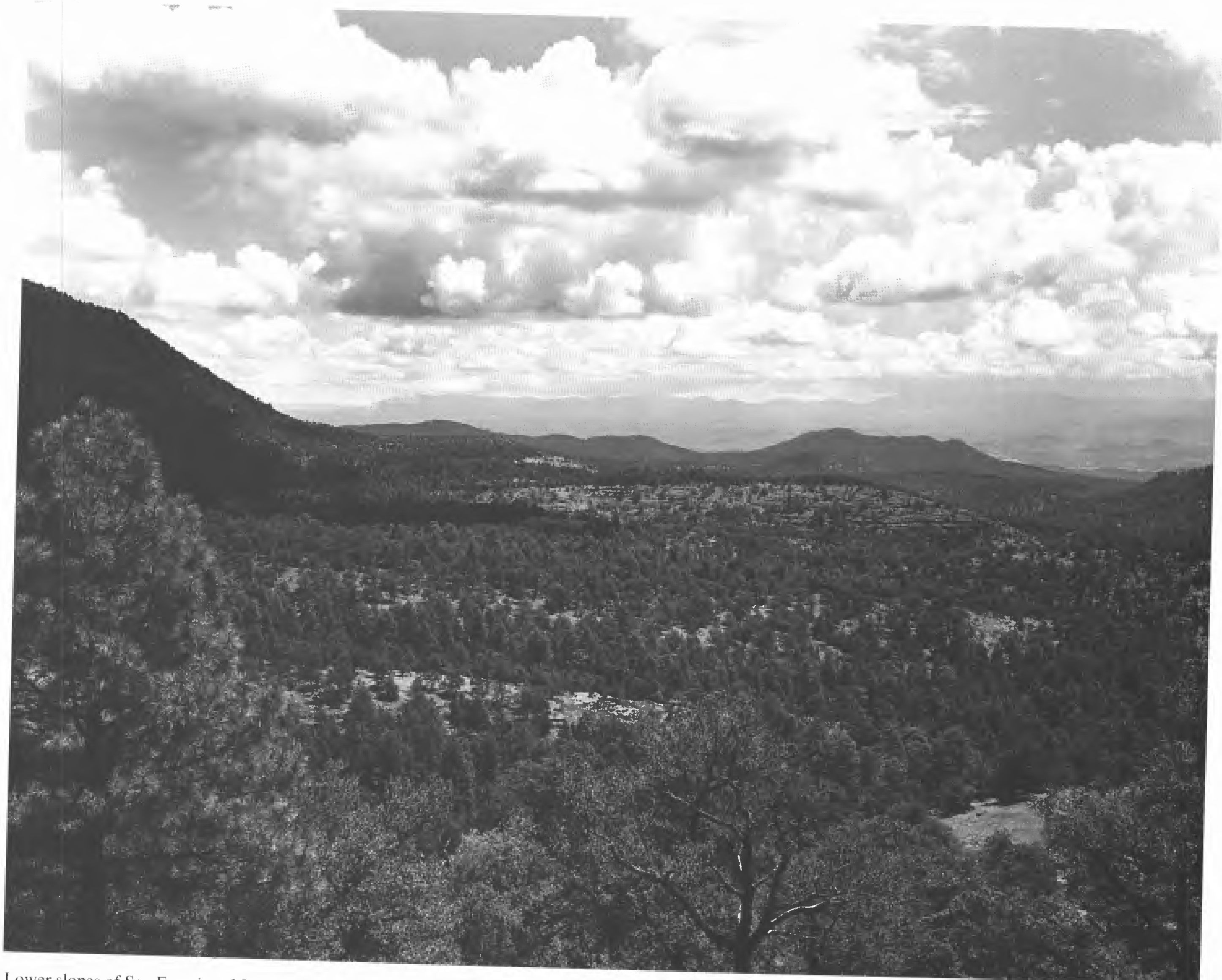
Smith, G. A., 1991, Facies sequences and geometries in continental volcaniclastic sediments: SEPM Special Publication no. 45, p. 109-121.

Willard, M. E., 1957, Reconnaissance geologic map of the Piñonville thirty minute quadrangle: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 3; scale 1:126,720.

Willard, M. E. and Weber, R. H., 1958, Reconnaissance geologic map of Cañon Largo thirty-minute quadrangle: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 6; scale 1:126,720.

Witcher, J. C., Hahman, W. R. and Swanberg, C. A., 1994, Alpine 1/Federal—Subsurface stratigraphy of the eastern White Mountains, Apache County, Arizona: New Mexico Geological Society, Guidebook 45.

Wrucke, C. T., 1961, Paleozoic and Cenozoic rocks in the Alpine-Nutrioso area, Apache County, Arizona: U.S. Geological Survey, Bulletin 1121-H, 26 p.



Lower slopes of San Francisco Mountains approximately 17 km west of Reserve, New Mexico. View is N74°E. Layered volcaniclastic conglomerates in foreground (Heifer Basin) are assigned to the Pueblo Creek Formation (upper Eocene to lower Oligocene) of the middle Spears Group. Tularosa Mountains are on the distant horizon east of the Reserve graben. John Kerr Peak, at center on horizon (touching clouds), is an upper Miocene rhyolite lava dome. Camera station is along side Highway 180 in SW ¼ sec. 32, T6S, R20W. Altitude is about 2375 m. Wayne Lambert photograph No. 93L61. August 14, 1993, 12 noon MDT.