Geologic Map of the Cat Mountain Quadrangle, Otero County, New Mexico

By

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May, 2009

New Mexico Bureau of Geology and Mineral Resources
Open-file Digital Geologic Map OF-GM 183

Scale 1:24,000

This work was supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program (STATEMAP) and the New Mexico Bureau of Geology and Mineral Resources.

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Geologic Map of the Cat Mountain 7.5-Minute Quadrangle, Otero County, New Mexico

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INTRODUCTION

The Cat Mountain 7.5-minute quadrangle is located northeast of the village of Tularosa on the eastern margin of the Tularosa Basin in south-central New Mexico. Main access is via U.S. Highway 70 through the southeastern corner of the area and by a maintained dirt road through Coyote Canyon in the central part of the quadrangle. Southwest-flowing Tularosa Creek and Temporal Creek are the most significant drainages. A mix of private, Bureau of Land Management and State stakeholders own or manage the land. A portion of the western edge of the Mescalero Apache Reservation occupies the northeast corner of the quadrangle.

Moore et al. (1988) mapped the northwestern part of the Mescalero Apache Reservation, including the northeastern corner of the Cat Mountain quadrangle at a 1:24,000 scale. We did not have permission to work on the reservation, so we used a slightly modified version of the Moore et al. (1988) map on the reservation land. Moore et al. (1988) originally lumped the Triassic Moenkopi Formation and and the Permian Grayburg Formation into a unit described as Triassic Santa Rosa Formation. We modified their "Triassic" contacts using Google Earth images and air photos. Otte (1959) mapped the southern quarter of the quadrangle at a scale of 4 inches to 1 mile (1:15,840). Otte (1959) focused his excellent and thorough work on the Pennsylvanian to Permian Labrocita Formation, which we correlate to the Bursum Formation in this report. Otte (1959) mapped the Labrocita Formation and the lower part of the overlying Abo Formation on a bed-by-bed basis using a plane table, creating a map of unprecedented detail. Kelley (1971) measured a complete section of the Yeso Formation in this area.

The quadrangle is in the transition between the east-dipping Sacramento Mountains and the Sierra Blanca volcanic field. In addition, this area is located on the southwestern margin of the Sierra Blanca basin, a north-northeast trending Laramide basin that contains sedimentary rocks as young as Eocene in age. The volcanic and plutonic rocks of the Sierra Blanca complex and Lincoln County porphyry belt were erupted onto and intruded into the Sierra Blanca basin ~26 to 38 million years ago. Countless dikes and sills associated with Sierra Blanca volcanism criss-cross the Cat Mountain region; the dikes follow a pronounced NE-trend. Rio Grande rift extensional faulting has since disrupted the Sierra Blanca basin and the volcanic centers. Rock exposures are generally quite good due to the sparse Chihuahuan desert vegetation and the moderate topography.

UNIT DESCRIPTIONS

Quaternary Deposits

Qal **Quaternary alluvium (Holocene):** Unconsolidated gravel, sand, clay, and silt, deposited in major modern drainage and tributary channels and associated floodplains. Locally contains small amounts of alluvial fan, colluvium and other Quaternary units. up to 5 m thick.

Qc **Undivided colluvium (Holocene)**: Hillslope colluvial deposits composed of pebble to boulder size clasts from a variety of lithologies, mainly limestone. Common on north-facing slopes. Varies in thickness from ~ 5 – 50 m

Qt **Terrace deposits (Holocene):** Unconsolidated gravel, sand, and silt deposits along major present-day drainages inset into older alluvial deposits _ m above modern grade. 1-2 m thick.

Qsw **Slopewash deposits - Holocene:** Unconsolidated tan silt with lenses of gravel and sand that consists primarily of eolian material reworked by sheetflow. These deposits cover the floors of broad valleys in the central part of the quadrangle. These deposits commonly sit on well-consolidated older alluvium. 1- 5 m thick.

Qls **Landslide deposit – middle Pleistocene to Holocene:** Undivided landslide deposits composed of locally derived, cohesive blocks of Yeso Formation. Generally associated with a head scarp in their source area. Varies in thickness from ~ 5 – 50 m.

