Map Unit Properties Table: Fort Union Trading Post National Historic Site

Colored map units are mapped within Fort Union Trading Post National Historic Site. Colors correspond to those on geologic map poster. Bold text refers to sections in report.

Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Resource Management Issues	Geologic History
QUATERNARY (Holocene)	Alluvium (Qal)	Brown, olive, and gray boulders, cobbles, gravel, sand, silt, and clay deposited in stream channels and on floodplains. Deposits are poorly to well sorted, poorly to well stratified, and clasts may be as much as 0.6 m (2 ft) in diameter. Generally less than 6 m (20 ft) thick, but locally as much as 12 m (40 ft) thick.	**River Features** Cutbanks, point bars, mid-channel bars, and islands. **Paleontological Resources** Potential to yield Pleistocene megafauna and Holocene paleoenvironmental fossils, including trace fossils (burrows), charcoal, vertebrate fossils, such as bison bones, pollen, spores, and aquatic microfossils. **Qal** contains Knife River Flint (silicified plant material) associated with archeological (cultural resource) sites.	**Missouri River Bank Erosion** Erosion along the south bank of the Missouri River has caused active slumping and may intersect an irrigation ditch in the future. The Missouri River may eventually breach the southern boundary of Fort Union Trading Post National Historic Site. **Flooding** Flooding on the Missouri River during extremely wet years and backup from flooding on the Yellowstone River may inundate low-lying areas of the park. **Current and Potential Oil and Gas Development** Well pads, drill rigs, geophysical seismic activity, and access roads may erode and/or compact **Qal**. Drilling activities may also impact the viewshed. **Earthquakes** Potential earthquakes may occur due to secondary waste fluid disposal associated with the hydraulic fracturing process. These fluids may lubricate buried faults and cause the faults to slip, resulting in movement on the surface of **Qal**. This connection has not been demonstrated in North Dakota. **Abandoned Mineral Lands** A small abandoned quarry east of the reconstructed Fort Union contains a mix of **Qal**, **Qac**, and **Qgt**. The quarry is unlikely to pose a safety issue for visitors and is overgrown with weeds. **Paleontological Resources Inventory and Monitoring** Fossils found in the historic site, museum collections, or associated with archeological (cultural resource) sites should be inventoried and/or monitored.	**The Past 12 Thousand Years (Cenozoic Era): Holocene Thaw** The Missouri and Yellowstone rivers created modern floodplains and channels within the broad meltwater channels that formed at the end of the Pleistocene ice ages.

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		Sand, silt, and clay in glacial meltwater channels. Colors reflect that of older Quaternary and Paleogene units from which sediment was derived. May locally overlie glacial outwash deposits. Thickness not determined.	**Bodmer Overlook and Surrounding Landscape** The trail to the overlook crosses **Qac**. **Paleontological Resources** Potential to yield Pleistocene megafauna and Holocene paleoenvironmental fossils, including trace fossils (burrows), charcoal, vertebrate fossils, such as bison bones, pollen, spores, and aquatic microfossils. **Qac** contains Knife River Flint (silicified plant material) associated with archeological (cultural resource) sites. **Glacial Features** Coarse sand and gravel from glacial outwash.	**Current and Potential Oil and Gas Development** Well pads, drill rigs, geophysical seismic activity, and access roads may erode and/or compact **Qac**. Drilling activities may also impact the viewshed. **Slope Movements** Downslope movement of colluvium may occur. **Earthquakes** Potential earthquakes may occur due to secondary waste fluid disposal associated with the hydraulic fracturing process. These fluids may lubricate buried faults and cause the faults to slip, resulting in movement on the surface of **Qac**. This connection has not been demonstrated in North Dakota. **Abandoned Mineral Lands** A small abandoned quarry east of the reconstructed Fort Union contains a mix of **Qal**, **Qac**, and **Qgt**. The quarry is unlikely to pose a safety issue for visitors and is overgrown with weeds. **Paleontological Resources Inventory and Monitoring** Fossils found in the park, museum collections, or associated with archeological (cultural resource) sites should be inventoried and/or monitored.	**The Past 12 Thousand Years (Cenozoic Era): Holocene Thaw** Sediments filled the broad meltwater channels that formed at the end of the Pleistocene ice age.
	Alluvial terrace deposit (Qat)	Brown and gray, dominantly well-rounded gravel, sand, and silt in terrace remnants at elevations ranging from 1.5 m (5 ft) to 110 m (360 ft) above modern rivers and streams. Deposits are generally well sorted, but poorly to well stratified, with thicknesses generally less than 6 m (20 ft).	**Paleontological Resources** Potential to yield Pleistocene megafauna and Holocene paleoenvironmental fossils. These may include trace fossils (burrows), charcoal, vertebrate fossils, such as bison bones, pollen, spores, and aquatic microfossils. **Qat** contains Knife River Flint (silicified plant material) associated with archeological (cultural resource) sites.	None documented.	**From 2 Million to 12 Thousand Years Ago (Cenozoic Era): Pleistocene Deep Freeze** When the glaciers melted, vast amounts of meltwater spread gravel, sand, and silt across the region. Modern rivers and streams incised into these ancient deposits and left them as terraces above newly developed floodplains.
	Till (Qgt)	Heterogeneous mixture of brown and gray clay, silt, sand, and gravel with rare to abundant cobbles and boulders. Locally contains lenses and stringers of moderately well sorted clay, silt, sand, or gravel. Thickness is generally less than 9 m (30 ft), but may be as much as 30 m (100 ft).	**Paleontological Resources** **Qgt** contains Knife River Flint (silicified plant material) associated with archeological (cultural resource) sites. **Glacial Features** Heterogeneous mixture of sediment left behind when the glaciers melted.	None documented.	**From 2 Million to 12 Thousand Years Ago (Cenozoic Era): Pleistocene Deep Freeze** The landscape was covered by a heterogeneous mixture of sediments when the last phase of Pleistocene glaciation ended with the melting of the continental ice sheet from western North Dakota and eastern Montana.

