Map Unit Properties Table: El Morro National Monument

Colored rows indicate units mapped within El Morro National Monument. Italicized text corresponds to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History and Park Connections
QUATERNARY (Holocene)	Eolian deposits (Qe)	Windblown silt and sand in small dunes and sheets.	*Loss of Inscriptions*—eolian processes aid disintegration of inscriptions on the friable Zuni Sandstone (**Jz**), which is the source of eolian sediment today. Eolian deposits (**Qe**) are accumulating at the base of Inscription Rock. *Tinaja Pit*—eolian processes transport limestone dust produced during blasting and as a result of hauling of aggregate on roadways.	*El Morro and Inscription Rock*—**Qe** is part of apron of sediments that surrounds the El Morro cuesta. *Box Canyon*—disintegrated rock debris eroded during canyon formation is transported away via eolian processes. *Tinajas*—eolian processes may be a factor in tinaja formation. *Eolian Features and Processes*—infilling by eolian dust on basalt flows (**Qb**) is the first stage of soil development. *Paleontological Resources*—potential for mammalian fossils and other fossil assemblages.	The El Morro area is characterized by small eolian deposits (**Qe**) oriented east–northeast. Blowouts with dunes on lee (east–northeast) sides are common in the northern part of the El Morro quadrangle. Anderson and Maxwell (1991) mapped only the thickest accumulations of **Qe** within the El Morro quadrangle, but small dunes and sand sheets occur within the national monument. A cycle of eolian transport and deposition started during the Jurassic Period, when the Zuni Sandstone (**Jz**) was deposited as sand dunes. The cycle continues as the sandstone now provides sand grains for windblown transport to modern landscapes composed of **Qe**.
QUATERNARY (Holocene)	Alluvium (Qal)	Mainly silt and fine-grained sand in active stream floodplains. Includes some eolian and colluvial deposits.	*Rockfall Hazards*—colluvial deposits were deposited via mass wasting (gravity-driven processes).	*El Morro and Inscription Rock*—**Qal** is part of the apron of sediment that surrounds the El Morro cuesta. *Box Canyon*—**Qal** covers the floor of box canyon, which is cut into the El Morro cuesta. *The Pool*—a well in **Qal** replaced the pool as the source of El Morro National Monument's water supply. *Lava Flows*—alluvium often covers lava flows. *Paleontological Resources*—potential for mammalian fossils and other fossil assemblages.	Records recent landscape evolution: alluvial deposits by streams, eolian deposits by wind, and colluvial deposits by mass wasting. Aquifer for current water supply at El Morro National Monument.
QUATERNARY (Holocene and Pleistocene)	Alluvium and slopewash (Qas)	Unconsolidated clay, silt, and sand.	None reported.	*Paleontological Resources*—potential for mammalian fossils and other fossil assemblages.	Mostly floodplain deposits along larger streams and slopewash on adjacent gentle slopes and broad flats. Includes eolian deposits and low stream-terrace deposits locally.
QUATERNARY (Holocene and Pleistocene)	Alluvium, colluvium, and eolian deposits (Qac)	Variable mixtures of alluvium and colluvium, small landslide blocks, and small sand dunes. Generally stabilized by vegetation.	None reported.	*El Morro and Inscription Rock*—**Qac** forms apron of sediment around the El Morro cuesta. *Paleontological Resources*—potential for mammalian fossils and other fossil assemblages.	Covers the majority of the ground surface at El Morro National Monument. A typical example of **Qac** is the slope west of the visitor center.
QUATERNARY (Holocene and Pleistocene)	Landslide deposits (Ql)	Large sandstone landslide blocks, talus, and mudslides. May be partly covered by colluvium and eolian deposits. Occur as displaced masses of shale, siltstone, and sandstone on steep slopes formed by Rio Salado Tongue of the Mancos Shale (**Kmr**).	*Rockfall Hazards*—Wieczorek and Snyder (2009) provided vital signs for monitoring.	*Paleontological Resources*—potential for mammalian fossils and other fossil assemblages.	Anderson and Maxwell (1991) mapped **Ql** in the southeastern corner of El Morro National Monument.

