Map Unit Properties Table: Chickasaw National Recreation Area

Gray-shaded map units are not mapped within Chickasaw National Recreation Area.

Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Resource Management Issues	Geologic History
QUATERNARY (Holocene)	Artificial fill (Qaf)	Unconsolidated sand, silt, clay, and gravel used as artificial fill at Lake of the Arbuckles dam site.	None reported.	**Abandoned Mineral Lands** Two abandoned surface mine sites may require mitigation.	**Phase 4. Erosion Shapes the Modern Landscape: Permian through Quaternary Periods, the Past 299 Million Years** Millions of years of erosion transformed southeastern Oklahoma into today's low mountains and hills.
	Alluvium and colluvium, undifferentiated (Qac)	Unconsolidated sand, silt, clay, and gravel along rivers and streams; includes small areas of terrace deposits and small alluvial fan and colluvial deposits along the flanks of major valleys. Thickness: 1–15 m (3–50 ft). Travertine is not mapped separately, but it occurs along streams mapped as **Qac**.	**Travertine Creek and Travertine Island** Porous travertine precipitates from groundwater along Travertine Creek and Travertine Island. **Cave and Karst Features** Dissolution caves in the travertine along the banks of Travertine Island. **Rock Creek Drainage Basin** Alluvium is deposited by Rock, Travertine, Guy Sandy, Buckhorn, and Wilson creeks. V-shaped river valley. Creeks contain fluvial features, such as point bars and cutbanks.	**Water Quality** A systematic monitoring program now monitors both water quality and quantity of springs and streams. Natural asphalt seeps occur in Veterans Lake and Lake of the Arbuckles. **Flooding and Debris Flows** Flash floods may cause flooding on Rock and Travertine creeks. **Rockfall** Colluvium is a result of slope movement, including rockfall. **Lakeshore Erosion** Erosion of Lake of the Arbuckles shoreline may expose and/or destroy archeology sites.	
PERMIAN (Lower)	Pontotoc Group: Stratford Formation (Ps)	Red shale and sandstone containing the Hart Limestone Member at its base in the Sulphur area. Grades into limestone conglomerate and arkose towards the mountains west of Sulphur.	None reported.	None reported.	**Phase 4. Erosion Shapes the Modern Landscape: Permian through Quaternary Periods, the Past 299 Million Years** Erosion of the Arbuckle Mountains led to the shale and sandstone of **Ps**.
PENNSYLVANIAN (Upper)	Pontotoc Group: Vanoss Formation, upper shale facies (PNvs)	Green, gray, locally red shale and silty shale with some tan to reddish-brown, poorly sorted, fine- to coarse-grained arkosic (feldspar-rich) sandstone interbeds. Thin beds of gray limestone conglomerate occur locally. Grades into limestone conglomerate and arkose towards the mountains west of Sulphur. Contact with **PNvc** is gradational. Thickness: 9–24 m (30–80 ft).	**Freshwater and Mineralized Springs** Groundwater flows from the Arbuckle-Simpson aquifer through the Vanoss Formation to the surface. Freshwater springs include Antelope and Buffalo springs. Mineralized springs include Hillside, the Pavilion group, Black Sulphur, Bromide, and Medicine springs. **Vendome Artesian Well** Mineralized water flows from the Vendome Well, an artesian well drilled through the confining layers of the Vanoss Formation. **Sedimentary Features in the Vanoss Formation** Upward-fining cycles of conglomerate to clay, parallel laminations, trough cross-bedding, ripple marks, fenestrae, mud cracks, rip-up clasts, varves, and nodular limestone. **Cave and Karst Features** Small caves in the cliff at Bromide Hill. **Bromide Hill** Steep cliff adjacent to Rock Creek.	**Groundwater Use and Spring Discharge Monitoring** A systematic monitoring program now monitors both spring discharge and groundwater flow to streams. Because the Arbuckle-Simpson aquifer is recharged outside the recreation area, contamination external to the park could affect springs in the park. **Water Quality** Natural asphalt seeps through **PNvc** and into Veterans Lake. The asphalt migrates upward from a subsurface unit that contains petroleum and may seep into the lake through fractures or other permeability conduits. **Flooding and Debris Flows** During wet years, water in Lake of the Arbuckles may rise and flood shoreline facilities in the recreation area. Flash floods may inundate the Rock Creek floodplain and impact campgrounds and infrastructure. Flood water may flow into springs, especially the vaults of Medicine and Bromide springs. Surface water resources may become contaminated. **Rockfall** Potential cliff collapse and rockfall at Bromide Hill. **External Mineral Exploration and Development** Dewatering pits in aggregate quarries east of the park may threaten groundwater flow to springs and streams.	**Phase 3. Uplift and Deformation: Late Mississippian through Pennsylvanian Periods, 331 Million to 299 Million Years Ago** Tectonic plate collisions resulted in folding and faulting of older strata to form the Arbuckle Mountains during the Wichita and Arbuckle Orogenies. The anticlines and synclines that are currently exposed east of the recreation area formed at this time. The Vanoss Formation was deposited following the deformation of **PNd**.
