Map Unit Properties Table: Pecos National Historical Park

Colored map units indicate those mapped within Pecos National Historical Park. Bold text corresponds to headings in the Geologic Features and Processes, Geologic Resource Management Issues, and Geologic History sections of the report.

Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Resource Management Issues	Geologic History
QUATERNARY (Holocene)	Artificial fill (**Qaf**)	Anthropogenic deposits of rock, soil, gravel or other material to fill depressions, open space, or construct dams. Mapped at El Molino Mills Site and dams.	**Geologic Resources in a Cultural Context**—El Molino Mills Site processed ore from Pecos Mine.	None documented.	**The past 66 million years: Mountain Building, Erosion, and Emergence of the Modern Landscape**—artificial fill was placed over the El Molino Mills Site and used to create dams in the tailings ponds.
QUATERNARY (Holocene)	Alluvium (**Qa**)	Unconsolidated valley fill sediments in active perennial and ephemeral stream channels and on floodplains. Composed of clay, silt, sand, and gravel. Grades into minor colluvial and alluvial fans at valley margins. Thickness 08 m (0–25 ft). Mapped in all units of the park.	**Fluvial Features**—**Qa** represents modern stream deposits in channels and on floodplains.	**Fluvial Erosion**—accelerated erosion in the Pecos River and Glorieta Creek affects these deposits. **Slope Movement Hazards and Risks**—slumping occurs along river corridors.	**The past 66 million years: Mountain Building, Erosion, and Emergence of the Modern Landscape**—the Laramide orogeny raised the Rocky Mountains, including the Sangre de Cristo Mountains. Weathering and erosion carried silt, sand, and gravel down from the high mountains to the Pecos valley. **Qa** represents recent deposits along the banks and in the floodplains of the Pecos River and Glorieta Creek.
QUATERNARY	Colluvium (**Qc**)	Locally derived talus from nearby cliffs. Commonly occurs as a veneer of variable thickness, 0–9 m (0–30 ft), on slope-forming bedrock. Mapped in all units of the park.	**Slope Movements**—**Qc** consists of talus deposits.	**Slope Movement Hazards and Risks**—slope movements may occur.	**The past 66 million years: Mountain Building, Erosion, and Emergence of the Modern Landscape**—the Laramide orogeny raised the Rocky Mountains, including the Sangre de Cristo Mountains. Weathering and erosion carried silt, sand, and gravel down from the high mountains to the Pecos Valley.
QUATERNARY	Colluvium and alluvium (**Qca**)	Intermixed, unconsolidated colluvial and alluvial deposits. Locally contains well-developed soils. Thickness 0–6 m (0–20 ft).	**Fluvial Features**—**Qca** represents modern stream deposits mixed with colluvium. **Slope Movements**—**Qca** formed as a result of hillslope processes.	**Slope Movement Hazards and Risks**—slumping occurs along river corridors.	
QUATERNARY	Valley fill (**Qvf**)	Unconsolidated to consolidated, fine-grained valley fills composed of clay, silt, and sand along the margins of active stream channels and in areas of low relief or where runoff is not channelized. **Qvf** may form terraces when incised by modern arroyos. Thickness 0–12 m (0–40 ft). Mapped in the Pecos Unit and the Pigeon's Ranch Subunit.	**Fluvial Features**—**Qvf** represents modern stream deposits.	**Fluvial Erosion**—accelerated erosion in the Pecos River and Glorieta Creek affects these deposits.	
QUATERNARY	Landslide deposits (**Ql**)	Large sandstone blocks.	**Slope Movements**—**Ql** consists of predominantly rockfall deposits that are downslope from sandstone cliffs of the Santa Rosa Formation.	None reported.	**The past 66 million years: Mountain Building, Erosion, and Emergence of the Modern Landscape**—weathering and erosion of the cliff-forming Santa Rosa Formation produced these rockfall deposits.