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QUATERNARY (Pleistocene)	Basalt flows or volcanic rocks (Qb)	Flows of dark-gray, vesicular basalt and basaltic andesite. Weathered and generally covered with soil, alluvium, or sand dunes. Anderson and Maxwell (1991) described unit as "essentially the same flows as 'Qbo' of Maxwell (1986)" (see Anderson and Maxwell's description on map). Qbo of Maxwell (1986) is Oso Ridge lava flows, as mapped near El Malpais National Monument. However, more recent field mapping and age dating show that unit **Qb** is equivalent to Maxwell's (1986) Qb (old basalt flows), not Qbo (Nelia Dunbar, New Mexico Bureau of Geology and Mineral Resources, volcanologist, e-mail communication, 9 March 2012).	None reported.	*Ephemeral Streams and Arroyos*—no stream crosses the lava plain between the Zuni Mountains and El Morro; all water sinks very quickly into **Qb**. *Eolian Features and Processes*—eolian silt has "infilled" the vesicles, cracks, and fissures of the basalt flows (**Qb**). *Lava Flows*—composed of aa lava. *Unconformities*—at least 65 million years of the rock record are missing between the Upper Cretaceous Dakota Sandstone (**Kdm**) and **Qb**. *Paleontological Resources*—potential for tree molds on lava flows and mammalian fossils in cave sediments of lava-tube caves.	Flows are part of the Zuni–Bandera volcanic field. Forms open grasslands with small outcrops of basalt. Underlies campground at El Morro National Monument. Buried Chinle Formation (**TRc** units) in valleys. Luedke and Smith (1978) reported ages of 788,000 years near Cerro Bandera east of map area and 1.38 million years several kilometers southwest of map area; however, more recent dating and field investigation by Laughlin et al. (1993b) yielded an age of 700,000 years for the "old basalt flows" (**Qb**) of Maxwell (1986) at El Malpais National Monument and, by correlation, for the flows at El Morro National Monument.
UPPER CRETACEOUS	Mancos Shale, Pescado Tongue (Kmp)	Dark-gray shale. Contains prominent, dark-gray, brown-weathering septarian limestone concretions. A bed about 1 m (3 ft) thick of calcareous siltstone about 3 m (10 ft) above the base of the tongue caps high buttes in the northwestern part of the El Morro quadrangle. Exposed thickness 6–12 m (20–40 ft).	None reported.	None reported.	Deposited in the Western Interior Seaway. Indicative of the migration of marine waters back and forth across the area.
	Tres Hermanos Formation, Fite Ranch Sandstone Member (Kthf)	Light-gray, mostly fine-grained sandstone. Thickness 3–6 m (10–20 ft).	None reported.	None reported.	Deposited in the Western Interior Seaway. Indicative of the migration of marine waters back and forth across the area.
	Tres Hermanos Formation, Carthage Member (Kthc)	Light-gray and light-yellowish-gray, very fine to fine-grained, cross-bedded sandstone in lenticular beds. Also, light-gray siltstone, dark-gray mudstone, brown carbonaceous shale, and minor beds of coal. Thickness about 45 m (150 ft).	None reported.	None reported.	Deposited in the Western Interior Seaway. Indicative of the migration of marine waters back and forth across the area.
	Tres Hermanos Formation, Atarque Sandstone Member (Ktha)	Light- or pinkish-gray, fine-grained, flat-bedded and cross-bedded sandstone. Some interbedded, dark shale and sandy shale. Thickness 15–18 m (50–60 ft).	None reported.	None reported.	Deposited in the Western Interior Seaway. Indicative of the migration of marine waters back and forth across the area.
	Mancos Shale, Rio Salado Tongue (Kmr)	Dark-gray shale and interbeds of light-gray siltstone and very fine-gained sandstone, mostly at the top of the unit. Calcareous shale, white-weathering shaly limestone, and a few thin layers of bentonite in the basal 10–12 m (30–40 ft). Thickness about 75 m (250 ft).	None reported.	None reported.	Deposited in the Western Interior Seaway. Indicative of the migration of marine waters back and forth across the area.
	Dakota Sandstone, Twowells Tongue (Kdt)	Light-gray and light-yellowish-gray, fine- to medium-grained sandstone. Generally cross-bedded. Thickness 3–8 m (10–25 ft).	None reported.	*Paleontological Resources*—potential for terrestrial plant fossils and vertebrate tracks.	Deposited in the Western Interior Seaway. Indicative of the migration of marine waters back and forth across the area.