Qao_2 **Old alluvium - Pleistocene:** Well-consolidated gravel, sand, and silt deposited by alluvial fans sourced from Black Mountain, located northeast of the quadrangle, and the northern foothills of the Sacramento Mountains. Gravel includes sedimentary (mainly limestone) and volcanic clasts. Red soil with carbonate stringers is well-developed at the top of the unit and gypsiferous silt is usually present in the uppermost part of the alluvium. Qao2 is usually covered by a thin veneer of young alluvium or slopewash and is best observed in deeply incised arroyos. Surfaces developed on this deposit are near modern grade. Younger thin cut and fill deposits along Salinas Draw on the northern edge of the quadrangle are lumped with Qao2. Up to 15 m thick.

Qao_1 **Older alluvium - Pleistocene:** Well-consolidated gravel, sand, and silt deposited by alluvial fans sourced in the northern foothills of the Sacramento Mountains on a high level strath cut on Permian Abo Formation in south-central part of the map area. Strath surfaces beneath this deposit are 50 to 70 m above modern grade. The gravels are typically clast-supported, imbricated, subrounded to subangular, poorly sorted, and consist of pebbles and cobbles. Gravel includes sedimentary (mainly limestone) and volcanic clasts. Up to 25 m thick.

Neogene Igneous Rocks

No age dates are available for these units. The ages are likely 37 to 42 Ma, based on $^{40}Ar/^{39}Ar$ age determinations for dikes and sills in the Three Rivers area to the north and in the Sacramento Mountains to the southeast (McManus and McMillan, 2002). The age of emplacement of the Black Mountain stock just northeast of the quadrangle is middle Eocene based on a biotite $^{40}Ar/^{39}Ar$ age of 37.8 Ma, a $^{40}Ar/^{39}Ar$ plagioclase age of 34.6 Ma, and a hornblende $^{40}Ar/^{39}Ar$ age of 37.3 Ma (Allen and Foord, 1991). Mineralization is generally absent along the dikes and sills. Occasionally, hematite, limonite, barite, calcite, copper, and manganese minerals occur in the vicinity of intrusions. Dikes generally fill fractures and are 1 to 2 m wide. More rarely, dikes fill

faults, but the dikes are not deformed by reactivation of the faults. Sills are oftern cut by dikes and sills can be cut by faults.

Ti **undifferentiated dikes and sills mapped from air photos.**

Tif **Fine-grained trachyte (Eocene?):** Black to dark green, fine-grained dikes with barely discernable needles of plagioclase and pyroxene. Dikes 1 to 2 m wide.

Tit **Trachyte (Eocene)**: Dikes of light gray to dark-gray porphyry with 15 to 25% plagioclase laths 10 to 20 mm long set in an equigranular to fine-grained matrix of dark green pyroxene and feldspar. The plagioclase laths are often distinctly aligned parallel to the margins of the dike. Dikes 1 to 4 m wide.

Figure 1. Trachyte dike that cuts the syenite intrusion in the northeastern part of the quadrangle.

Tita **Porphyritic trachyandesite (Eocene):** dikes and sills of light-gray porphyry with 5 to 15% phenocrysts of plagioclase feldspar, dark green pyroxene, and potassium feldspar that are 1-10 mm across. These intrusive bodies may grade into more equigranular textures (Tig). Syenitic and sedimentary xenoliths are locally present.

Titd **Porphyritic trachydacite (Eocene)**: dikes and sills of light-gray porphyry with 5 to 15% phenocrysts of plagioclase feldspar, biotite ± hornblende, and dark green pyroxene that are 1-10 mm across.

Tig **Alkali gabbro-syenogabbro (Eocene)**: equigranular, fine- to medium-grained, salt-and-pepper textured dikes and sills with plagioclase feldspar and pyroxene phenocrysts. These intrusive bodies may grade into more porphyritic textures (Tita). These intrusions often contain xenoliths of syenite (Figure 2). Dikes of this composition cut sills of megacrystic trachyte porphyry south of Coyote Peak and on the Tularosa NE quadrangle to the west. Alkali gabbro may contain amphibole and biotite (Moore et al., 1988). Thick sills of this composition in the northeastern parts of the map area have cumulate pyroxene at the base (Figure 3).

