Geologic Resources Inventory Scoping Summary
Fort Union Trading Post National Historic Site
North Dakota and Montana

Prepared by Trista L. Thornberry-Ehrlich
January 12, 2012

Geologic Resources Division
National Park Service
US Department of the Interior

The Geologic Resources Inventory (GRI) provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a geologic resources inventory report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

The National Park Service held a GRI scoping meeting for Fort Union Trading Post National Historic Site on August 17, 2011 at the Confluence Interpretive Center outside of Williston, North Dakota. A visit to the historic site followed the meeting. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Lisa Norby (NPS-GRD) led the discussion regarding geologic processes and features at the park. After an introduction by park superintendent Andy Banta, Joseph Hartman (University of North Dakota) presented a geologic overview of the park and surrounding area. Participants at the meeting included NPS staff from the park, Geologic Resources Division, and Northern Great Plain Network; geologists from Dickinson State University and the University of North Dakota; and a cooperator from Colorado State University (see table 2). This scoping summary highlights the GRI scoping meeting for Fort Union Trading Post National Historic Site including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Fort Union Trading Post National Historic Site was authorized on June 20, 1966 and encompasses 180 ha (444 ac) with the purpose of commemorating the site and history of Fort Union, the American Fur Company's principal fur trading post on the upper Missouri River. American Indian tribes, including Assiniboine, Blackfeet, Cree, Crow, Sioux, Hidatsa, Mandan, Arikara, and Ojibwa, traded furs and other goods with the post between 1828 and 1867. The trading post took advantage of its position along the north bank of the Missouri River, at the confluence with the Yellowstone River. Today, the historic site is 3.6 km (2.2 mi) northwest and upstream of the confluence with the Yellowstone River as the location of the confluence has changed dramatically since the Lewis and Clark expedition. The Missouri was a primary transportation corridor in the 1800s, and it remains to be an interpretive story.

Fort Union Trading Post National Historic Site is located at 580 m (1,900 ft) elevation in Williams and McKenzie counties in North Dakota, and Richland and Roosevelt counties in Montana. On the southern edge of the glaciated portion of the Coteau Slope, this area is near the maximum extent of Pleistocene glacial advance in North Dakota. Glacial deposits and other surficial unconsolidated sediments cover the underlying bedrock. The bedrock exposed in this area of western North Dakota and eastern Montana includes middle to late Paleocene (spanning 61 to 56 million years ago) sedimentary rocks.

According to North Dakota Geological Survey nomenclature, the local bedrock consists of the Bullion Creek Formation and Sentinel Butte Formation of the Fort Union Group (the U.S. Geological Survey and Montana Bureau of Mines and Geology identify the units as members of the Fort Union Formation, using Tongue River Member for the Bullion Creek interval) (fig. 1). These units were deposited in a broad, low-lying rainforest and swamp setting within the Williston Basin. The upper levels of the Bullion Creek Formation were deposited during a particularly swampy period (many organic-rich layers), whereas the Sentinel Butte Formation records primarily fluvial depositional settings. Sediment transport direction was to the southeast, towards the receding remnants of the Cretaceous Interior Seaway.

The Fort Union National Historic Site area was covered with thick sheets of ice during several Pleistocene glacial advances. The extent of the last major advance is marked roughly by the location of the present-day Missouri River, whose formerly northeastern-flowing (towards Hudson Bay) course was altered by the glaciers. Previous glacial events likely covered the area in ice, but surficial geologic processes of erosion and weathering have removed much of the evidence of glaciation from the landscape. Glacial deposits may include end moraines, ground moraine, outwash terraces, and glacial erratics. The Quaternary Oahe Formation comprises mixed glacial, aeolian, and fluvial deposits.

The landscape of the park features large river bluffs and terraces flanking floodplain areas and meandering river channels. The local Glass Bluffs cause the river’s kinked flow pattern. Slough scars that are visible in aerial photographs demonstrate how much the Missouri River and its confluence with the Yellowstone River has moved throughout time. Today, surficial processes such as weathering, erosion, lateral movement of the river channel, freeze-and-thaw cycles, and flooding continue to shape the landscape at Fort Union Trading Post National Historic Site.