QUATERNARY	Terrace deposits (**Qt**)	Undivided, gravel-capped terrace deposits along the Pecos River and Glorieta Creek. Thickness 0–80 m (0–260 ft). Mapped in all units of the park.	**Fluvial Features**—**Qt** marks the position of past stream channels. **Geologic Resources in a Cultural Context**—Pueblo Indians used much older (Paleozoic Era) cobbles from this unit to build the stone walls of Pecos Pueblo.	**Fluvial Erosion**—accelerated erosion in the Pecos River and Glorieta Creek affects these deposits. **Slope Movement Hazards and Risks**—slumping occurs along river corridors.	**The past 66 million years: Mountain Building, Erosion, and Emergence of the Modern Landscape**—the Laramide orogeny raised the Rocky Mountains, including the Sangre de Cristo Mountains. Weathering and erosion carried silt, sand, and gravel down from the high mountains to the Pecos Valley. These are recent deposits along terraces of the Pecos River and Glorieta Creek.

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Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Resource Management Issues	Geologic History
QUATERNARY-TERTIARY	Gravel deposits, younger (**QTg**)	Gravel and cobble deposits composed of rounded Paleozoic and Proterozoic clasts. Thickness 0–9 m (0–30 ft). Mapped in Pecos Unit.	**Geologic Resources in a Cultural Context**—Pueblo Indians used Paleozoic cobbles from this unit to build the stone walls of Pecos Pueblo. Around 1965–1975, gravel was extracted from this unit for use as aggregate in interstate construction.	None reported.	**The past 66 million years: Mountain Building, Erosion, and Emergence of the Modern Landscape**—the Laramide orogeny raised the Rocky Mountains, including the Sangre de Cristo Mountains. Weathering and erosion carried silt, sand, and gravel down from the high mountains to the Pecos Valley. **QTg** deposited prior to the establishment of the incised modern Pecos River and Glorieta Creek.
QUATERNARY-TERTIARY	Ancha Formation (**QTa**)	**QTa** represents the uppermost basin fill unit in the Santa Fe embayment. Light-tan to pink and orange, thick-bedded silt, arkosic sand, and gravel. Mostly non-cemented and weakly consolidated. Sediments are composed of Proterozoic granite, granite gneiss, and amphibolite gneiss derived from the southwestern flank of the Sangre de Cristo Mountains.	Not mapped in Pecos National Historical Park. West of the park, in the Santa Fe embayment, the Ancha Formation constitutes an important hydrogeologic unit relied upon for groundwater by many local communities.		**The past 66 million years: Mountain Building, Erosion, and Emergence of the Modern Landscape**—the Laramide orogeny raised the Rocky Mountains, including the Sangre de Cristo Mountains. Weathering and erosion carried silt, sand, and gravel down from the high mountains to the Pecos Valley.
TERTIARY	Galisteo Formation (**Tg**)	Tan to white cross bedded massive sandstone interbedded with pink to red siltstone and mudstone. Contains conglomerate lenses. Limestone beds present in the lower portion of unit.	**Paleontological Resources**—**Tg** contains silicified logs up to 1 m (4 ft) in diameter and 9 m (30 ft) in length.		
TERTIARY	Gravel deposits, older (**Tgv**)	Fine- to coarse-grained deposits dominated by rounded Proterozoic boulder and cobble gravel with fewer Paleozoic clasts. Deposits are typically poorly exposed, but cobbles and boulders form highs in the landscape, up to 460 m (1,500 ft) above the modern Pecos River, and colluvium mantles hillsides. Thickness 0–37 m (0–120 ft).	None reported.		
TERTIARY	Tesuque Formation (**Tt**)	Tan, pinkish-tan, and orange, thick-bedded, coarse-grained, arkosic sandstone and some interbedded siltstone and pebble to boulder conglomerate. Moderately well cemented by calcium carbonate. Contains clasts of granite, granite gneiss, amphibolite gneiss, and the Madera Formation limestone.			

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TRIASSIC	Chinle Group, undivided (**TRc**)*	Reddish-brown mudstone interbedded with lavender-gray sandstone. Contains pebble conglomerate lenses. *Nomenclature of the "Chinle Group" has changed over time. This report follows the "Chinle Group" nomenclature as per the source maps published in 1997 and 2002. More recently, the US Geological Survey and some state surveys prefer the "Chinle Formation" nomenclature. Refer to the US Geological Survey GEOLEX for additional information (http://ngmdb.usgs.gov/Geolex/Units/Chinle_4997.html, accessed 9 April 2015). Mapped in the Cañoncito Subunit.	**Glorieta Mesa**—TRc is mapped on the western flank of Glorieta Mesa, in Galisteo Creek valley. **Faults**—only mapped west of the Glorieta Mesa fault zone. **Paleontological Resources**—fossils may be present within **TRc**.	**Paleontological Resource Inventory, Monitoring, and Protection**—a field-based survey could help determine presence of fossils in this formation in Pecos National Historical Park.	**252 million–66 million years ago: Sedimentary Basins**—seas advanced over the land, eroding material from the underlying formations and depositing it just offshore in shallow water.