	Mancos Shale, Whitewater Arroyo Tongue (Kmw)	Dark-gray and yellowish-gray silty shale. Thickness 12–15 m (40–50 ft).	None reported.	None reported.	Deposited in the Western Interior Seaway. Indicative of the migration of marine waters back and forth across the area.

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UPPER CRETACEOUS	Dakota Sandstone (Kdm)	Sandstone, mudstone, carbonaceous mudstone/shale, and conglomeratic sandstone. Upper part is light-gray to light-yellowish-gray, fine- to medium-grained, thinly bedded, locally cross-bedded sandstone. Middle part is olive-gray and light- to dark-gray mudstone and shale with fine- to coarse-grained lenticular sandstone beds that are commonly cross-bedded. Lower part consists of medium- to coarse-grained, cross-bedded sandstone and conglomeratic sandstone. Hardened with silica cement. Lower part may be absent. Locally gradational into underlying reworked Zuni Sandstone (**Kl**). Total thickness up to 45 m (150 ft).	None reported.	*El Morro and Inscription Rock*—**Kdm** rests on top of the bleached horizon of the Zuni Sandstone (**Jz**). Forms cap rock on the El Morro cuesta. *Box Canyon*—loss of **Kdm** cap rock facilitates canyon formation via groundwater sapping. *Tinajas*—occur within the **Kdm** cap rock. *Unconformities*—more than 60 million years of the rock record is missing between the bleached horizon of **Jz** and the overlying **Kdm**. *Paleontological Resources*—most likely among rock units in El Morro National Monument to contain fossils, including plants, petrified wood, or casts of burrowing and crawling organisms.	Preserved along the Mesa Top Trail. Pueblo ruins were built on the middle part (gray mudstone to shale) of the unit. Records the initial advance of the Western Interior Seaway into New Mexico from the north/northeast.
LOWER CRETACEOUS (?)	Zuni Sandstone, reworked (Kl)	Light-colored sandstone. Represents fluvial reworking of up to (30 ft) of the upper part of the Zuni Sandstone (**Jz**).	None reported.	*Paleontological Resources*—petrified wood may occur in the reworked zone.	Present at several locations in the region, notably in the southern part of El Morro National Monument and southward. The reworking involves redistribution of the eolian sand, oxidation, addition of some clay and chert grains and pebbles, and introduction of lenses of pebble conglomerate. Typical examples are found along the Mesa Top Trail.
MIDDLE JURASSIC	Zuni Sandstone (Jz)	Generally pale-yellowish-gray or tan sandstone; however, locally chalk white or pale greenish gray ("bleached zone"). Predominantly eolian and cross-bedded, but locally flat-bedded or massive. Very well-sorted, fine- to medium-sized, well-rounded grains, largely of quartz. Up to 6-m- (20-ft-) thick bed of conglomerate at base contains pebbles and cobbles with diameters up to 15 cm (6 in) of black, red, gray, and white chert and gray and brown quartzite. Total thickness ranges from 60 m (200 ft) in southeastern part of the El Morro quadrangle to as much as 110 m (350 ft) at El Morro Lookout; thickest in the northwest.	*Loss of Inscriptions*—inscriptions weathering away on friable Zuni Sandstone (**Jz**). *Rockfall*—vertical joints in the sandstone result in rockfall. Spalling of friable sandstone occurs in areas of groundwater sapping. *Tinaja Pit*—vibrations from blasting and hauling trucks on Highway 53 may exacerbate spalling of sandstone and loss of inscriptions.	*El Morro and Inscription Rock*—**Jz** makes up bulk of the El Morro cuesta and cliffs of Inscription Rock. *Box Canyon*—joints in **Jz** focus groundwater and result in sapping and box canyon development. *Tinajas*—occur in the topmost bleached zone and the iron-stained zone. *Eolian Features and Processes*—unit composed of 160-million-year-old sand dunes—the most conspicuous eolian feature in El Morro National Monument. Source of eolian sediment today. *Unconformities*—unconformities above and below **Jz**. In the El Morro area, at least 24 million years of the rock record are missing between **TRcr** and **Jz**, and at least 62 million years of the rock record are missing between **Jz** and **Kdm**. *Paleontological Resources*—fossils very rare.	Lowermost part (red sandstone and thin layers of red sandy mudstone) may be equivalent to the Entrada Sandstone (Anderson 1983). Deposited at the southern edge of a vast desert 160 million years ago.