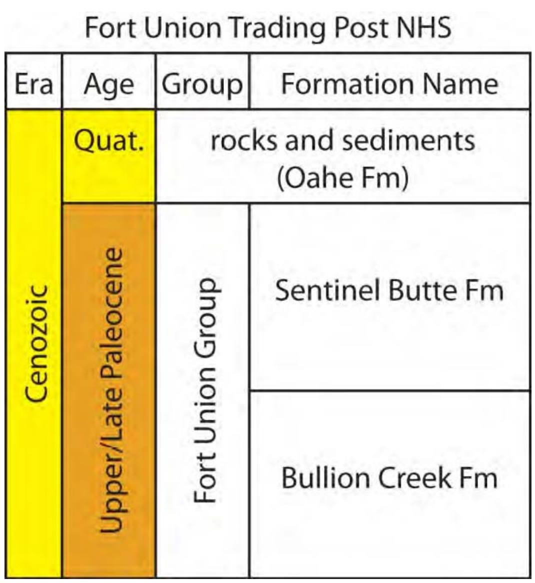

Figure 1. Schematic stratigraphic column for Fort Union Trading Post National Historic Site. Older formations are at the bottom of the column and younger rocks are toward the top. Fm=Formation. Colors based upon the standard U.S. Geological Survey timescale color scheme, graphic is figure 6 from Tweet et al. (2011).

Geologic Mapping for Fort Union Trading Post National Historic Site

During the scoping meeting, Tim Connors (NPS-GRD) showed some of the main features of the GRI's digital geologic maps, which reproduce all aspects of paper maps, including notes, legends, and cross sections, with the added benefit of being GIS compatible. The NPS GRI Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRI Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRI digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files (complete with feature symbology), FGDC-compliant metadata, an Adobe Acrobat PDF help document that captures ancillary map data, and a map document that displays the map, and provides a tool to access the PDF help document directly from the map document. Final data products are posted at http://science.nature.nps.gov/nrdata/. The data model is available at http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm.

When possible, the GRI Program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, which is often composed of the 7.5-minute quadrangles that contain park lands (fig. 2). Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps (table 1) and mapping needs in the vicinity of the historical park. Scoping session participants then select appropriate source maps for the digital geologic data or develop a plan to obtain new mapping, if necessary.

During GRI scoping it was decided that coverage was most desired for areas of the Bainville SE and Dore 7.5' quadrangles and the best available maps for Fort Union Trading Post National Historic Site were two 30'x60' compilations by the Montana Bureau of Mines and Geology for the Culbertson (2006) and Sidney (2003) 30x60 sheets. After the August scoping, GRI staff completed digital conversions of these maps cropped down to the Bainville SE and Dore 7.5' area extents. The map is posted at https://irma.nps.gov/App/Reference/Profile/21762257. A screen capture of this map is presented in Figure 2 and it features layers for the following:

- Geologic units
- Geologic contacts
- Structure contour lines (top of Pierre / Bearpaw Shale)

While there is also bedrock geology available at the county level for the North Dakota side of Fort Union Trading Post National Historic Site for Williams and McKenzie counties, it was decided to exclude these maps based upon the terminology being quite dated and the small-scale. Other mapping data layers that may be of interest include the confluence area itself in the Buford, ND quadrangle, fossil localities, oil and gas well locations, and North Dakota Geological Survey landslide maps (if available).

