Map Unit Properties Table: El Malpais National Monument

Gray-shaded rows indicate units not mapped within El Malpais National Monument. Italicized text corresponds to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
QUATERNARY (Holocene)	Eolian deposits (Qe)	Recent accumulations of windblown silt and sand. Forms sand sheets, dune fields, longitudinal dunes, and smaller deposits.	*Erosion*—**Qe** is highly susceptible to erosion. Issue in the Sandstone Bluffs Overlook area. *Disturbed Lands*—**Qe** is easily disturbed by grazing. Channel diversions cut through **Qe**.	*Eolian Features and Processes*—significant for landscape evolution. Amount of "dust infilling" in lava flows provides a means of determining relative ages of lava flows. *Biologic and Geologic Connections*—eolian habitat (e.g., sand dunes). Inhabited by pocket gophers (*Thomomys bottae* and *T. talpoides*). *Paleontological Resources*—**Qe** may yield Quaternary fossils.	Maxwell (1986) mapped only the most prominent accumulations. Occur mostly to the east of El Malpais National Monument, but also on lava flows within the national monument. Characteristic of drier Holocene climatic conditions.
QUATERNARY (Holocene and Pleistocene)	Alluvium (Qal)	Mostly fine-grained, stream-deposited silt and sand. A few local lenses contain coarse sand or pebbles. As much as 15 m (50 ft) exposed in recent gullies. Includes some eolian (**Qe**) and colluvial (**Qac**) deposits.	*Mass Wasting*—landslides (**Ql**) are usually older than **Qal** that covers valley floors. *Flooding*—flash flooding produces deep gullies in **Qal**, exhuming some landslide blocks (**Ql**).	*Lava Flows*—depending on age, lava flows may cover or be covered by **Qal**. For example, McCartys flow (**Qbm**) overlies older alluvium. **Qal** covers El Calderon flows (**Qbc**) near vent. *Paleontological Resources*—**Qal** may yield Quaternary fossils.	Much of the alluvium on the valley floor today spread across during the Pleistocene wet period, but alluvium also includes material deposited during present-day flooding.
	Terrace alluvium and gravel (Qtg)	Composed largely of pebbles, cobbles, and boulders of volcanic and Precambrian rocks in a matrix of silt and sand.	Unknown.	*Paleontological Resources*—**Qtg** may yield Quaternary fossils.	Terraces represent previous floodplains that were active during the Pleistocene Epoch. Indicates erosion and transport of exposed Precambrian rocks in the Zuni Mountains.
	Landslide deposits (Ql)	Composed mostly of rotational-block slides of Tertiary basalt and Cretaceous sandstone and shale that have slid over soft shale units. Includes some rock slides and mudflows, and talus and fan accumulations, some of which are derived from outcrops and others from landslide debris.	*Mass Wasting*—extensive landslide deposits east of El Malpais National Monument. *Flooding*—**Ql** blocks become exposed during flash floods.	None reported.	Landslide deposits are generally older than alluvium (**Qal**) and formed during Pleistocene wet period, which was followed by progressive changes in climate to present-day arid conditions.
	Alluvium, colluvium, and soil (Qac)	Soil and alluvium. Locally covered by recent alluvium (**Qal**) and eolian deposits (**Qe**).	*Seismic Activity*—disturbed by recent faulting in southern part of the map area.	*Lava Flows*—**Qac** covers old basalt flows (**Qb**). *Paleontological Resources*—**Qac** may yield Quaternary fossils.	Started accumulating during Pleistocene wet period, but still being deposited. May be as young as Holocene eolian deposits (**Qe**).
	Colluvium of McCartys Mesa (Qc)	Mantling deposits composed largely of colluvial soil, caliche, terrace sand and gravel, alluvium, and windblown sand. Includes local small outcrops of Mancos Shale and Twowells Tongue. **Note**: "**Qc**" is used as the map symbol for both colluvium of McCartys Mesa (Maxwell 1977) and cinder cones (Maxwell 1986).	Unknown.	None reported.	Started accumulating during Pleistocene wet period, but still being deposited. Initial deposition of this colluvium predates deposition of landslide deposits (**Ql**).