	Santa Rosa Formation (**TRs**)	Brown sandstone alternating with red shale. Mapped in the Cañoncito Subunit.	**Glorieta Mesa**—Santa Rosa Formation is the youngest formation on the mesa. Caps the mesa, including the highest point, Cerro de Escobas. Erosion has removed much of this formation, leaving about 15 m (50 ft). In other places in New Mexico, the formation is as much as 140 m (450 ft) thick. **Paleontological Resources**—fossil wood is common in the lower member of the formation. In the north and east sections of the formation contains petrified wood, which may have eroded from **TRsl**.	**Slope Movement Hazards and Risks**—this formation has produced rockfalls in the past. Rockfalls are mapped as landslide deposits (**Ql**). **Paleontological Resource Inventory, Monitoring, and Protection**—a field-based survey could determine the source of the petrified wood and the presence of additional fossils in this formation. **Land Subsidence**—dissolution of the underlying San Andres Formation has caused this formation to collapse in locations outside Pecos National Historical Park.	
	Santa Rosa Formation, upper member (**TRsu**)	Buff to dark brown, thick-bedded, fine-grained sandstone with limestone and chert-pebble conglomerates near base. Cross-bedding is uncommon. Thickness 18–25 m (60–80 ft). Mapped in the Cañoncito Subunit.			
	Santa Rosa Formation, middle member (**TRsm**)	Purple and green mudstone with nodular limestone, gray to buff, thinly laminated siltstone, and brown to buff, thick-bedded, fine- to medium-grained sandstone. Thickness generally 30–40 m (100–130 ft). Mapped in the Cañoncito Subunit.			
	Santa Rosa Formation, lower member (**TRsl**)	Light gray to buff, thick-bedded, fine- to coarse-grained, cross-bedded sandstone with conspicuous iron oxide staining. Limestone- and chert-pebble conglomerates present in most places, particularly along the southwestern edge of the quadrangle. Thickness 30–40 m (90–120 ft). Mapped in the Cañoncito Subunit.			
	Moenkopi Formation (**TRm**)	Grayish red to purplish-red sandstones, conglomerates, mudstones, and siltstones. Lacks gypsum. Sandstones are micaceous lithic arenites or lithic graywackes. Sandstones are moderately to poorly sorted, subangular to angular, and fine to coarse grained. Sandstones and conglomerates are generally trough cross-bedded and lenticular. Contact with underlying Artesia Formation is disconformable. Thickness is up to 2,500 m (8,300 ft). Mapped in the Cañoncito Subunit.	**Glorieta Mesa**—**TRm** is mostly covered by vegetation and talus. **Paleontological Resources**—no fossils documented from **TRm** in Pecos National Historical Park. Calcareous microfossils are in lacustrine and fluvial sediments of this unit in the Lucero Mesa area of Cibola County, New Mexico. Other **TRm** fossils include vertebrate bones and coprolites, footprints, charophytes, and ostracods.	**Paleontological Resource Inventory, Monitoring, and Protection**—a field-based survey could help determine presence of fossils in this formation in Pecos National Historical Park.	**252 million–66 million years ago: Sedimentary Basins**—**TRm** consists of sands deposited by rivers and in lakes.