	Pontotoc Group: Vanoss Formation, lower limestone conglomerate facies (PNvc)	Lower limestone conglomerate facies consisting of limestone boulders, cobbles and pebbles in a calcareous matrix with finely-dispersed clay.			

Gray-shaded map units are not mapped within Chickasaw National Recreation Area.

Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Resource Management Issues	Geologic History
PENNSYLVANIAN (Middle)	Deese Group, undifferentiated (PNd)	Massive sandstone, gray and red shale, conglomerate, and fossiliferous limestone. Exposed in the Mill Creek syncline along the banks of Lake of the Arbuckles and the northern parts of the Arbuckle anticline southwest of the recreation area. Includes the Devils Kitchen Conglomerate, Milsap Lake Formation, and West Arm Formation.	**Paleontological Resources** Crinoids, endothyrids, brachiopods, and mollusks. **Folds and Faults** Deformed during the Arbuckle Orogeny. Part of the Mill Creek syncline fault block and Mill Creek fault zone.	**Water Quality** Natural asphalt seeps through **PNd** and into Lake of the Arbuckles. The asphalt migrates upward from a subsurface unit that contains petroleum. **Flooding and Debris Flows** During wet years, water in the Lake of the Arbuckles may rise and flood shoreline facilities in the recreation area.	**Phase 3. Uplift and Deformation: Late Mississippian through Pennsylvanian Periods, 331 Million to 299 Million Years Ago** Tectonic plate collisions resulted in folding and faulting of older strata to form the Arbuckle Mountains. The anticlines and synclines that are currently exposed east of the recreation area formed at this time. **PNd** was deposited on the erosion surface that formed following the Wichita Orogeny, and was then deformed during the younger Arbuckle Orogeny.
PENN. (Lower)	Atoka and Wapanucka Formations, undifferentiated (PNaw)	**Atoka Formation**: unfossiliferous sandstone and shale. **Wapanucka Formation**: massive limestone with interbedded shale and siltstone. A massive white limestone at the base is overlain by shale and sandstone in the Mill Creek syncline. Unit thins to the west.	**Paleontological Resources** Wapanucka Formation: sponges, corals, brachiopods, foraminifers, and ostracodes. **Folds and Faults** Deformed during the Arbuckle and Wichita orogenies.	None reported.	**Phase 3. Uplift and Deformation: Late Mississippian through Pennsylvanian Periods, 331 Million to 299 Million Years Ago** **PNaw** formed in the deep basins that subsided in southern Oklahoma.