Figure 2. Pink syenite xenolith in alkali gabbro sill. Map case is 31 cm long.

Figure 3. Cumulate pyroxene phase at the base of an alkali gabbro (Tig) sill in the northeastern Cat Mountain quadrangle.

Tbag **Coarse-grained alkali gabbro (Eocene):** Black to dark green medium to coarse-grained sill with subequal amounts of black pyroxene and plagioclase with sparse apple green pyroxene located on the southwest side of Cat Mountain. The coarse gabbro grades upward into a fine- to medium grained equigranular gabbro.

Tim **Megacrystic trachyte porphyry (Eocene):** greenish gray porphyritic sills and dikes with megacrysts of embayed tschermakitic hornblende or green pyroxene that are up to 2 to 4 cm across. Often contains hornblende ± biotite. These intrusives can contain xenoliths of pink coarse-grained syenite with phenocrysts of orthoclase feldspar and hornblende.

Tip **Amphibole-rich trachydacite (Eocene):** Black to dark green, medium-grained sills composed of ~30% dark green elongate amphibole needles, and subequal amounts of plagioclase and potassium feldspar. Sills 1 to 5 m thick.

Tis **Syenite (middle Eocene)**: pink, medium-grained equigranular sill composed of potassium feldspar, plagioclase feldspar, pyroxene, and biotite.

Tid **Alkali gabbro of Granite Well (Eocene)**: Greenish gray, equigranular, fine- to medium-grained, salt-and-pepper textured sill with plagioclase feldspar, pyroxene and biotite phenocrysts exposed south of Granite Well along Temporal Creek near the mountain front. This sill has a pryoxene-rich cumulate phase near the base. Sill is about 30 to 35 m thick

Tsp **Syenite of Temporal Creek (middle Eocene)** : Tan to pink, equigranular to porphyritic stock exposed in the northeast corner of the quadrangle (Moore et al., 1988) north of Temporal Creek straddling the western boundary of the Mescalero Apache Indian Reservation. The most common phenocrysts are clinopyroxene, plagioclase feldspar, and potassium feldspar. Some phases of this stock have amphibole (Moore et al., 1988), while others have sparse phenocrysts of quartz. Trachyte dikes with large plagioclase phenocrysts cut this stock.

Mesozoic to Paleozoic Sedimentary Rocks

Km **Mancos Shale (Upper Cretaceous)** – Black, finely-laminated, fossiliferous shale with thin beds of limestone and intercalated bentonite beds near the base. Brown to tan, cross-bedded to tabular-bedded sandstone and sandstone containing abundant oyster fossils occur higher in the exposed section. These marine deposits are in the lower part of the Rio Salado Tongue of the Mancos Shale (Moore et al., 1988).

Kd **Dakota Sandstone (Upper Cretaceous)** – Medium to thick-bedded to thinly laminated, medium- to coarse-grained, cross bedded white sandstone with lenses of dark gray shale. Chert and quartzite pebble conglomerate commonly occurs at or near the base of the unit. Distinctive, cylindrical *Ophiomorpha nodosa* burrows are abundant at the top of the Dakota Sandstone.

TRm **Moenkopi Formation (Upper Triassic)** –Red-brown, fine-grained, thin bedded, trough cross-bedded to ripple laminated sandstone. The sand grains are subround to round and include muscovite and lithic fragments. Conglomeratic sandstones with pebbles of chert and quartz are present in a few localities. The upper and lower contacts are disconformable. The fluvial Moenkopi Formation scoured channels into the underlying Grayburg Formation of the Artesia Group. The unit thickens toward the east. Thickness up to 10 m.

Pag **Grayburg Formation, Artesia Group (Permian)** - red siltstone with green reduction spots, red mudstone, and massive gypsum. Siltstone is massive to occasionally cross-laminated. Base with underlying Fourmile Draw Member of the San Andres Limestone is sharp and has a lag gravel. Gypsum occurs in the upper 10 m of the unit. The top is eroded and scoured by the Moenkopi Formation.