Table 1. GRI Mapping Plan for Fort Union Trading Post National Historic Site

Covered Quadrangles	Relationship to the park	Citation	Format	Assessment	GRI Action
Culbertson 30x60	Intersects the park	Colton, R. B., D. S. Fullteron, and W. C. Ehrler. 2006. Geologic map of the Culbertson 30' x 60' quadrangle (surficial emphasis), Roosevelt, McCone, and Richland counties, Montana, and Divide and Williams counties, North Dakota (USGS field study)(scale 1:100,000). Open-File Reports 539, unpublished. Montana Bureau of Mines and Geology, Butte, Montana, USA. http://www.mgmb.mtech.edu/mbmgcat/public/ListCitation.asp?selectby=series&series_type=MBMG&series_number=359&series_sub=&.	Digital	Yes	Convert to GRI data model
Sidney 30x60	Intersects the park	Vuke, S. M., E. M. Wilde, and L. N. Smith. 2003. Geologic and structure contour map of the Sidney 30' x 60' quadrangle, eastern Montana and adjacent North Dakota (scale 1:100,000). Open-File Reports MBMG-478. Montana Bureau of Mines and Geology, Butte, Montana, USA. http://www.mgmb.mtech.edu/mbmgcat/public/ListCitation.asp?selectby=series&series_type=MBMG&series_number=478&series_sub=&	Digital	Yes	Convert to GRI data model