MISS. (Upper)	Springer Formation (PNMs)	Dark (black to blue) fissile, bituminous shale separated by thin beds of sandstone and limestone, with iron-rich and calcareous concretions. Some of the sandstone beds can vary from a few feet to tens of feet thick. Maximum thickness is 1,829 m (6,000 ft). Exposures are most abundant in the Criner Hills area, a mountain range which climbs to 298 m (978 ft) above sea level in Carter County, Oklahoma, southwest of the recreation area.	**Paleontological Resources** Various species of brachiopods, bryozoans, and bivalves. **Folds and Faults** Deformed during the Arbuckle and Wichita orogenies. Part of the Tishomingo anticline, Mill Creek syncline fault block, and Mill Creek fault zone.	None reported.	**Phase 3. Uplift and Deformation: Late Mississippian through Pennsylvanian Periods, 331 Million to 299 Million Years Ago** Tectonic plate collisions resulted in folding and faulting of older strata as major land masses sutured together to form the supercontinent Pangaea. Deep basins subsided in southern Oklahoma and filled with shale, sandstone, and limestone.
MISSISSIPPIAN (Lower)	Caney Shale (Mc)	Dark gray to black, laminated, fissile and friable shale containing septarian (roughly spheroidal) and phosphatic concretions with diameters that may be 1 m (3 ft) or larger. Because it is so friable, individual outcrops are rarely exposed. Underlies lush, grassy fields and slopes.	**Paleontological Resources** Conodonts, pelecypods, gastropods, ostracodes, goniatites, and cephalopods. **Folds and Faults** Deformed during the Arbuckle and Wichita orogenies. Part of the Tishomingo anticline, Mill Creek syncline fault block, and Mill Creek fault zone.	**Water Quality** Natural asphalt seeps through **Mc** and into Lake of the Arbuckles. The asphalt migrates upward from a subsurface unit that contains petroleum.	**Phase 2. Shallow Seas Flood the Craton: Late Cambrian through Middle Mississippian Periods, 500 Million to 330 Million Years Ago** Active subduction zones form along the western and southern margins of proto-North America causing sea level to rise. Deeper marine environments covered southern Oklahoma. Dark, fissile shale (**MDsw**) was deposited over the old erosion surface and under anaerobic conditions.
DEVONIAN	Sycamore Limestone, Welden Limestone, and Woodford Shale, undifferentiated (MDsw)	Mapped together over the coverage area. Thickness ranges from 101 m (330 ft) to over 305 m (1,000 ft) in the Hunton anticline area. **Sycamore Limestone**: shale and argillaceous cherty to silty limestone overlain by shale and marly (mixture of clay and calcium carbonate) limestone. Varies from 40–107 m (130–350 ft) thick. **Welden Limestone**: generally not exposed, or thinly exposed, in the Arbuckle Mountains. **Woodford Shale**: dark, fissile shale, siliceous shale, bedded chert and black bituminous shale. Thickness varies from 61 m (200 ft) to 213 m (700 ft).	**Folds and Faults** Deformed during the Arbuckle and Wichita orogenies. Part of the Tishomingo anticline, Mill Creek syncline fault block, and Mill Creek fault zone.	**Water Quality** Natural asphalt seeps through **MDsw** and into Lake of the Arbuckles. The asphalt migrates upward from a subsurface unit that contains petroleum. **External Mineral Exploration and Development** Potential for hydrocarbon production from the Woodford Shale.	
DEVONIAN (Lower)	Hunton Group (DSOh): Upper part of Hunton Group, undifferentiated (Dhu)	Alternating blue to white shale and thin-bedded, argillaceous limestone that weathers to yellowish to tan mudstone. Overlain by thin-bedded limestones with rare cherty and marly lentils and intercalated, yellowish shale. Thickness varies from 0 to 78 m (256 ft). Average thickness is 49 m (160 ft).	**Paleontological Resources** Brachiopods, trilobites, corals, gastropods, bivalves, straight cephalopods (*Rhinoceras* sp.), gastroliths (stomach stones), and goniatites (ammonites). **Folds and Faults** Deformed during the Arbuckle and Wichita orogenies. Part of the Tishomingo anticline, Mill Creek syncline fault block, and Mill Creek fault zone.	**Water Quality** Natural asphalt seeps through **DSOh** and into Lake of the Arbuckles. The asphalt migrates upward from a subsurface unit that contains petroleum. **Paleontological Resource Inventory, Monitoring, and Protection** Potential fossil theft. Management is preparing a paleontological resources plan that will address a paleontological inventory and assessment of fossils in the recreation area.	**Phase 2. Shallow Seas Flood the Craton: Late Cambrian through Middle Mississippian Periods, 500 Million to 330 Million Years Ago** Sea level fell. The Hunton Group (**Dhu**, **SOhl**) represents fluctuating sea levels and near-shore marine environments that formed in southern Oklahoma during an overall marine regression that began in the Late Ordovician. Areas exposed above sea level were eroded.