Psa **San Andres Formation (Permian)-** Kelley (1971) recognized three members in south central New Mexico. The lower part of the deposit, the Rio Bonito Member, is composed of medium- to thick-bedded dark gray, fossiliferous limestone, golden tan dolomite, and thin beds of yellow siltstone and gypsum. The middle part of the unit, the Bonney Canyon Member, is fossiliferous, gray thin-thick bedded dark gray limestone. The intercalated limestone gypsum unit in the upper part of the San Andres Formation belongs to the Fourmile Draw Member of Kelley (1971). In this area, only the Rio Bonito Member and the Fourmile Draw Member are present.

Psr **Rio Bonito Member:** Dark gray, thin to thick bedded, fossiliferous limestone with thin to medium-bedded gypsum near the top of the unit. Fossils include productid brachiopods, crinoids, echinoderm spines, and bryozoa fragments. The contact with the underlying Yeso Group is generally quite sharp; however thin (<0.5 m) gypsum beds can persist a few meters above the contact. The Rio BonitoMember is 60 to 75 m thick.

Psh **Hondo Sandstone:** This unit was described by Harbour (1971). The sandstone is present within the Rio Bonito Member approximately 30 m above the base of the limestone. The Hondo Sandstone is a gold-brown to tan, well-sorted, medium to fine-grained quartz arenite with well-rounded sand grains. Bedding is commonly tabular, cross-bedding is rare. The sandstone is discontinuous and ranges from 0 to 10 m thick. The sandstone, where present, is only 0.7 m thick on Cat Mountain (13 S 415916 3670526 NAD27) and is 5 to 10 m thick on the west end of Coyote Ridge.

Psf **Fourmile Draw Member:** The Fourmile Draw Member is composed of interbedded light gray dolomite, dark gray limestone, and laminated gypsum. The carbonates contain fossils, but fossils are not as common as they are in the Rio Bonito Member. The relative percentage of gypsum to carbonate increases upsection through the member. The thickness of this unit is uncertain because the top is not exposed on the quadrangle and this unit is quite deformed. Estimated thickness is on the order of 300 m.

The contact between the Rio Bonito and Fourmile Draw members is very gradational and is here defined to be at the base of a distinctive limestone bed present across the map area. The marker limestone is dark gray, fossiliferous, and has a gypsum bed that is about 6 m thick below it. The carbonates above the marker limestone become progressively more dolomitic up section. The marker limestone is generally the thickest succession of limestone above cliffs of the Rio Bonito Member, but the marker does vary in thickness (20 to 80 feet; average is 40). The marker limestone forms an easily tracable unit on poorly exposed, gypsum-mantled hills.

The 6 m thick gypsum bed is continuous across the area, but thin, discontinuous gypsum and intercalated limestone beds often occur in the uppermost Rio Bonito Member as much as 25 m below the mappable marker limestone. Similarly, thin sequences of dark gray, fossiliferous limestone that grade up into dolomite and thick beds of gypsum are present above the marker limestone.