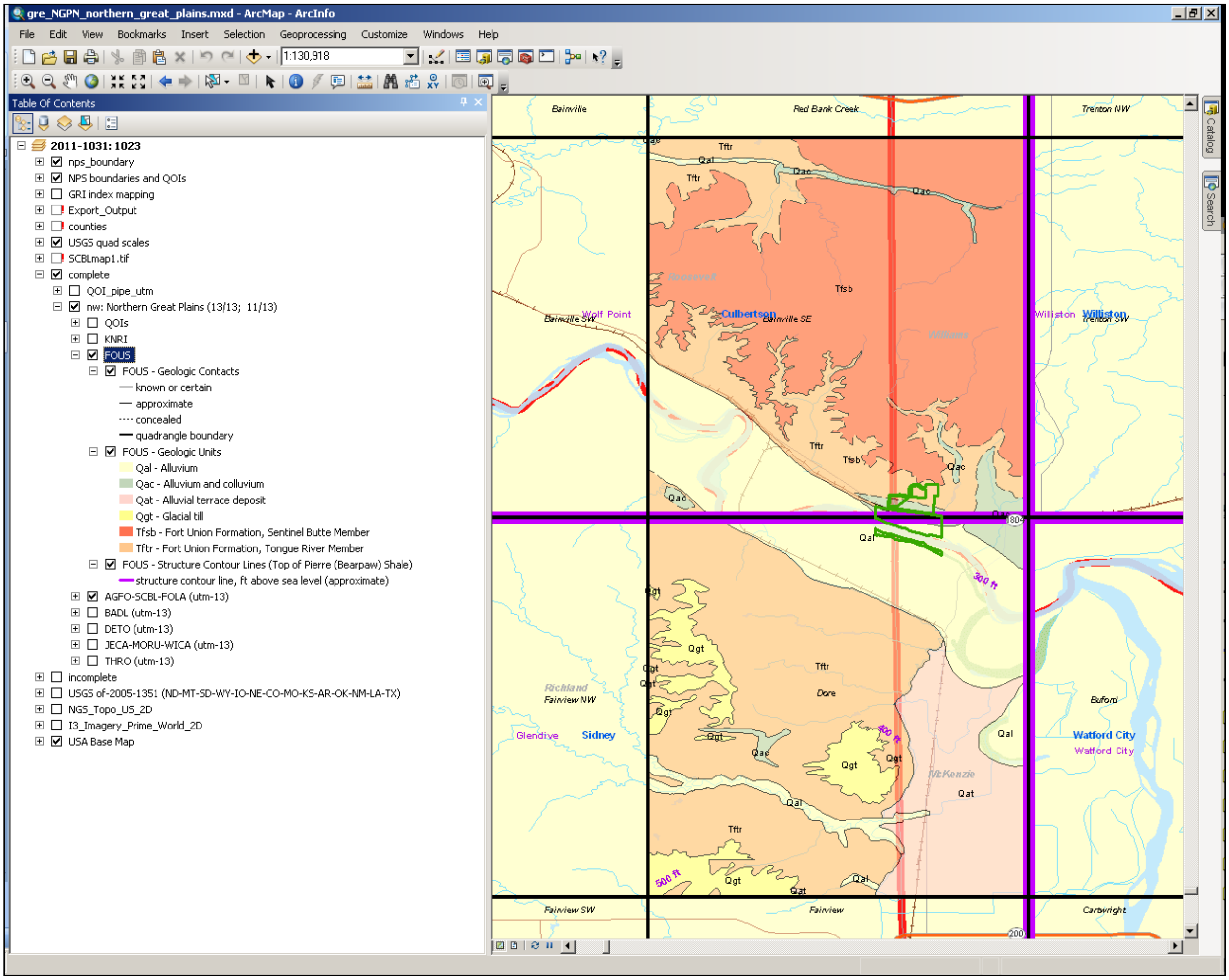

Figure 2. Screen capture showing geologic map coverage for Fort Union National Historic Site from Colton et al. (2006) and Vuke et al. (2003) (see Table 1, above). Black labels indicate 7.5x7.5-minute quadrangle names, blue labels indicate 30x60 quadrangle names, and purple labels indicate 1 degreex2 degree sheets. Green outline indicates park boundary.

Geologic Resource Management Issues

The scoping session for Fort Union Trading Post National Historic Site provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRI report. During the meeting, participants prioritized the most significant issues as follows:

(1) Flooding and fluvial processes, and
(2) Current and potential oil and gas development.

Other geologic resource management issues discussed include slope processes, seismicity, and disturbed lands.

Flooding and fluvial processes

The Missouri River is the primary natural feature at the park and its associated fluvial processes drive much of the local landscape change. Fort Union Trading Post National Historic Site is located downstream of the Fort Peck Dam. This earthen dam was constructed in the 1940s and has created an unnatural river system. The dam prevents regular downstream (below the dam) flooding needed to replenish floodplain/riparian environments with sediment and nutrients, traps sediments behind the dam, and starves the downstream portion of the river of sediment. When the unimpounded Yellowstone River is running high it will back up into the Missouri River. Other than occasional ice dams and extreme flow years (such as 2011 when water reached the lower parking lot below the fort and breached the south riverbank), the Missouri River is unlikely to cause significant flooding in the park. During 2011's high flow, trees and vegetation were scoured from intra-channel islands below the fort. Similar severe flood events may inundate some low-lying park housing and maintenance infrastructure, and the lower parking lot in the park.

The Missouri and Yellowstone rivers are naturally meandering across the landscape as can be seen by numerous slough scars in aerial photographs. The Missouri River's south bank is eroding within the park with active slumping and development of cutbanks (fig. 3). The bank becomes undercut, the sediment on the bank slumps downward, and the toe of the slope is eroded. The park has been conducting erosion monitoring for the past 10 years using fenceposts to measure migration of the Missouri River. Since monitoring began, as much as 12 m (40 ft) of shoreline has been lost in a single year and now the park boundary is a total of 30 to 60 m (100 to 200 ft) beyond the riverbank. The U.S. Army Corps of Engineers installed bentway-weirs to move the thalwag back to the north side of the river where the Buford-Trenton pumping station is located. During the scoping meeting it was noted that there is some interest in developing fluvial erosion studies for students at the University of North Dakota. At the current time, the river is migrating away from the fort and erosion is not threatening any park resources but is threatening farmland across the river.