	McCartys flow and cinder cone (Qbm and Qcm)	Flows (**Qbm**) and cinder cone (**Qcm**) are composed of basalt that is generally unweathered, uneroded, and relatively barren of vegetation. Contains plagioclase and olivine phenocrysts. Plagioclase phenocrysts predominant within 4 km (2.5 mi) of the crater. Olivine phenocrysts predominant in remainder of the flow. **Note**: Maxwell (1977) mapped the McCartys flow using map symbol **Qbd** in the McCartys quadrangle.	*Cave Management*—contains lava-tube caves. *Flooding*—flooding causes erosion between the sandstone bluffs and the McCartys flow. *Disturbed Lands*—military used **Qbm** as a bombing range and **Qcm** as a target. *Seismic Activity*—surface faults mapped by Maxwell (1986) have not been field verified. *Geochronology, Research, and Interpretation*—dated using ^{14}C, ^{3}He, and ^{36}Cl methods. Currently under study. Ideal field-trip location.	*Volcanic Features*—flows (notable pahoehoe) exhibit inflation pits and mounds, grooved lava, squeeze-ups and squeeze-outs, aa lava, ropes, and spatter cones. *Eolian Features and Processes*—mostly clean, silt-free surface. *Biologic and Geologic Connections*—**Qbm** and **Qcm** are part of lava-flow habitat/"mesic island." **Qbm** hosts "Pygmy Forest" and provides lava-tube habitat. Sand habitats are best developed between **Qbm** and bases of sandstone bluffs. **Qbm** forms one side of Hole-in-the-Wall kipuka. *Sandstone Features*—black basalt of **Qbm** contrasts with light-colored sandstone (**Jz** and **Kdo**) at Sandstone Bluffs Overlook.	Part of El Malpais event. Approximately 3,900 years old. Flow originated at a small cinder cone (**Qcm**). Some lava flowed to the south. More flowed to the north, extending to Rio San Jose, and eastward along Interstate 40.

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Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
QUATERNARY (Holocene and Pleistocene)	Bandera flows, crater, and cinder field (Qbb, Qcb, and Qvb)	Rock of flows (**Qbb**) and crater (**Qcb**) is similar to that of the McCartys flow (**Qbm**). Ultramafic inclusions in final tephra eruptions. Fine cinders of cinder field (**Qvb**) surround north, east, and west sides of crater (**Qcb**), and cover sedimentary rocks and older basalt flows.	*Cave Management*—contains extensive lava-tube system and ice caves. *Flooding*—near agricultural source area of pollutants that enter lava-tube system during flash floods. *Disturbed Lands*—past mining produced highly visible cinder quarry. *Geochronology, Research, and Interpretation*—dated using ^{14}C, ^{3}He, ^{36}Cl, and Ar-Ar methods. U-series dating of gypsum crusts in lava tubes. Currently under study. Ideal field-trip location.	*Volcanic Features*—lava flows (notable aa), crater, and cinder field. Ideal example of breached cinder cone; symmetrical and distinctive. Flows host spatter cones. *Lava Tubes*—hosts longest lava-tube system in El Malpais National Monument, in the continental United States. Contains xenoliths. *Ice Caves*—ice caves in flows, including privately owned/commercially operated Ice Caves. *Biologic and Geologic Connections*—part of lava-flow habitat/"mesic island." Hosts mixed-conifer woodlands. Provides lava-tube cave habitat. Notable lichen cover. **Qbb** forms one side of Hole-in-the-Wall kipuka. *Paleontological Resources*—tree molds.	Part of El Malpais event. Approximately 11,000 years old. **Qbb** originated at Bandera Crater (**Qcb**) adjacent to Highway 53.
	Hoya de Cibola flows and shield volcano (Qbw and Qvw)	Basalt of **Qbw** and **Qvw** is similar to that of the McCartys flow (**Qbm**) but slightly higher in Al_2O_3 and alkalis, and lower in MgO.	*Cave Management*—lava-tube caves (e.g., Braided Cave). *Geochronology, Research, and Interpretation*—dated using Ar-Ar method, but results seem "too old." Exact (absolute) age still under consideration.	*Volcanic Features*—lava flows and shield volcano. *Biologic and Geologic Connections*—part of lava-flow habitat/"mesic island." Hosts mixed-conifer woodlands. Provides lava-tube cave habitat. **Qbw** forms one side of Hole-in-the-Wall kipuka.	Part of El Malpais event. Dunbar and Phillips (2004) used map symbol "**Qh**" for Hoya de Cibola flows, and "**Qbw**" for Bluewater flows west of Grants, which were not mapped by Maxwell (1986). Western flows originated from Hoya de Cibola crater and shield volcano (**Qvw**) in western part of El Malpais National Monument. Lava flowed south, east, and probably northeast.