PERMIAN	Artesia Formation (**Pa**)	Orange to brick-red sandstones, siltstones, and gypsum. Sandstones and siltstones are quartzarenites and usually gypsiferous. Sandstones are well sorted, subrounded to subangular, and very fine to fine grained. Sandstones are ripple laminated. Cross-bedding is rare. Mottled greenish-white reduction spots are common. Thickness 10–20 m (32–65 ft). Mapped in the Cañoncito Subunit.	**Glorieta Mesa**—**Pa** is mostly covered by vegetation and talus. **Paleontological Resources—**bioturbated beds are evidence of animal activity in the past. **Geologic Resources in a Cultural Context**—selenite used in window panes of mission churches may have come from an exposure of this formation southwest of the Canoñcito Subunit.	**Paleontological Resource Inventory, Monitoring, and Protection**—a field-based survey could help determine extent or significance of fossils in this formation in Pecos National Historical Park.	**542 million–252 million years ago: Rise and Fall of the Ancestral Rocky Mountains**—sea level dropped, waves eroded the San Andres Formation and deposited the eroded material as the Artesia Formation. The Ancestral Rocky Mountains were largely worn down by this time.

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PERMIAN	San Andres Formation (**Psa**)	Buff to light gray, thin-bedded, dense, silty limestone and interbedded calcareous sandstone. Reddish-orange chert or white aragonite satin spar (potentially after gypsum). Thickness is 5–13 m (15–45 ft). Mapped in the Cañoncito Subunit.	**Glorieta Mesa**—**Psa** is commonly present near the contact with the underlying Glorieta Sandstone. **Cave and Karst Resources**—may have developed karst topography that was then filled in with younger sediments. **Geologic Resources in a Cultural Context**—Pueblo Indians may have used chert and chalcedony from this formation to make stone tools. Selenite used in the window panes of mission churches may have come from an exposure of this formation southwest of the Canoñcito Subunit.	**Land Subsidence**—dissolution of limestone and gypsum has caused land subsidence near Santa Rosa, New Mexico, which is approximately 145 km (90 mi) southeast of Pecos National Historical Park.	**542 million–252 million years ago: Rise and Fall of the Ancestral Rocky Mountains**—sea level continued to rise and limestone was deposited in deeper areas.
	Glorieta Sandstone (**Pg**)	Yellow to buff, thick bedded, fine- to medium-grained quartz sandstone. Grains are well rounded, well sorted, and frosted. Thickness 20–33 m (80–120 ft). Mapped in the Cañoncito Subunit.	**Glorieta Mesa**—**Pg** is the most conspicuous formation on the mesa. Well cemented, very hard, resists erosion. Caps the mesa in most places. **Paleontological Resources**—fossils may be present within **Pg**.	**Paleontological Resource Inventory, Monitoring, and Protection**—a field-based survey could help determine presence of fossils in this formation in Pecos National Historical Park.	**542 million–252 million years ago: Rise and Fall of the Ancestral Rocky Mountains**—rising seas allowed waves to erode the underlying Yeso Formation, producing quartz sand, which was deposited to form Glorieta Sandstone.
	Yeso Formation (**Py**)	Reddish-orange to red, thick-bedded mudstone and interbedded buff to reddish-orange and yellow, fine-grained sandstone and some buff, coarse-grained, arkosic sandstone. Thin beds of gypsum have been observed in **Py** in a few locales, but not on Glorieta Mesa. Thickness 22–42 m (160–200 ft). Mapped in the Cañoncito Subunit.	**Glorieta Mesa**—locally exposed along the base of Glorieta Mesa. **Paleontological Resources**—no fossils. **Py** is composed of dense, crystalline limestone.	None reported.	**542 million–252 million years ago: Rise and Fall of the Ancestral Rocky Mountains**—muds and sands accumulated in an intertidal environment.