Potential oil and gas, and coal development

North Dakota is currently experiencing extensive oil and gas development in the Devonian–Mississippian Bakken Shale. Currently 75% of the state's production is from the Bakken Formation. Other units of interest to the oil and gas industry include the Devonian Three Forks Formation and Pennsylvanian Tyler Formation. There is also renewed interest in the Ordovician Red River Formation that was heavily drilled in the 1980s and 1990s. These units occur beneath the park, and interest is centered near the town of Williston, North Dakota. Approximately 2,000 wells are currently producing oil and gas in this area. Geologists estimate development of the Bakken oil and gas play will last at least 10 years. Several oil and gas wells are present within the park's viewshed. There is a producing well approximately 1 km (0.5 mi) east of the park boundary. Gas flares from this operation are visible from the park. Other drilling operations occurred 1.6 km (1 mi) north of the park and within 1.6 km (1 mi) west of the park in the fall of 2011 (Andy Banta, NPS-FOUS, written communication 12 January 2012). There are proposals to drill another 20,000 Bakken wells; the website https://www.dmr.nd.gov/oilgas/ has important statistics and information regarding oil and gas development in North Dakota. One proposal seeks to drill a horizontal well around one corner of the park. Modern technology allows horizontal drilling of up to 3,050 m (10,000 ft), so drilling within park boundaries is unnecessary. An oil company recently wanted to lease mineral rights nearby including private minerals beneath the park. The Bureau of Land Management has lands adjacent to the park that could also be leased. The park does not own the mineral rights; however, nonfederal entities must submit plans of operations for approval to the National Park Service according to the National Park Service's nonfederal oil and gas regulations (36 CFR Part 9 Subpart B). The North Dakota Oil and Gas Division website (https://www.dmr.nd.gov/oilgas/) has an online GIS tool that will show the locations and horizontal extents of oil and gas wells.

The population influx to support the Bakken oil and gas exploration and production effort has created many adverse effects on North Dakota. This includes development of rural and agricultural areas, increased traffic on local roads, increased crime, excessive wastewater demands, impacts on wildlife popultions, and additional impacts to soil, water and air resources. Landowners are taking advantage of the economic boom by leasing their land for RV parks and storage of oilfield materials, a short-term economic benefit but possibly having long-term adverse effects on natural resources. Other new impacts include new rail loading facilities 11 km (7 mi) east of the park and about 8 km (5 mi) south of the park. At these locations, well pipe, sand, load oil, and propane are unloaded to support the exploration effort. This may increase truck traffic in the area as these facilities will use truck to ship in and out what has been brought in or goes out on the railroads (Andy Banta, NPS-FOUS, written communication 12 January 2012).

Other materials including coal and salt are mined within the greater Williston area. Extensive underground coal and salt mines may later pose subsidence issues. Weathered coal exposures (Leonardite: an oxidation product of lignite) provide additive material used to improve soils.

Other geologic resource management issues

Slope Processes

Besides streambank erosion, as described above under "Flooding and fluvial processes", only minor slope mass wasting occurs within the park. The highest, steepest slopes occur at the Bodmer overlook (fig. 4); the larger, higher buttes are several miles north and south of the park. A minor slump in 2010 exposed an Indian burial site. Some mapped colluvium reveals occasional mass wasting in the northern reaches of the park.

Seismicity

North Dakota is not considered to be an area prone to seismic hazards. A magnitude 2 earthquake occurs in the state on average once a decade. However, the northwest corner of the state is considered at the highest risk for seismic shaking in North Dakota. The largest local earthquake felt in northwest North Dakota was a magnitude 5. Its epicenter was in Canada. There are buried geologic structures in the park area that could slip to accommodate tectonic stresses. In other words, an earthquake could happen anywhere, but is relatively unlikely.

Disturbed lands

The lower parking lot west of the fort is located in a low depression and was once a gravel mine prior to the establishment of the park. This operation once quarried through the base of the old fort, but the slope was recontoured to the historic appearance after establishment of the park. Immediately east of the fort is a small quarry that is still being used for park maintenance use (i.e. NPS Administrative sand and gravel) (fig. 5). These gravel deposits are likely a mix of glacio-fluvial sediments. There is an old agricultural dumpsite near the park boundary on the southern bank of the Missouri River. Local residents historically pushed machinery over the edge of the Missouri River bank, and the river promptly washed the debris away.

Figure 3. Active slumping along the south riverbank across the Missouri River from the fort at Fort Union Trading Post National Historic Site. Photograph by Trista L. Thornberry-Ehrlich (Colorado State University), August 17, 2011.