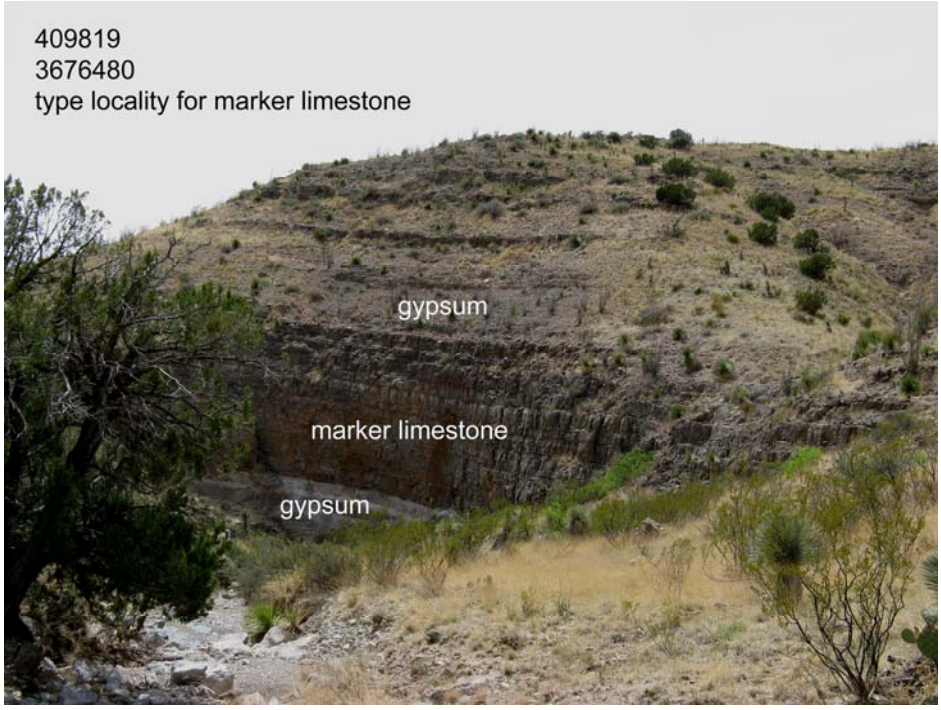

Figure 4. Marker limestone bed at contact of Rio Bonito Member and Fourmile Draw Member of the San Andres Formation.

Py **Yeso Formation (Permian):** Red and yellow siltstone and thin beds of gray limestone and laminated to thin bedded gypsum dominate the basal part of the section. A 30 m thick medium-bedded limestone forms a prominent bed in the middle portion of the unit. The upper part of the Yeso on Cat Mountain is gypsum with yellow and red siltstone and thin-bedded limestone. Red siltstone often occurs near the top of the unit. In contrast, the upper Yeso Formation to the north is primarily gypsum and limestone. The limestones are sparsely fossiliferous, containing brachiopods. A solitary nautiloid 15 cm across was found in limestone near the base of the unit. Sea star fossils are at the Yeso/San Andres contact in the northeastern part of the map area. Oncolites are preserved in the limestone at 13 S 416913 3670824 (NAD 27). The Yeso Formation has a gradational contact with the underlying Abo Formation that is particularly well exposed south and southwest of Cat Mountain. The red arkosic sandstone and red and green mudstone of the Abo Formation grade upward into thin beds of black and green shale, fine-grained green and yellow, sandstone, and thin beds of gypsum and limestone. The upper contact is gradational with the San Andres Formation . Kelley (1971) measured a complete section of Yeso Formation on the Cat Mountain quadrangle in the vicinity of Coyote Peak in T13S, R10E, sec. 21 and 22. Maximum thickness 372 m (1220 ft).