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Age	Map Unit (Symbol)	Geologic Description	Geologic Features and Processes	Geologic Resource Management Issues	Geologic History
		Dark-gray shale locally underlain by orange- brown or brown, iron oxide-stained, cross-bedded channel sandstone with medium- to coarse-grained, poorly sorted clasts. Gray or brown, easily eroded mudstone about 6 m (20 ft) thick underlies the sandstone locally. Erosion has removed the upper part of member. Thickness in the map area is about 90 m (300 ft). North Dakota Geological Survey assigns these rocks to the Sentinel Butte Formation of the Fort Union Group.	**Fort Union Formation Type Section and Stratigraphic Features** Cross-bedded sandstone, rip-up clasts, and lignite coal beds. **Paleontological Resources** Abundant freshwater mollusks. Similar diverse fossil assemblage as **Tftr**, including invertebrate, vertebrate, and many plant fragments of petrified wood. **Aeolian Features** Blowouts on hilltops. **Volcanic Ash Layers** Volcanic ash altered to bentonite.	**Current and Potential Oil and Gas Development** Well pads, drill rigs, geophysical seismic activity, and access roads may erode and/or compact these units. Drilling activities may also impact the viewshed. **Slope Movements** Downslope movement may displace these strata, which form the steepest slopes in the park. **Earthquakes** Potential earthquakes may occur due to secondary waste fluid disposal associated with the hydraulic fracturing process. These fluids may lubricate buried faults and cause the faults to slip, resulting in movement on the surface. This connection has not been demonstrated in North Dakota. **Paleontological Resources Inventory and Monitoring** Fossils found in the park, museum collections, or associated with archeological (cultural resource) sites should be inventoried and/or monitored.	**From 66 Million to 2 Million Years Ago (Cenozoic Era): Paleocene Swamps and Floodplains and Climate Change** Once the Cannonball Sea retreated from the Fort Union region, sediments were deposited in river channels, avulsions, floodplains, lakes, and swamps. Peat that accumulated in swampy areas would eventually become part of North Dakota's lignite reserves. Volcanic ash, drifting in from the west, would alter to bentonite, a clay mineral with shrink-swell characteristics.
		Yellow, orange, or tan, fine- to medium-grained sandstone and thinner interbeds of yellowish-brown, orange, or tan siltstone and light-colored mudstone and clay. Consists of four basic stratigraphic layers, often in cycles. From lowest to highest, these cycles include: (1) gray claystone and siltstone, often containing plant and mollusk fossils; (2) a lignite layer; (3) yellow siltstone and sandstone, which may contain plant and mollusk fossils; and (4) sandstone deposits. The clay in the unit is not prone to swelling. Generally poorly cemented and weathers to badlands topography. Some relatively resistant sandstone beds form caprocks. Thickness is about 250 m (800 ft). North Dakota Geological Survey assigns these rocks to the Bullion Creek Formation of the Fort Union Group.	**Fort Union Formation Type Section and Stratigraphic Features** Cycles of sandstone, siltstone, and mudstone; also contains lignite coal beds. **Bodmer Overlook and Surrounding Landscape** The summit of the overlook is on **Tftr**. **Paleontological Resources** Abundant freshwater mollusks. Diverse assemblage of invertebrate, vertebrate, and plant fossils (table 1). Includes eroded pieces of petrified wood on Bodmer Overlook. **Aeolian Features** Blowouts on hilltops.		