Figure 4. View to the north of Bodmer Overlook from the fort. Photograph by Trista L. Thornberry-Ehrlich (Colorado State University), August 17, 2011.


Figure 5. View to the east of the small, active gravel quarry just east of the fort. Photograph by Trista L. Thornberry-Ehrlich (Colorado State University), August 17, 2011.

Features and Processes

History and geology connections

Fort Union Trading Post National Historic Site focuses on the human stories of fur trapping and trading, and the rich history of the upper Missouri River area. This historical setting has many connections with the geologic framework and processes that shaped the landscape (e.g., Missouri River fluvial processes and glaciation). As described below, under “Glacial features”, vast continental glaciers covered the park area during the Pleistocene Epoch. Approximately 12,000 years before present, the ice retreated from the area after diverting the Missouri River southward. The confluence of the Missouri and Yellowstone rivers was a focal point for wildlife and attracted the first human inhabitants of the area, American Indians of the northern Great Plains. Later, American and European explorers discovered the natural richness of the area including the Lewis and Clark expedition in 1804. Notable personalities and geological studies/surveys of the area include: George Catlin (famous for western paintings), the German prince Maximillian, Edward Harris (collected fossils for the Philadelphia Academy of Natural Science), John James Audubon (studied area mammals), J. C. Fremont (following the Oregon trail), Evans and Shumard in 1853 (surveyed geology and paleontology), F.V. Hayden in 1857 (presented a composite Fort Union section in the confluence area, and with Meek described Fort Union’s classic fossil fauna), and Raynolds in 1859–1960 (explored the Yellowstone and Missouri rivers).

The Missouri River was a major transportation corridor and valued trade route during the early western exploration of the North American continent. The American Fur Trading Company constructed Fort Union Trading Post to serve trading operations along the upper Missouri River. During the June river rise (from meltwater from the west), steamboats were able to travel up the river to the trading post and deliver goods for trade and gather the pelts from the previous season. Though this passing was dangerous, the fort’s location gave the American Fur Company and Fort Union a competitive advantage over other fur trading forts.

The Fort was constructed of wood and stone. Building stone is locally scarce due to the poorly exposed and consolidated Paleocene-age bedrock. Throughout North Dakota, sandstone caprock and glacial erratics provide most of the building stone. Buttes and highlands are supported by more resistant sandstones which likely provided the source material for the bastions and powder magazine of the fort, which are within the reconstructed fort structures (fig. 6). There is a quarry near Hardscrabble, North Dakota, approximately 10 km (6 mi) away that may have provided local building material for the fort.

Paleontological resources

According to the paleontological resource inventory and monitoring report prepared by the Geologic Resources Division for the Northern Great Plains Network and Fort Union Trading Post National Historic Site, fossils have not yet been documented from the geologic units within the park boundaries (Tweet et al. 2011). There is a long history of fossil collection from the Fort Union vicinity, including collecting by Edward Harris and John James Audubon in 1843. Local collecting by Ferdinand Vandiveer Hayden between 1855 and 1860 yielded a classic “Fort Union” freshwater mollusk fauna. The famous Johnsrud collection of myriad leaf fossils from over 20 species was collected in nearby Trenton, North Dakota.

In-situ fossil remains in the locally-exposed Bullion Creek Formation may include coal, petrified wood, and freshwater mollusks. Plants or gastropods may be present in concretions within the Bullion Creek Formation. Microfossils may include foraminifera, diatoms, spores, and pollen. Flora assemblages may include more than 100 taxa: leaves, ferns, water lilies, dawn redwood, bald cypress, katsura, palms, palmettos, plant trees, and magnolia. Invertebrates may include bivalves, gastropods, insects, ostracodes, crustaceans, and worm burrows. Among vertebrate remains may be sharks, bony fish, salamanders, frogs, turtles, snakes, crocodilians, birds, and mammals. The Sentinel Butte Formation may contain coal, silicified peat, pollen, plant macrofossils, spores, freshwater bivalves and gastropods, ostracodes, beetles, fish, giant salamanders, turtles, champsosaurs, crocodilians, and mammals. The Quaternary deposits of the Oahe Formation may also contain fossil resources including charcoal, burrows, pollen, spores, aquatic microfossils, plant fragments, shell fragments, ostracodes, insect fragments, and vertebrate fossils such as mammoth remains. Insect impressions may be present in clinker (local "brick" or "scoria" layers created by burning lignite coal seams) layers. A formal (field-based) paleontological inventory of on-site resources has not been completed for Fort Union Trading Post National Historic Site.