	Paxton Springs flows, crater, and cinder field (Qbp, Qcp, and Qvp)	Flows (**Qbp**), crater (**Qcp**), and cinder field (**Qvp**) composed of vesicular basalt. Contains olivine phenocrysts. Consists of volcanic material from two separate eruptions; the only polygenetic cinder cone vent known from the Zuni–Bandera volcanic field.	*Geochronology, Research, and Interpretation*—dated using ^{36}Cl method. Separated into northern flow (20,700 years old) and southern flow (15,000 years old) by Dunbar and Phillips (2004).	*Volcanic Features*—lava flows, crater, and cinder field. Cinder field (**Qvp**) includes three small cinder cones.	Originated from a volcanic center in the Precambrian core of the Zuni Mountains and flowed 3 km (2 mi) down Agua Fria Creek, and 27 km (17 mi) northeast down Zuni Canyon to the area between Grants and San Rafael.
	Zuni flows (Qbz)	Basalt flows. **Note**: Maxwell (1977) mapped the oldest Zuni basalt flow (**Qba**) in the McCartys quadrangle.	*Geochronology*—exact age unknown.	*Volcanic Features*—lava flows.	Lava flows from Zuni Mountains, north of El Malpais National Monument. Originated from volcanic centers about 1.7 km (1 mi) north of boundary.
	Oso Ridge flows and lava cone (Qbo and Qvo)	Basalt flows (**Qbo**) from Oso Ridge (northwest of Bandera Crater). Lava cone (**Qvo**) composed largely of breccia, welded pyroclastic debris, and glassy flows.	*Geochronology*—exact age unknown.	*Volcanic Features*—lava flows and cone.	Lava flows in the Zuni Mountains, north of El Malpais National Monument. Originated from a lava cone (**Qvo**) on Oso Ridge. Basalt flows (**Qbo**) extended eastward to Agua Fria Creek and southward almost to Malpais flows. Overlain by the Paxton Springs flows (**Qcb**).
	Twin Craters flows, cones, and mixed pyroclastics (Qbt, Qct, and Qvt)	Basalt flows (**Qbt**) from Twin Craters cinder cones (**Qct**). Mixed pyroclastics (**Qvt**) surround the cinder cones (**Qct**) and partially bury sedimentary rocks in the area. Flows (**Qbt**) originated from complex of cinder cones (**Qct**), which extends in northeast-trending line with Twin Craters at the approximate center of the line, Lost Woman center to southwest, and La Tetra center to northeast.	*Geochronology, Research, and Interpretation*—consists of several overlapping flows from different vents, which made them difficult to delineate for early investigators, including Maxwell (1986). Recently dated using ^{14}C, ^{3}He, and ^{36}Cl methods.	*Volcanic Features*—lava flows, cones, and mixed pyroclastics. *Biologic and Geologic Connections*—part of lava-flow habitat/"mesic island." Hosts mixed-conifer woodlands. Provides lava-tube cave habitat.	Part of El Malpais event. Approximately 18,000 years old. Includes many prominent El Malpais features such as Twin Craters, Lost Woman, La Tetra, Lava Crater, and Cerro Candelaria. Includes most flows under or adjacent to Highway 53.