ORDOVICIAN-SILURIAN	Hunton Group (DSOh): Lower part of Hunton Group, undifferentiated (SOhl)	Fossiliferous, oolitic limestone and micritic (fine-grained) limestone overlain by massive limestone and thin-to thick-bedded, crystalline to argillaceous (clay-rich) limestone with interbedded shale in the upper part of the unit. Thickness varies. Average thickness is 38 m (125 ft). Maximum thickness is 90 m (295 ft).			

Gray-shaded map units are not mapped within Chickasaw National Recreation Area.

Age	Map Unit (Symbol)		Geologic Description	Geologic Features and Processes	Resource Management Issues	Geologic History
ORDOVICIAN (Upper)	Sylvan Shale and Viola Group (Osv)	Sylvan Shale (Os)	Green to gray or tan, fissile, calcareous and dolomitic shale that weathers easily and forms rolling hills between the resistant limestone formations. Rarely exposed. Thickness varies from 15–91 m (50–300 ft).	**Paleontological Resources** **Os:** Graptolites and chitinozoans. **Ov**: Trilobites (*Crytolithus trilos*, *Isotelus*) and graptolites. **Folds and Faults** Deformed during the Arbuckle and Wichita orogenies. Part of the Tishomingo anticline, Mill Creek syncline fault block, Mill Creek fault zone, Belton anticline fault block, and the Sulphur syncline. **Cave and Karst Features** Erosional knobs outside the park may be remnants of strata that collapsed into Paleozoic sinkholes.	**Water Quality** **Ov**. Natural asphalt seeps occur in quarries south of the Arbuckle Dam. **Paleontological Resource Inventory, Monitoring, and Protection** Potential fossil theft. Management is preparing a paleontological resources plan that will address a paleontological inventory and assessment of fossils in the recreation area.	**Phase 2. Shallow Seas Flood the Craton: Late Cambrian through Middle Mississippian Periods, 500 Million to 330 Million Years Ago** Shallow seas covered southern Oklahoma. Carbonates were deposited on a submarine ramp that extended offshore from the Transcontinental Arch and tilted gently seaward. Marine invertebrates populated open marine, well-circulated environments.
		Viola Group (Ov)	Limestones of the Welling and Viola Springs Formations. Up to 213 m (700 ft) thick. **Welling Formation** (previously Fernvale Limestone): gray, coarse-grained, fossiliferous limestone. **Viola Springs Formation**: white to bluish-gray, cherty, fine- to medium-grained, locally very fossiliferous limestone. Thin interbeds of fissile shale. Limestone may contain chert nodules in its lower and middle parts.			