Glacial features

During the Pleistocene, episodic cooler climates led to widespread glaciations. Of these, the Illinoian and later Wisconsinan events strongly influenced the development of the landscape in the Fort Union Trading Post National Historic Site area. The park sits at or near the glacial terminus of the last major ice advance and the surrounding area exhibits a glaciated landscape to the north and an unglaciated landscape to the south. The Missouri River's course was changed from a northeasterly direction (toward Hudson Bay) to its present southeastern flow by glaciers during the last major glacial advance. The Little Muddy River, northeast of Fort Union, used to be approximately the same size as the modern Missouri River. The confluence of the Yellowstone and Little Missouri rivers was located north of its present-day location.

North of the park area, there is topography typical of a glaciated landscape including moraines and ice contact deposits. The geologic unit "Qac" within the park contains glacial outwash deposits. These are generally coarse gravels and sands indicating a close proximity with the glacial terminus. Finer grained material tends to be washed further away from the melting glacier. At this time, the Missouri River was acting as a major trench to carry glacial outwash away.

Soils developed from the glacial deposits at Fort Union Trading Post National Historic Site. Complex interactions between parent material, time, climate, topography, and organisms (plants and animals) create soil to a particular depth, below which soil processes are not active. A soils inventory map of the park was completed in 2006–2007 by the NPS Soil Resources Inventory. This data is available from the NPS Datastore (http://science.nature.nps.gov/nrdata/).

Other notable features

Fort Union Formation

Although there is no defined, exact "type" section, the Fort Union Trading Post area served as a type locality for the Fort Union geologic formation. This is an area where this particular unit of rock is well-exposed and/or first described. Geologist Hayden first presented a Fort Union section from the river confluence area in 1857. At this time, he also described the Great Lignite Tertiary Basin, known today as the Williston Basin—a site of noncontinuous deposition since the Ordovician over 440 million years ago. This area helped geologists define the Paleocene Epoch (the period of time from 66–55 million years ago) in North America. More than 400 geological observation points (coal beds, paleontological sites, measured sections, oil and gas logs, etc.) exist along the Missouri River near the park. Formally measuring and describing a Fort Union type section would help solve local mapping issues regarding unit nomenclature among persons mapping the geologic units in the area. Coal and clinker beds could help correlate different exposures.

Aeolian features

North Dakota is ranked as having the top wind power potential in the United States. Local features associated with wind include blowouts. In these areas wind has removed all of the fine-grained material leaving a depression with coarser grained remnants behind. These blowouts frequently occur as depressions on hilltops (potentially Bodmer overlook). Blowouts also occur near large glacial erratics and may be due to bison using the large rock for scratching and subsequently removing the vegetation around the rock, exposing the deposits to the wind. Blowouts also tend to be good locations to find fossils.

Volcanic ash layers

Layers of altered volcanic ash (bentonite) occur within the geologic units (Sentinel Butte Formation) of Fort Union Trading Post National Historic Site. In some thicker layers, unaltered ash may occur. Bentonite is prone to shrink-and-swell processes; its crystalline structure swells when saturated with water and shrinks when dry. Outcrops of bentonite appear gray and display popcorn-like textures when dry. These types of clays are particularly slippery when wet and may compromise road and trail integrity.

The eruptions of Mt. St. Helens in the early1980s deposited distinct layers of ash over the park area. These ash layers added nutrients to the soil profile and impacted the local natural environment.

Figure 6. Southwest bastion of Fort Union composed in part of locally-sourced sandstone. Photograph by Trista L. Thornberry-Ehrlich (Colorado State University), August 17, 2011.