UPPER TRIASSIC	Chinle Formation, Rock Point Member (TRcr)	Alternating red-brown, even-bedded, fine-grained, silty sandstone and chocolate-brown to red, thin-bedded, fine-grained sandstone that grades upward into a friable, well-sorted reddish-brown sandstone and chert-pebble conglomerate. *Note*: Mapel (1985) and Mapel and Yesberger (1985) mapped this unit as Rock Point Member of the Wingate Sandstone (TRwr), but the unit is now considered part of the Chinle Formation.	None reported.	*Unconformities*—at least 124 million years of the rock record are missing between **TRcr** and **Jz** in the El Morro area. *Paleontological Resources*—known to contain petrified wood elsewhere.	Deposited by rivers and streams in valleys and on broad plains. Easily eroded and underlies valleys in El Morro area. Some exposures on the flanks of the Zuni Mountains.
UPPER TRIASSIC	Upper part of Chinle Formation (TRcu)	Banded, grayish-red to pale-reddish-brown and grayish-purple mudstone, siltstone, and silty sandstone. Thickness about 30 m (100 ft).	None reported.	*Paleontological Resources*—known to contain petrified wood elsewhere.	Deposited by rivers and streams in valleys and on broad plains. Easily eroded and underlies valleys in El Morro area. Some exposures on the flanks of the Zuni Mountains.

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UPPER TRIASSIC	Chinle Formation, Sonsela Sandstone Member (TRcs)	Yellowish-gray to grayish-red, fine- to coarse-grained sandstone with granule to pebble conglomerate. Medium to thick cross-bed sets. Thin partings of purple-gray and red siltstone and mudstone. Maximum thickness 43 m (140 ft); appears to thin westward.	None reported.	*Paleontological Resources*—known to contain petrified wood elsewhere.	Deposited by rivers and streams in valleys and on broad plains. Easily eroded and underlies valleys in El Morro area. Some exposures on the flanks of the Zuni Mountains.
UPPER TRIASSIC	Chinle Formation, Lower Member (TRcl)	Grayish-red and reddish-brown sandstone interbedded with reddish-brown siltstone. Contains medium- to coarse-grained, arkosic, micaceous sandstone beds and lenses of pebble conglomerate. Both calcitic- and silicic-cemented facies present. Thickness 30–45 m (100–150 ft).	None reported.	*Unconformities*—at least 42 million years of the rock record are missing between **Psa** and **TRcl** in the El Morro area. *Paleontological Resources*—known to contain petrified wood elsewhere.	Deposited by rivers and streams in valleys and on broad plains. Easily eroded and underlies valleys in El Morro area. Some exposures on the flanks of the Zuni Mountains.
LOWER PERMIAN	San Andres Limestone (Psa)	Upper part is massive, pinkish-gray limestone. Middle part is yellowish-gray sandstone with calcitic cement, locally grading into sandy dolomitic limestone. Lower part is mostly yellowish-gray to gray, thick-bedded, fossiliferous, dolomitic limestone with thin calcareous shale partings and thin sandy limestone lenses. Lower part is generally the thickest of the three. Total thickness 35 to 45 m (115 to 145 ft).	*Tinaja Pit*—source of aggregate. Mined by C & E Concrete, Inc. east of El Morro National Monument.	*Unconformities*—at least 42 million years of the rock record are missing between **Psa** and **TRcl** in the El Morro area.	**Psa** caps the steep, southwest-facing mountain front that can be seen from El Morro. Uplifted during the Laramide Orogeny and exposed along the Zuni Mountain front. Deposited in Permian seas.
LOWER PERMIAN	Glorieta Sandstone (Pg)	Very pure, well-sorted, white to buff, medium- to coarse-grained quartz sandstone, massively cross-bedded. Weathers yellow to light brown. Well cemented with silica or calcite. Thickness approximately 45 m (150 ft).	None reported.	None reported.	Exposed in Zuni Mountains. Deposited in Permian seas.