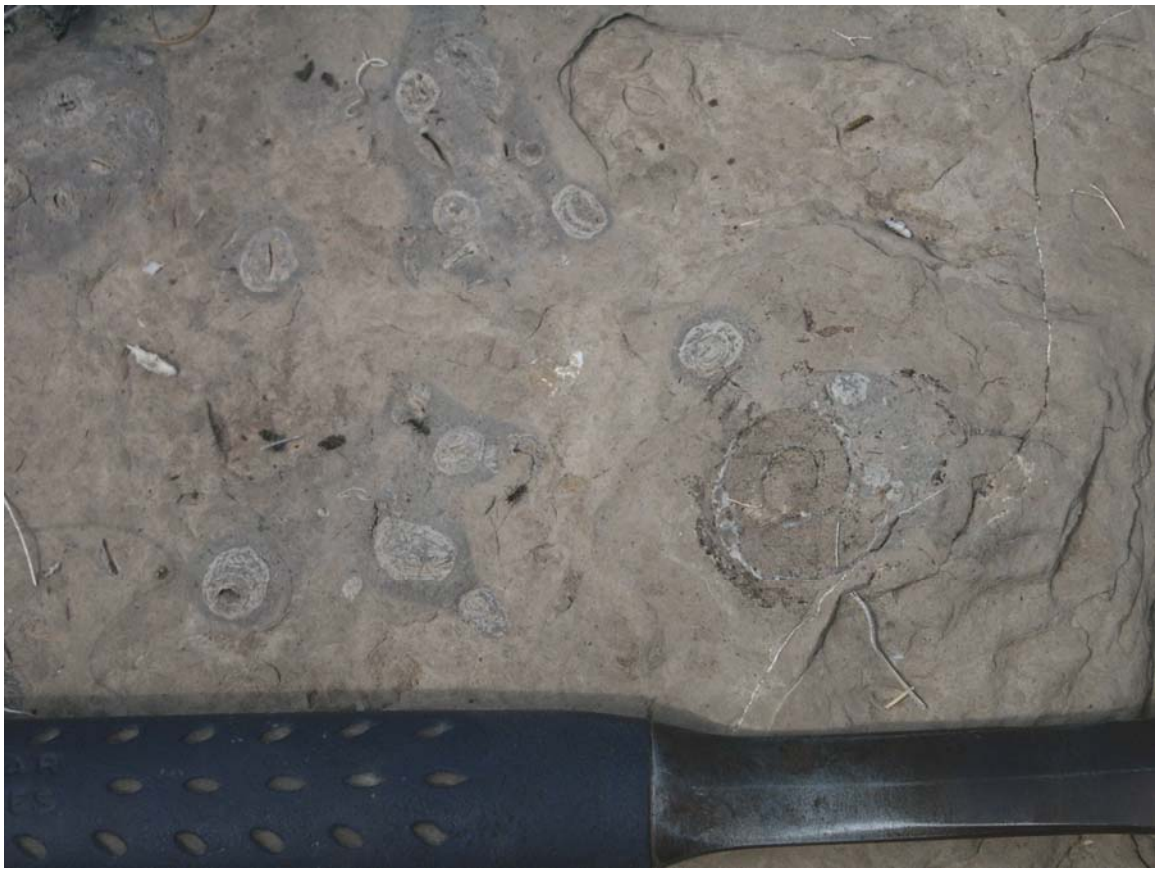

Figure 5. Oncolites and nautiliod in the Yeso Formation on the south side of Cat Mountain.

Figure 6. Exposures of the Abo – Yeso contact south of Cat Mountain.

Pa **Abo Formation (Permian):** Brick red sandstone, mudstone, siltstone, and conglomerate. The Abo Fomation is dominated by mudstone (50%) and arkosic sandstone and conglomerate (40%). Fossiliferous limestone and pedogenic carbonate, which are primarily found in the basal 150 m, make up the rest of the unit (Otte, 1959). Sandstones are cross-bedded to tabular, coarse to medium-grained, and poorly to moderately sorted. Angular to subround quartz, orthoclase feldspar, and muscovite are common sand grains. Conglomerates contain well-rounded clasts of Proterozoic quartzite, Proterozoic rhyolite porphyry, chert of uncertain age, and sandstone. Thin fossiliferous limestone beds that are 0.2 to 0.7 m thick locally occur near the transitional base of the unit, particularly in the southeast corner of the quadrangle. Thin (4 to 20 cm) chert beds are locally found just above the contact with the Labrocita Formation and above a thin (0.2 m) limestone bed at 13 S 408507 3666281 (NAD 27). Petrified wood is preserved in the Abo Formation at 13 S 408658 3664679 (NAD27). Malachite and hematite mineralization is associated with the Abo Formation. 427 m to 550 m thick (Otte, 1959; Speer, 1983).

IPb **Bursum Formation (Late Pennsylvanian to Early Permian):** Maroon and green sandstone interbedded with fossiliferous limestone and black shale. Biohermal mounds (**IPbb**) are dominantly composed of algae but have abundant crinoid stems preserved at the top. Bryozoans and brachipods are other common fossils on the mountds. This unit is equivalent to the Labrocita Formation of Otte (1959). We followed Otte (1959) by using a continuous limestone bed (Otte's bed 55) to mark the gradational contact between the Bursum and the Abo formations. Base not exposed. Maximum thickness in the northern Sacramento Mountains is 330 m (Raatz, 2002) and estimated thickness northeast of Tularosa is 305 m (Otte, 1959).

GEOLOGIC HISTORY

Late Paleozoic

The Bursum Formation was deposited in the eastern margin of the Orogrande Basin during late Pennsylvanian to early Permian time. The initial stages of uplift of the basement-cored Pedernal highland located to the north-northeast of this area contributed Proterozoic quartzite and rhyolite clasts to redbed conglomerates interbedded with marine limestone. Bioherms composed of sponges, crinoids, bryozoans, and brachiopods formed in the shallow marine water. Continued uplift of the Pedernal highland to the north and retreat of the ocean toward the south led to continental deposition of the fluvial Abo Formation. The retreat of the sea was gradual because a few fossiliferous marine beds are preserved in the basal Abo Formation. The lower part of the Abo Formation in this area, which corresponds to the middle Abo Formation of Speer (1983), contains more conglomerate with larger clasts compared to the more muddy upper part. Thin orange chert beds that may represent silicified ash beds are in the lower part of the section. Pedogenic carbonate horizons are common throughout the section. Paleocurrent data indicate flow toward the southwest to west (Speer, 1983). The Abo Formation was deposited by southward flowing rivers in a semi-arid climate. The Abo Formation is