Recommendations for Resource Managers and GRI

1. Consult U.S. Geological Survey website regarding the seismic risk in the Fort Union Trading Post National Historic Site area.
2. Conduct a field-based paleontological survey of Fort Union Trading Post National Historic Site.
3. Consult with NPS-GRD for recommendations for stabilizing the riverbank in sensitive resource areas and investigate rates of riverbank retreat along the southern bank.
4. Consult the North Dakota Geological Survey website for general geologic guidance, information related to landslides, and mineral resources development information.
5. Download soils and GRI geologic digital maps from the NPS DataStore (http://science.nature.nps.gov/nrdata/) for use in resource management.
6. Obtain oil and gas development information from the North Dakota Oil and Gas Division website (https://www.dmr.nd.gov/oilgas/).
7. Contact Pat O'Dell and/or Edward Kassman at NPS-GRD regarding oil and gas issues and mineral rights.

Action Items

1. GRI report author will note the preference of using Paleogene, Eocene, etc. in lieu of Tertiary on the Map Unit Properties Table in the final GRI report.
2. GRI report author will note nomenclature differences of geologic units between state surveys, academics, and USGS. A map by Johnson and Kunkel has an appropriate stratigraphic column.
3. GRI report author will consult Geologic Resources Division (2006) Potential for the Development of Oil and Gas Resources in and adjacent to Fort Union Trading Post National Historic Site, Williston, North Dakota and Strategies for addressing such Development. Internal Report, Geologic Resources Division, National Park Service, Denver, Colorado, USA.
4. GRI report author will use Ellis, L. 2005. Geomorphological Assessment of Bank Erosion along the Missouri River near Fort Union Trading Post National Historic Site (FOUS) North Dakota. Geoscientists-in-the-Parks document 2005-FOUS. National Park Service, Denver, Colorado, USA when preparing final geological report.

References

Tweet, J.S., V. L. Santucci, and J. P. Kenworthy. 2011. Paleontological resource inventory and monitoring—Northern Great Plains Network. Natural Resource Technical Report NPS/NRPC/NRTR—2011/437. National Park Service, Fort Collins, Colorado.

National Park Service. 2011. Fort Union Trading Post National Historic Site. www.nps.gov/fous (accessed August 18, 2011).

Hoganson, J. W. and E. D. Murphy. 2003. Geology of the Lewis & Clark Trail in North Dakota. Mountain Press Publishing Company, Missoula, Montana, USA.

North Dakota Geological Survey. 2011. https://www.dmr.nd.gov/ndgs/ (accessed August 29, 2011).

Table 2. Scoping Meeting Participants

Name	Affiliation	Position	Phone	E-Mail
Ken Anderson	NPS, FOUS	Maintenance	701.572.0233	Ken_m_anderson@nps.gov
Andy Banta	NPS, FOUS	Superintendent	701.572.1029, ext. 211	Andy_banta@nps.gov
Eric Brevik	Dickinson State University	Associate Professor of Geology and Soils	701.483.2359	eric.brevik@dickinsonstate.edu
Tim Connors	NPS, Geologic Resources Division	Geologist	303.969.2093	tim_connors@nps.gov
Joseph Hartman	University of North Dakota	Professor, Department Chair	701.777.5055	joseph_hartman@engr.und.edu
Mike Hodgkinson	NPS, FOUS	Maintenance worker supervisor	701.572.0233	Mike_hodgkinson@nps.gov
Lisa Norby	NPS, Geologic Resources Division	Geologist	303.969.2318	lisa_norby@nps.gov
Tim Shepherd	NPS, Northern Great Plains Network	NGPN Data Manager	605.341.2809	Tim_shepherd@nps.gov
Trista Thornberry-Ehrlich	Colorado State University	Geologist		tthorn@warnercnr.colostate.edu
Loren Yellowbird	NPS, FOUS	Chief ranger	701.572.9083	Loren_yellowbird@nps.gov