PENNSYLVANIAN-PERMIAN	Sangre de Cristo Formation (**PPNsc**)	Brownish red to purple, thick-bedded mudstone and interbedded mottled buff to dark brown and green, lens-shaped coarse-grained arkosic conglomeratic sandstone. Contains some gray to purple, thin-bedded, dense, microcrystalline limestone and buff, thin-bedded, medium-grained quartz sandstone. Thickness ranges from 900 m (3,000 ft) near Cañoncito to 90 m (300 ft) to the south near Lamy. Mapped in all units of the park.	**Glorieta Mesa**—oldest formation exposed on Glorieta Mesa. Upper 30 m (100 ft) is well exposed on the lower face of the mesa wall. Majority of thickness (4/5) occupies the valley floor where it is covered by thick red soil derived from the weathering of the formation itself. **Paleontological Resources**—fossils documented from this formation in Pecos National Historical Park include a shark tooth, and amphibian and reptile bone fragments. Fossil vertebrates have also been found in this formation in Colorado. Marine fossils have been found in several limestone beds in the lower part of the formation in Colorado locations. **Cave and Karst Resources**—the Baca Cave developed between a sandstone and limestone layer in this formation. **Geologic Resources in a Cultural Context**—Pueblo Indians used conglomerate and sandstone blocks from this formation for the stone walls of Pecos Pueblo. Flagstone was quarried for walkways, steps, and shelves in Spanish mission churches. This formation contains the Baca mine which may have been opened in search of uranium or copper.	**Disturbed Land Restoration**—most of the areas of disturbed lands in Pecos National Historical Park are underlain by the Sangre de Cristo Formation. **Abandoned Mineral Lands Hazards**—the Baca mine and surrounding area are closed with fencing and signs for visitor safety. **Paleontological Resource Inventory, Monitoring, and Protection**—a field-based survey could help determine presence of additional vertebrate fossils in the park. **Caves and Associated Landscape Management**—a cave management plan could be developed for Baca Cave and small cave.	**542 million–252 million years ago: Rise and Fall of the Ancestral Rocky Mountains**—the shallow sea of Pennsylvanian time receded, giving way to terrestrial deposition. Rivers and streams deposited sediments eroded from the Ancestral Rocky Mountains in the Rowe-Mora basin. These sediments became the Sangre de Cristo Formation.

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PENNSYLVANIAN	Madera Formation (**PNm**)	Gray to light-brown and purple, thick-bedded, dense, fossiliferous limestone with interbedded gray to brown, calcareous sandstone and coarse-grained arkosic sandstone. Minimum thickness 250 m (820 ft).	**Paleontological Resources**—the formation contains marine invertebrate fossils in locations throughout New Mexico and Colorado. **Geologic Resources in a Cultural Context**—Pueblo Indians used chert and chalcedony from this formation to make stone tools.	None reported.	**542 million–252 million years ago: Rise and Fall of the Ancestral Rocky Mountains**—interbedded offshore and land-derived sediments accumulated in the Rowe-Mora basin—a basin in a shallow sea trapped between ranges of the Ancestral Rocky Mountains.
	Alamitos Formation (**PNal**)	Gray, medium to thin-bedded, fossiliferous marine limestone, interbedded buff to brown, coarse-grained arkosic sandstone, and dark gray to reddish shales. Contact with overlying Sangre de Cristo Formation is locally sharp just east of Pecos but is gradational or poorly exposed in most places. Basal feldspathic unit is cemented by silica or clay. Thickness approximately 450 m (1,500 ft). Mapped in the Pecos Unit.	**Sangre de Cristo Mountains**—this formation comprises the foothills of the Sangre de Cristo Mountains in Pecos National Historical Park. **Paleontological Resources**—marine invertebrates such as bivalves, gastropods, ammonites, and crinoids are documented from this formation in the park.	**Paleontological Resource Inventory, Monitoring, and Protection**—a field-based survey could help determine variety of species and abundance of fossils from this formation in Pecos National Historical Park.	
	La Posada Formation (**PNlp**)	Gray, medium to thick-bedded, fossiliferous marine limestone with banded chert layers. Limestone is interbedded with thin shales and sandstones. Uppermost unit is quartz sandstone with calcite cement. Thickness approximately 300 m (1,000 ft).	None reported.	**Slope Movement Hazards and Risks**—thick limestone beds form cliffs where **PNlp** is exposed near the State Fish Hatchery.	
	Sandia Formation (**PNs**)	Buff to brown, fine-grained, thinly to thickly laminated course-grained arkosic sandstone with interbedded gray shale, sandy shale, and lesser amounts of black, thin-bedded coaly shale. Thickness at least 45 m (150 ft).	**Paleontological Resources**—fossil fragments are present in oolitic limestone layers outside of Pecos National Historical Park.	None reported.	
MISSISSIPPIAN	Tererro Formation (Mt)	Buff to dark brown, thick-bedded, coarse grained limestone breccia in a calcareous arkose matrix. Thickness approximately 15 m (50 ft). Restricted to local outcrops near railroad tracks between Lamy and Cañoncito in the Glorieta quadrangle.	None reported.		**542 million–252 million years ago: Rise and Fall of the Ancestral Rocky Mountains**—landscape of New Mexico was subdued at this time and covered in a shallow sea where limestone and dolomite were deposited.