ORDOVICIAN (Middle)	Simpson Group	Bromide, Tulip Creek, and McLish Formations (Obm)	Alternating brown to white sandstone, green shale, and buff-colored limestone. **Bromide Formation**: interbedded fossiliferous (brachiopods, ostracodes) limestone and shale. Sandstone at base varies in thickness up to 91 m (300 ft). Overall thickness varies from 96 m (315 ft) to over 183 m (600 ft). **Tulip Creek Formation**: shale (upper part) and sandstone (lower part) with minor limestone and a basal sandstone bed. Grades upward into basal sandstone of Bromide Formation. Ranges from 91–122 m (300–400 ft) thick. **McLish Formation**: interbedded limestone and shale with a sandstone at its base. Locally contains small blebs of calcite known as "birdseye" limestone. Maximum thickness is 137 m (450 ft) in the eastern parts of the Arbuckle Mountains.	**Fresh Water and Mineralized Springs** and **Vendome Artesian Well** Groundwater flows from the Arbuckle-Simpson aquifer. **Paleontological Resources** **Obm**. Brachiopods, trilobites, bryozoans, graptolites, pelycopods, ostracodes, and echinoderms. **Folds and Faults** Deformed during the Arbuckle and Wichita orogenies. Part of the Tishomingo anticline, Mill Creek syncline fault block, Mill Creek fault zone, Belton anticline fault block, and the Sulphur syncline. **Cave and Karst Features** **Obm**. Erosional knobs outside the park may be remnants of collapsed strata in Paleozoic sinkholes.	**Water Quality** Asphalt seeps occur in the Simpson Group in quarries directly east of the recreation area. Asphalt in **Ooj** sandstones was mined for road-surfacing material from 1890 to 1962. Because the Arbuckle-Simpson aquifer is recharged outside the recreation area, contamination external to the park could affect springs in the park. **Paleontological Resource Inventory, Monitoring, and Protection** Potential fossil theft. Management is preparing a paleontological resources plan that will address a paleontological inventory and assessment of fossils in the recreation area. **External Mineral Exploration and Development** Dewatering pits in aggregate quarries east of the park may threaten groundwater flow to springs and streams.	**Phase 2. Shallow Seas Flood the Craton: Late Cambrian through Middle Mississippian Periods, 500 Million to 330 Million Years Ago** Shallow seas covered southern Oklahoma. Carbonates were deposited on a submarine ramp that extended offshore from the Transcontinental Arch and tilted gently seaward. Marine invertebrates populated open marine, well-circulated environments.
		Oil Creek and Joins Formations (Ooj)	Gray to tan, granular, limestone with greenish-gray shale and brown, fine- to medium-grained sandstone. **Oil Creek Formation**: basal quartz sandstone overlain by limestone and shale. Locally argillaceous or calcareous and petroliferous (tar sand was mined in the east of the recreation area). Averages 229 m (750 ft) thick. **Joins Formation**: Thin-bedded limestone and shale with a persistent thin conglomerate layer at the base of the unit. May be as much as 91 m (300 ft) thick on the south side of the Arbuckle Mountians.			
ORDOVICIAN (Lower)	Arbuckle Group (Upper part)	West Spring Creek and Kindblade Formations (Owk)	Predominately fine-grained limestone that grades westward into greenish to tan dolomite with minor sandstone and shale lentils. Primarily limestone in the western part of the Arbuckles Mountains and dolomite in the eastern part. Sandstone is generally thicker and more abundant to the east.	**Fresh Water and Mineralized Springs** and **Vendome Artesian Well** Groundwater flows from the Arbuckle-Simpson aquifer. **Folds and Faults** Deformed during the Arbuckle and Wichita orogenies. Part of the Tishomingo anticline, Mill Creek syncline fault block, Mill Creek fault zone, Belton anticline fault block, Sulphur syncline, and Hunton anticline. **Cave and Karst Features** Dissolution of limestone formed cavities, collapse breccias, dissolution-enhanced fractures, and vuggy porosity.	None reported.	**Phase 2. Shallow Seas Flood the Craton: Late Cambrian through Middle Mississippian Periods, 500 Million to 330 Million Years Ago** Shallow seas covered southern Oklahoma. Carbonates were deposited on a submarine ramp that extended offshore from the Transcontinental Arch and tilted gently seaward. Marine invertebrates populated open marine, well-circulated environments.
		West Spring Creek Formation (Ow)	Gray to tan, fine-grained, thick- to thin-bedded, laminated dolomitic limestone with some sandstone and shale. Differentiated from the Kindblade Formation only in some parts of the Hunton anticline.			

MISS. = Mississippian; PENN. = Pennsylvanian.

Source map: Blome, C. D., D. J. Lidke, R. R. Wahl, and J. A. Golab. 2013. Geologic map of Chickasaw National Recreation Area, Murray County, Oklahoma (scale 1:24,000). US Geological Survey, Reston, Virginia. Scientific Investigations Map 3258. http://pubs.usgs.gov/sim/3258/ (accessed 3 March 2014).