unusually thick within the Cat Mountain quadrangle compared to areas to the south, indicating that this area was in a rapidly subsiding part of the Orogrande Basin during Wolfcampian time (Speer, 1983).

As Late Paleozoic tectonic activity waned, the ocean returned to this region, depositing first a thin layer of black shale, then limestone, gypsum, and silt to fine-grained sandstone across the area. The Leonardian Yeso Formation was deposited on a shallow restricted marine shelf in a semi-arid environment. The limestone beds in the Yeso Formation contain few fossils, mainly brachiopods. Echinoderm spines and oncolites were observed in Yeso Formation limestone beds on the south side of Cat Mountain. One nautiloid fossil found in the lower half of the Yeso Formation on Coyote Ridge has been tentatively assigned to *Metacoceras aff. M. unklesbayi* by Barry Kues based on the size, proportions, umbilicus, and knobby ornamentation of the shell. The maximum diameter of the shell of this particular fossil is about 160 mm, and the cross-section through the last chamber is roughly rectangular, measuring 74 mm wide by 55 mm high. This specimen most closely resembles a nautiloid found in the Leonardian Kaibab Limestone of Arizona (Miller and Youngquist, 1949).

Sea level continued to rise, leading to the deposition of the dark-gray fossiliferous limestone of the Guadalupian Rio Bonito Member of San Andres Formation. Nautiloids, brachipods, and bryozoans are common throughout these strata; horn corals are more common near the base of the unit. Cyclical oscillation of sea level during Permian time and near shore barrier island sandstone deposition associated with the Hondo Sandstone briefly interrupted relatively deep water sedimentation. Sea level then gradually dropped and restricted marine shelf conditions returned to the area. The dolomite, gypsum, and limestone of the Fourmile Draw Member of the San Andres Formation were deposited at this time. After a brief interval of erosion, red siltstone and gypsum of the Permian Grayburg Formation were deposited on a tidal flat next to the retreating sea. A period of erosion or nondeposition followed Grayburg Formation deposition.

Mesozoic

The trough-crossbedded reddish-gray fluvial sandstone and red floodplain siltstone of the Moenkopi Formation record the presence of a northerly to northwesterly flowing river system across the area during Triassic time. This river system carved noticeable channels into the underlying Grayburg Formation. The Triassic Chinle Group and Jurassic units are absent in this area, either because of erosion or nondeposition.

The cross-bedded sandstone and gray to black shale of a fluvial facies of the Dakota Sandstone rests unconformably on the Triassic Moenkopi Formation in this area. The presence of *Ophiomorpha nodosa* burrows in the uppermost part of the Dakota Formation signals the onset of flooding of this area by the Western Interior Seaway during Late Cretaceous time. The Dakota Formation grades up into the open marine and shoreface shale and sandstone deposits of the Mancos Shale. Only the lowermost part of the Mancos Shale is exposed on the Cat Mountain quadrangle.

Laramide Deformation

The general north to northeast tilt of the rock units, which causes younger rock units to be exposed toward the north and northeast across the map area, developed as the Sierra Blanca basin formed during Laramide compressional deformation. More complex

faulting and folding that is likely enhanced by dissolution and deformation in incompetent gypsum beds of the Yeso Formation is superimposed on the simple structural trend. Interestingly, the gypsum-rich sections of Fourmile Draw Member of the San Andres Formation do not display the convoluted internal deformation found in the gypsiferous strata of the Yeso Formation. One of the more notable structures of likely Larmide origin in the quadrangle is the east-northeast striking Cat Mountain monocline located north of Cat Mountain and on the south side of Coyote Ridge. A broad zone of north- to northwest dipping strata characterize this feature, juxtaposing Yeso Formation to the south against the Fourmile Draw Member of the San Andres Formation to the north. The amount of down-to-the-north structural offset across the monocline decreases dramatically toward the west. Other east-northeast-striking faults, such as the structure south of Maxwell Spring in Temporal Creek and the structure sub-paralleling Salinas Draw in the northwestern corner of the map area may have formed during Laramide deformation. The structures have been reactivated during Rio Grande rift extension.