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Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
QUATERNARY (Holocene and Pleistocene)	El Calderon flows, crater, and cinder field (Qbc, Qcc, and Qvc)	El Calderon crater (**Qcc**), cinder field (**Qvc**), and flows (**Qbc**) are composed of coarse-grained, porous basalt. **Qbc** largely covered by alluvium (**Qal**) or younger flows near source. Some rocks included with the old basalt flows (**Qb**), notably Cerro Bandera and Cerro Rendija, are similar and may correlate with El Calderon.	*Cave Management*—trail to El Calderon Bat Cave is prime location for observing bat flights. *Disturbed Lands*—abandoned cinder quarry on the side of El Calderon crater (**Qcc**). *Geochronology, Research, and Interpretation*—flows dated using ^{36}Cl and K-Ar methods.	*Volcanic Features*—lava flows, crater, and cinder field. *Eolian Features and Processes*—El Calderon flows noticeably infilled with loess. *Biologic and Geologic Connections*—part of lava-flow habitat/"mesic island." Hosts mixed-conifer woodlands. Provides lava-tube cave habitat.	Represents first eruption of El Malpais episode of Zuni–Bandera volcanic field. Less than 60,000 years old. Flows (**Qbc**) originated from El Calderon crater (**Qcc**) below and northeast of Cerritos de Jaspe.
	Basalt flows (Qbu), cinder cones (Qc), and volcanic debris (Qv)	Basalt flows, cinder cones, and volcanic debris west of El Malpais National Monument. Maxwell (1986) found these flows, cones, and volcanic debris to be stratigraphically related. **Qv** composed largely of weathered lava covered with coarse lava blocks and scoria. **Note**: "**Qc**" is used as the map symbol for both colluvium of McCartys Mesa (Maxwell 1977) and cinder cones (Maxwell 1986).	*Disturbed Lands*—cinders difficult to restore. *Geochronology, Research, and Interpretation*—currently under study.	*Volcanic Features*—lava flows, cinder cones, and volcanic debris (lava, lava blocks, and scoria).	Represent second episode of volcanism in Zuni–Bandera volcanic field. Approximately 150,000 years old. West of El Malpais flows. Represented by Chain of Craters area. Volcanic debris associated with cinder cones and with a few older flows.
	Old basalt flows (Qb)	Deeply weathered. Largely covered with soil and alluvium (**Qac**).	None reported.	*Biologic and Geologic Connections*—underlie many kipukas (e.g., Hole-in-the-Wall). Deeply weathered and covered by **Qac**. Produce open grasslands with small outcrops of basalt.	Represent first episode of volcanism in Zuni–Bandera volcanic field. Approximately 700,000 years old. Cover much of western half of map area. Same as flows at nearby El Morro National Monument.
TERTIARY (Pliocene)	Basalt flows on Cebollita Mesa, Mesa Negra, and Horace Mesa (Tb)	Generally aphanitic and vesicular olivine basalt and associated scoria. Flows generally 20–30 m (65–100 ft) thick, 100 m (300 ft) or more near smaller centers of eruption, and 300 m (1,000 ft) or more at Cebollita Peak. **Note**: Maxwell (1977) mapped basalt on Horace Mesa as **Tb** in the McCartys quadrangle.	*Mass Wasting*—part of rotational slide (**Ql**).	*Volcanic Features*—lava flows cap mesas seen from El Malpais National Monument. *Biologic and Geologic Connections*—largely covered with soil, alluvium, and pine trees.	Part of Mount Taylor volcanic field, and not related to Zuni–Bandera activity. About 3.73 million to 1.57 million years old. East of El Malpais National Monument.
	Diabase dikes (Td)	Very fine-grained diabase with grains of plagioclase, augite, magnetite, and apatite. Contacts with the enclosing rock are generally marked by a thin aphanitic chill border in the dike and a hardened or silicified zone in the enclosing sandstone or shale. Range in thickness from a few decimeters to slightly more than 6 m (20 ft).	Unknown.	*Volcanic Features*—igneous rock intruded "middle-aged rocks" such as Gallup Sandstone and Mancos Shale.	Intruded at the time of Mount Taylor volcanism.
UPPER CRETACEOUS	Crevasse Canyon Formation (Kcc)	Comprises an 80–100-m- (260–330-ft-) thick sequence of nonmarine sandstone, siltstone, carbonaceous shale, and coal beds. Members are (from youngest to oldest) Gibson Coal Member, Dalton Sandstone Member, and Dilco Coal Member. **Note**: Maxwell (1977) mapped the Gibson Coal Member (**Kcg**), Dalton Sandstone Member (**Kcd**), Stray Sandstone Member (**Kcs**), and Dilco Coal Member (**Kcdi**) in the McCartys quadrangle.	*Disturbed Lands*—coal present, but not an abandoned mineral land (AML) issue.	None reported.	Marine setting. Records retreat and advance of Western Interior Seaway.