	Espiritu Santo Formation (**Mes**)	Gray to brown, dense, microcrystalline dolomite and interbedded sandy limestone. Thickness approximately 10 m (33 ft). Restricted to local outcrops near railroad tracks between Lamy and Cañoncito in the Glorieta quadrangle.			
EARLY PROTEROZOIC EON	Granite to granitic gneiss (**Xgg**)	Medium- to coarse–grained, orange granite to gneissic granite consisting predominantly of plagioclase, potassium feldspar, quartz, biotite and iron oxides. The gneiss is strongly deformed. Contains small lenses and layers of amphibolite and is intruded by numerous pegmatites. Mapped in the Cañoncito Subunit.	**Sangre de Cristo Mountains**—**Xgg** comprises the majority of the core of the Sangre de Cristo Mountains. **Geologic Resources in a Cultural Context**—deposits in this unit may have been the target of the Old Bradley mine, which was north of the Pigeon's Ranch Subunit.	None reported.	**2,500 million–542 million years ago: Development of the Structural Foundation**—Precambrian igneous and metamorphic rocks form the "basement" under all younger rocks in Pecos National Historical Park as well as the core of the mountains to the north.
	Biotite granitoid (**Xg**)	Fine- to medium-grained, orange to pink to red granite. Ranges from strongly to weakly foliated.	**Faults**—mapped just east of the Borrego fault zone.		
	Granodiorite (**Xgr**)	Medium-grained, pink, unfoliated potassium feldspar, plagioclase, quartz and lesser amounts of biotite, chlorite, muscovite, epidote, and iron oxides. **Xgr** crosscuts both diorite (**Xd**) and leucogranite, and inclusions of both rock types exist within it.	**Faults**—within and east of the Picuris–Pecos fault zone, where the rock is highly fractured and brecciated.		
	Megacrystic granitoid (**Xmg**)	Megacrystic quartz, plagioclase, potassium feldspar, biotite granitoid. Megacrysts of potassium feldspar are up to 5 cm (2 in) long.	None reported.		

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EARLY PROTEROZOIC EON	Diorite (**Xd**)	Medium- to fine-grained, dark greenish diorite with hornblende, plagioclase, quartz, biotite, epidote, and iron oxides.	None reported.	None reported.	**2,500 million–542 million years ago: Development of the Structural Foundation**—Precambrian igneous and metamorphic rocks form the "basement" under all younger rocks in Pecos National Historical Park as well as the core of the mountains to the north.
	Amphibolite (**Xa**)	Coarse- to fine-grained, black to green amphibolite with blue-green hornblende, plagioclase, quartz, and minor sphene. Includes amygdaloidal amphibolite and metavolcanic breccia. Continuous layers and discontinuous lenses occur within the gneissic granitoid (**Xgg**).			
	Quartz muscovite schist (**Xqms**)	Gray, fine- to medium-grained, well foliated muscovite-rich schist with variable amounts of plagioclase, biotite, quartz, and minor amounts of iron oxide and chlorite.	**Geologic Resources in a Cultural Context**—muscovite used in the window panes of mission churches was sourced from an exposure of this unit in the mountains north of Pecos National Historical Park.		
	Felsic schist and phyllite (**Xf**)	Generally fine-grained, orange, brown, or light-gray schist and phyllite with primarily quartz, muscovite, microcline and plagioclase, and minor biotite and rare garnet. Amphibolite and quartzite layers are interlayered with felsic schists. **Xf** interpreted as metamorphosed volcanic rocks.	None reported.		
	Biotite and pelitic schist (**Xbp**)	A heterogeneous unit of biotite-rich schist, green-gray pelitic schist, mafic phyllite, and feldspar-quartz-magnetite phyllite..			
	Muscovite schist (**Xms**)	Strongly foliated and crenulated gray to brown muscovite schist.	**Geologic Resources in a Cultural Context**—muscovite used in the window panes of mission churches was sourced from an exposure of this unit in the mountains north of Pecos National Historical Park.		