Rio Grande Rift Extension and Sierra Blanca Volcanic Field Intrusive Activity

Volcanic rocks from the Sierra Blanca volcanic field are not preserved in this area. Intrusive dikes, sills, and small stocks and laccoliths that served as the plumbing system for the volcanic field during late Eocene time are common features. The sills seem to be the oldest intrusives because dikes and the northeast-striking normal faults associated with Rio Grande rift extension cut the sills. The sills may have been emplaced while the area was still under mild compression during the waning stages of Laramide deformation. The syenite stock of Temporal Creek near the Reservation boundary in the northeastern part of the quadrangle is cut by trachytic dikes, but is not cut by the northeast-striking faults. The thick laccolithic sills south of Granite Well and on the north side of Cat Mountain are not cut by dikes or faults. Dikes have filled some of the faults, but the dikes are only rarely deformed. Age determinations for the intrusive rocks in this area would help sort out the timing of the transition from Laramide compression to Rio Grande rift extension in this area (e.g., McMillan, 2004).

Collapse Feature

One of the more interesting structures in the Cat Mountain quadrangle is an elliptical shaped feature at the confluence of Dry Canyon and Rinconada Canyon. The rocks within the feature include the Permian Grayburg Formation, Triassic Moenkopi Formation, Cretaceous Dakota Sandstone, and the basal part of the Cretaceous Mancos Shale. San Andres Formation surrounds the younger rocks and the bedding in the San Andres Formation dips toward the center of the strucutre. In general, the units within the elliptical feature seem to be roughly in stratigraphic order, generally dipping steeply toward the northwest, but in places the units are jumbled or oddly juxtaposed. For example, along the northern margin of the feature, Grayburg Formation outcrops are located in close proximity to Mancos Shale outcrops. A line of tufa or travertine deposits sitting on Fourmile Draw Member dolomite marks the southeast margin of the feature, which appears to reactivate an older fault. The elliptical shape, the annular inward dip of the surrounding older rocks, and the somewhat jumbled nature of the younger rocks filling the feature suggest that this is a karst feature, possibly related to dissolution in the

underlying Yeso Formation. The sinkhole formed during post-Cretaceous time. A couple of sills and one dike are exposed within the collapse feature, but no intrusions cut across the margins of the sinkhole.

A similar, but poorly exposed, structure appears to be present in Salinas Draw in the northwestern corner of the map area. Here, a small hill of Dakota Sandstone is surrounded by outcrops of Permian Grayburg Formation and the Fourmile Draw Member of the San Andres Formation.

Quaternary Deposition and Exhumation

Well-developed old alluvial fan deposits are preserved along Coyote Creek on a strath cut on the Abo Formation that is 50 to 70m above modern grade. The older fan deposits in the Alamogordo area are estimated to be as older than 25,000 years and may be as old as 300,000 years (Koning , 1999; Koning et al., 2002). The ancient strath along Coyote Creek projects well above base level in the internally drained Tularosa Basin to the west. The old fans in the Coyote Creek area are on the footwall the Alamogordo fault; thus the strath has been uplifted and the area has been exhumed as a consequence of Quaternary motion along the fault. At least five rupture events have occurred along the fault near Alamogordo between 30,000 and 7500 years ago (Koning and Pazzaglia, 2002)

ACKNOWLEDGEMENTS

We thank the following landowners, ranch foremen and lease holders for permission to work on their property: David French, J.D. Yates, Gary Stallings, Justin Danley, Pete Griffin, and Ray Fletcher. Barry Kues helped with fossil identification. Dan Koning and Bruce Allen helped us sort out the Quaternary deposits in the area. Greg Mack generously shared his considerable knowledge of the Paleozoic and Mesozoic stratigraphy of southern New Mexico with us. We greatly appreciate Richard Kelley's help with the GIS aspects of this project.

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