	Gallup Sandstone (Kg)	Composed of an upper sandstone member, a middle silty shale unit, and a lower silty unit. Total thickness 80–100 m (260–330 ft). **Note**: Maxwell (1977) mapped the upper tongue (**Kgu**) and lower tongue (**Kgl**), as well as a main body (**Kgm**), in the McCartys quadrangle.	*Disturbed Lands*—lower silty unit contains coaly lenses, but not an AML issue.	None reported.	Marine and sandy beach settings. Records an entire transgression–regression cycle of Western Interior Seaway. Recorded regression is unique to New Mexico and adjacent northeastern Arizona.
	Mancos Shale, D-Cross Tongue (Kmd)	Light- to dark-gray shale containing local lenses and concretionary zones of sandy fossiliferous limestone, and thin-bedded sandstone in southeastern part of map area. Outcrops are sparse and generally confined to small areas under cliffs with overlying sandstones.	*Mass Wasting*—weathers to steep, soft slopes almost entirely covered by landslides, talus, or colluvium.	*Paleontological Resources*—marine invertebrates.	Marine setting. Records advance and subsequent retreat of Western Interior Seaway.

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Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
UPPER CRETACEOUS	Tres Hermanos Sandstone (Kth)	Composed of three units—sandstone at top, highly variable middle unit (see description below), and light-yellowish-gray sandstone at base. Middle unit around Mesa Negra is similar to the D-Cross (**Kmd**) or Rio Salado (**Kmr**) tongues, but grades southward to interbedded carbonaceous shale and sandstone containing lenticular coal beds. Locally grades into predominantly thin-bedded shaley sandstone and siltstone. In southern part of map area, grades into dark-gray, fossiliferous shale and light-gray and brown, thin-bedded, calcareous sandstone.	*Disturbed Lands*—coal present, but not an AML issue.	*Paleontological Resources*—shells.	Open-marine, shoreline, fluvial and marsh, barrier-island, coastal-plain, and delta-plain settings. Records mostly retreat of the Western Interior Seaway, with upper part showing advance along with overlying D-Cross Tongue (**Kmd**).
UPPER CRETACEOUS	Mancos Shale, Rio Salado Tongue (Kmr)	Light- to dark-gray friable shale and silty shale containing local lenses of calcareous, siliceous, and sandy siltstone, and fine-grained sandstone in upper part. Thickness 70–90 m (230–300 ft). **Note**: Maxwell (1977) mapped the Mulatto Tongue (**Kmm**); main body (**Km**); Whitewater Arroyo and Clay Mesa Shale Tongues, undivided (**Kmwc**); and Clay Mesa Shale (**Kcdi**) in the McCartys quadrangle.	*Mass Wasting*—friable. Weathers to steep, soft slopes almost entirely covered by landslides, talus, or colluvium.	None reported.	Marine setting. Records retreat of Western Interior Seaway.
UPPER CRETACEOUS	Twowells Tongue of Dakota Sandstone (Kdt)	Fine- to very fine-grained, silty, local, thin lenses of medium- to coarse-grained sandstone. Light gray, weathers to grayish orange, light brown and tan. Thin to medium bedded. Resistant, slabby beds at top grade downward to silty sandstone containing thin interbeds of siltstone. Thickness 1–25 m (3–80 ft).	*Mass Wasting*—resistant beds at top. *Disturbed Lands*—provided material in old sandstone quarry in Lava Falls area, which has been restored.	*Paleontological Resources*—uppermost part and overlying shale contain the extinct oyster (*Pycnodonte newberryi* Stanton). Also contains trace fossils, including many imprints, burrows, trails, and disturbed bedding.	Nearshore and marine settings. Records minor retreat of Western Interior Seaway within an overall advance, or perhaps a stillstand of shoreline.
UPPER CRETACEOUS	Mancos Shale, Whitewater Arroyo Tongue (Kmw)	Dark-gray shale, weathers to light gray and grayish tan. Uppermost part is silty shale and siltstone that is transitional into Twowells Tongue (**Kdt**).	*Mass Wasting*—weathers to steep, soft slopes almost entirely covered by landslides, talus, or colluvium.	None reported.	Marine and nearshore settings. Records retreat of Western Interior Seaway.
UPPER CRETACEOUS	Paguate Tongue of Dakota Sandstone (Kdp)	Light-brown and tan, fine- to very fine-grained sandstone. Local lenses medium to coarse grained, thin to medium bedded. Thickness 10–30 m (30–100 ft).	*Mass Wasting*—forms prominent cliffs along northeast side of El Malpais National Monument.	*Paleontological Resources*—potential for fossils such as marine invertebrates and trace fossils (burrows and bioturbation).	Nearshore and marine settings. Records minor retreat of Western Interior Seaway within an overall advance, or perhaps a stillstand of shoreline.
UPPER CRETACEOUS	Clay Mesa Tongue of Mancos Shale and lower part of Dakota Sandstone (Kdo)	Includes, from top to bottom, the Clay Mesa Tongue of Mancos Shale (dark-gray, fissile shale), Cubero Tongue of Dakota Sandstone (similar lithology to Twowells Tongue, **Kdt**), the Oak Canyon Member (calcareous or carbonaceous sandstone and siltstone), and a basal sandstone and conglomerate unit of Dakota Sandstone. Total thickness 30–70 m (90–200 ft). **Note**: Maxwell (1977) mapped the Cubero Sandstone Tongue (**Kdc**), Oak Canyon Member (**Kdo**), and basal sandstone unit of the Oak Canyon Member (**Kds**) in the McCartys quadrangle. "**Kdo**" is used as the map symbol for both the Oak Canyon Member of Dakota Sandstone (Maxwell 1977) and Clay Mesa Tongue of Mancos Shale and lower part of Dakota Sandstone (Maxwell 1986).	*Mass Wasting*—Clay Mesa Tongue is fissile and weathers to steep, soft slopes almost entirely covered by landslides, talus, or colluvium. *Erosion*—erosion of overlying eolian sediments (**Qe**) to **Kdo** of Maxwell (1986) in Sandstone Bluffs Overlook area. *Disturbed Lands*—provided material in old sandstone quarry in Lava Falls area, which has been restored. Carbonaceous material (coal) present, but not an AML issue.	*Paleontological Resources*—potential for fossils in Clay Mesa Tongue. Oak Canyon Member has fossils (marine invertebrates) in limestone lenses within El Malpais National Monument. Basal sandstone unit has trace fossils (trails and burrows).	Records first advance (transgression) of Western Interior Seaway into New Mexico. Mancos Shale—shallow marine setting. Dakota Sandstone—nearshore and marine settings. Also, swamps and rivers adjacent to seaway.
UPPER JURASSIC	Morrison Formation (Jm)	Grayish-green mudstone and siltstone and lenticular yellowish- and reddish-gray fine- to medium-grained sandstone. Lenticular, pale-brown to white, cross-bedded pebble conglomerate and sandstone at base. Pinches out about 5 km (3 mi) south of Interstate 40. Thickness up to 30 m (100 ft).	None reported.	*Paleontological Resources*—known for dinosaur bones in places such as Dinosaur National Monument (Utah and Colorado).	Fluvial setting.
MIDDLE JURASSIC	Zuni Sandstone and Wanakah Formation (Jz)	Zuni Sandstone: variably colored, generally yellowish-gray or tan, locally chalk white, fine- to medium-grained sandstone. Well-rounded grains largely of quartz. Conspicuous bleached zone at tip of unit. Wanakah Formation: white to pale-brown, thin- to medium-bedded, very fine-grained, silty sandstone interbedded with thin, dark-brown mudstone and claystone. Grades into thin-bedded, fluviatile sandstone at base of Zuni Sandstone. Combined thickness 110–180 m (360–600 ft).	*Erosion*—friable sandstone.	*Eolian Features and Processes*—160-million-year-old sand dunes with very well-sorted, large-scale eolian cross-beds. Source of eolian sediment today.	Eolian setting. Conspicuous bleached zone is remarkable at nearby El Morro National Monument.

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MIDDLE JURASSIC	Todilto Limestone Member of Wanakah Formation (Jt)	Composed of 3–12 m (10–40 ft) of pale-olive-gray, pale-olive-brown, and pale-yellow limestone. Thickly bedded, coarsely crystalline in top part. Crinkly bedded in middle part. Platy bedded at base.	*Disturbed Lands*—contains uranium.	*Paleontological Resources*—potential for dinosaur tracks, algal structures, fish scales, ostracodes, and worm burrows.	Deposited in a restricted marine embayment with an ephemeral connection to the sea.
	Entrada Sandstone (Je)	Reddish-orange to reddish-brown, fine- to medium-grained, eolian, cross-bedded, silty sandstone.	None reported.	*Eolian Features and Processes*—ancient sand dunes. *Paleontological Resources*—potential for trace fossils.	Eolian setting. **Jz** and **Je** stratigraphically correlated at nearby El Morro National Monument. Makes up arches in Arches National Park in Utah.
TRIASSIC	Chinle (Upper Triassic) and Moenkopi(?) (Middle and Lower Triassic) formations (TRcm)	Chinle Formation is 360–460 m (1,180–1,500 ft) thick in the region but only lowermost part, which is predominantly reddish-brown claystone and siltstone, is exposed in map area. Basal part of map unit is tentatively correlated with the Moenkopi Formation, which is composed of pale-reddish-brown and grayish-red sandstone interbedded with pebble conglomerate and reddish-brown, lenticular siltstone and mudstone. Thickness up to 15 m (50 ft).	None reported.	*Paleontological Resources*—Chinle Formation is known for petrified wood and other fossils outside of El Malpais National Monument, such as at Petrified Forest National Park in Arizona.	Terrestrial (fluvial) setting.
PERMIAN (Cisuralian or Early)	San Andres Limestone (Psa)	Mostly gray to yellow, thick-bedded, fossiliferous dolomitic limestone with thin, calcareous, shale partings and thin, sandy limestone lenses. A yellowish-gray sandstone bed about 6 m (20 ft) thick locally present in lower part. Total thickness 35–44 m (115–145 ft).	*Mass Wasting*—forms cliffs or persistent dip slopes.	*Paleontological Resources*—marine invertebrates in dolomitic limestone.	Marine setting. Deposited in Permian seas.
	Glorieta Sandstone (Pg)	White to buff, very pure, well-sorted, medium-grained, cross-bedded quartz sandstone and siltstone. Weathers yellow to light brown. Well cemented with silica or calcite. Thickness 45–50 m (150–165 ft).	*Mass Wasting*—forms cliffs, ridges, or dip slopes.	*Paleontological Resources*—potential for plant debris and trace fossils.	Marginal marine setting. Widespread beach deposits crossed by meandering streams.
	Yeso Formation (Py)	Pale-reddish-brown, medium- to fine-grained, thick- to thin-bedded, locally cross-bedded sandstone and siltstone. Grades upward into pink, white, and yellow alternating layers of friable sandstone. Three dense, fine-grained, light- to medium-gray limestone beds 3–4 m (10–13 ft) thick are present in upper part of formation. Locally overlain by 4–5 m (13–16 ft) of white to light-gray, poorly exposed gypsum beds. Total thickness about 400 m (1,300 ft).	*Mass Wasting*—friable sandstone.	*Lava Tubes*—**Py** may be a source of gypsum in cave minerals. *Paleontological Resources*—potential for marine invertebrates and trace fossils.	Coastal sabkha. Records transition from continental to marine conditions.
	Abo Formation (Pa)	Moderate-brick-red to dusky-red, medium- to fine-grained sandstone and siltstone. Locally cross bedded. At base is 1–3 m (3–10 ft) of arkosic conglomerate containing white quartz pebbles, overlain by about 10 m (30 ft) of dusky-red arkose containing thin, medium-gray, limestone beds. Thickness about 400 m (1,300 ft).	*Mass Wasting*—forms cliffs and steep slopes.	*Paleontological Resources*—potential for trace fossils, marine and terrestrial invertebrate fossils, and vertebrate fossils.	Thick wedge of terrestrial/continental material. Fluvial setting. Deposited on an eroded, undulating surface of Precambrian rocks.
PRECAMBRIAN	Hornblendite, gabbro, and intrusive basalt (PChb)	Hornblendite, gabbro, and intrusive basalt (dikes and small irregular bodies).	None reported.	*Lava Tubes*—**PChb** gabbro is a source of xenoliths in lava tubes and flows.	Records subsequent intrusion into sutured terranes of volcanic arc and oceanic crust. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Porphyritic aplite (PCpa)	Moderate-orange-pink, slightly gneissic, porphyritic aplite composed of scattered microcline phenocrysts in medium-grained groundmass of quartz, orthoclase, and minor biotite. Occurs as stocks and dikes that intrude gneissic granite (**PCgg**) and gneissic aplite (**PCap**).	None reported.	None reported.	Records subsequent intrusion into sutured terranes of volcanic arc and oceanic crust. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Gneissic aplite (PCap)	Grayish- to moderate-orange-pink, sugary, well-foliated aplite. Consists of microcline, quartz, and some orthoclase and oligoclase. Contains minor amounts of muscovite and biotite. Occurs as irregular masses and dikes intruding or locally gradational into gneissic granite (**PCgg**).	None reported.	None reported.	Records subsequent intrusion into sutured terranes of volcanic arc and oceanic crust. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.

Gray-shaded rows indicate units not mapped within El Malpais National Monument. Italicized text corresponds to report sections.

Age	Map Unit (Symbol)	Geologic Description	Geologic Issues	Geologic Features and Processes	Geologic History
PRECAMBRIAN	Porphyritic granite (PCpg)	Light-brownish-gray, porphyritic granite. Large, white orthoclase and small bluish quartz phenocrysts in fine-grained groundmass of quartz, orthoclase, hornblende, and biotite; slightly gneissic. Occurs as dikes that intrude gneissic granite (**PCgg**).	*Disturbed Lands*—**PCpg** contains veins of fluorite that were mined during World War II.	*Lava Tubes*—**PCpg** is a source of xenoliths in lava tubes and flows.	Records subsequent intrusion into sutured terranes of volcanic arc and oceanic crust. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Aplitic granite (PCag)	Grayish to pink, gneissic, fine to medium grained, composed of potassium feldspar, quartz, and small amounts of oligoclase, biotite, and muscovite. Gradational with gneissic granite (**PCgg**).	*Disturbed Lands*—**PCag** contains veins of fluorite that were mined during World War II.	*Lava Tubes*—**PCag** is a source of xenoliths in lava tubes and flows.	Records accretion of terranes to older craton. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Gneissic granite (PCgg)	Pinkish- to medium-gray, fine- to coarse-grained, locally porphyritic, gneissic granite composed of orthoclase, quartz oligoclase, and abundant hornblende and biotite.	*Disturbed Lands*—**PCgg** contains veins of fluorite that were minded during World War II. Contains fluorite vein within El Malpais National Monument.	*Lava Tubes*—**PCgg** is a source of xenoliths in lava tubes and flows.	Records accretion of terranes to older craton. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Quartz monzonite gneiss (PCmg)	Medium to dark gray, medium grained, strongly gneissic, slightly banded. Composed of oligoclase, biotite, quartz, and some orthoclase. Occurs as xenolithic masses in gneissic granite (**PCgg**).	*Disturbed Lands*—**PCmg** contains veins of fluorite that were mined during World War II.	None reported.	Records accretion of terranes to older craton. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Quartzite (PCqt)	Brown, fine to medium grained, locally contains phyllite beds.	None reported.	None reported.	Records accretion of terranes to older craton. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Hornblende gneiss (PChg)	Dark-green gneiss. Contains lenses of gneissic gabbro and layers of aplite.	*Disturbed Lands*—**PChg** contains veins of fluorite that were mined during World War II.	None reported.	Records accretion of terranes to older craton. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Injection gneiss (PCig)	Quartz biotite gneiss.	*Disturbed Lands*—**PCig** contains veins of fluorite that were mined during World War II.	None reported.	Records accretion of terranes to older craton. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.
	Biotite schist (PCsc)	Biotite schist.	None reported.	None reported.	Records accretion of terranes to older craton. Uplifted and exposed in Zuni Mountains during Laramide Orogeny.