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North Dakota Geological Survey
Edward C. Murphy, Acting State Geologist

GEOLOGY OF THE BISMARCK - MANDAN AREA

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LITHOLOGY

Windblown silt caps this exposure east of the railroad bridge in Bismarck.

Qw Windblown sediments are typically moderately to well sorted, grayish brown to tan, sand and silt. These sediments commonly contain one or two ancient soil horizons, or paleosols, consisting of one- or two-foot thick layers of dark brown, silty clay. The eolian sediments are often moderately to poorly vegetated. The windblown sediments in this area form gently rounded topography that slightly modifies the original topography. The silt was deposited east of the Missouri River by westerly winds that eroded flood deposits from the Missouri River Valley. These deposits are typically less than three feet thick, but may be up to 10 feet thick in places.

Modern depressions often contain dark, organic-rich silt and clay that were deposited in pond or small lake settings. **Qp** Both the windblown and pond sediments are less than 10,000 years old.

Randomly oriented pebbles and cobbles in fractured glacial till.

Qg Till is a poorly sorted mixture of pebbly, gray to brown sand, silt, and clay. Till once covered the entire area as evidenced by the presence of erratics scattered throughout the map area. Till has been eroded from much of the area and now is concentrated in the uplands surrounding the communities of Bismarck and Mandan. The uplands are generally well vegetated and till exposures are extremely limited. Exposures of till are often limited to temporary excavations made by building contractors. Till is recognizable on aerial photographs due to its relatively flat featureless surface. In contrast, the underlying, older bedrock units are highly dissected and often exhibit a discernible outcrop pattern on air photos due to the presence of alternating layers of poorly to well cemented or indurated layers. Till in this area is likely 10,000 to 20,000 years old.

Glacial outwash in terrace deposits above the Heart River west of Mandan. The cobbles in this photograph are up to 8 inches in diameter.

Qo Glacial outwash consists of moderately to poorly sorted sand and gravel deposited by melting glacial ice. Outwash sand and gravels are generally preserved in this area as terrace deposits **Qat** within the Missouri and Heart river valleys. Large-scale mining **Qor** of terrace gravels has occurred along the southern edge of the Heart River Valley (photo) as well as both south and west of the Bismarck airport. Cut terraces, such as the one the Heskett power plant and Tesoro refinery are situated upon, consist primarily of bedrock capped by a thin layer of sand and gravel. Glacial outwash in the Bismarck-Mandan area is at least 10,000 years old and may have been deposited tens of thousands of years ago.

Round "cannonball" concretions in North Bismarck. The pick in the photograph is three feet long.

Tc The Cannonball Formation is the dominant rock unit in this area. It consists of alternating beds of marine sandstone and mudstone. The Cannonball Formation was named for the rounded concretions that are typical of this unit but are rare in the surrounding nonmarine rocks. These rocks were deposited in a sea that covered portions of North Dakota approximately 61 to 64 million years ago. The Cannonball Formation has a maximum thickness of approximately 300 feet in this area. Cannonball strata are generally poorly exposed due to the vegetative cover and slopewash. The most extensive outcrops of the Cannonball Formation in this area can be found along the Heart River Valley.

An outcrop of Cannonball mudstone (gray rocks) adjacent to the Heart River west of Mandan.

Tc Mudstone in the Cannonball Formation consists of light gray to black, blocky claystone that is interbedded with lenses of white to yellowish-brown silt and very fine sand. The mudstone forms smooth, rounded slopes, not unlike the strata of the underlying Ludlow and Hell Creek formations. Approximately two-thirds of the Cannonball Formation is mudstone.

Cannonball sandstone exposed above old Highway 10 west of Mandan. A well-cemented layer of sandstone (dark brown) forms a ledge above poorly cemented (gray) sandstone.

Tc Sandstone in the Cannonball Formation is grayish-green to yellowish-brown and medium to fine grained. The sandstone is generally poorly but commonly contains two- to three-foot-thick lenses of well cemented sandstone. When present at, or near, the surface, the well-cemented sandstone lenses often create flat topography or overhanging ledges that are easily discernable on aerial photographs.

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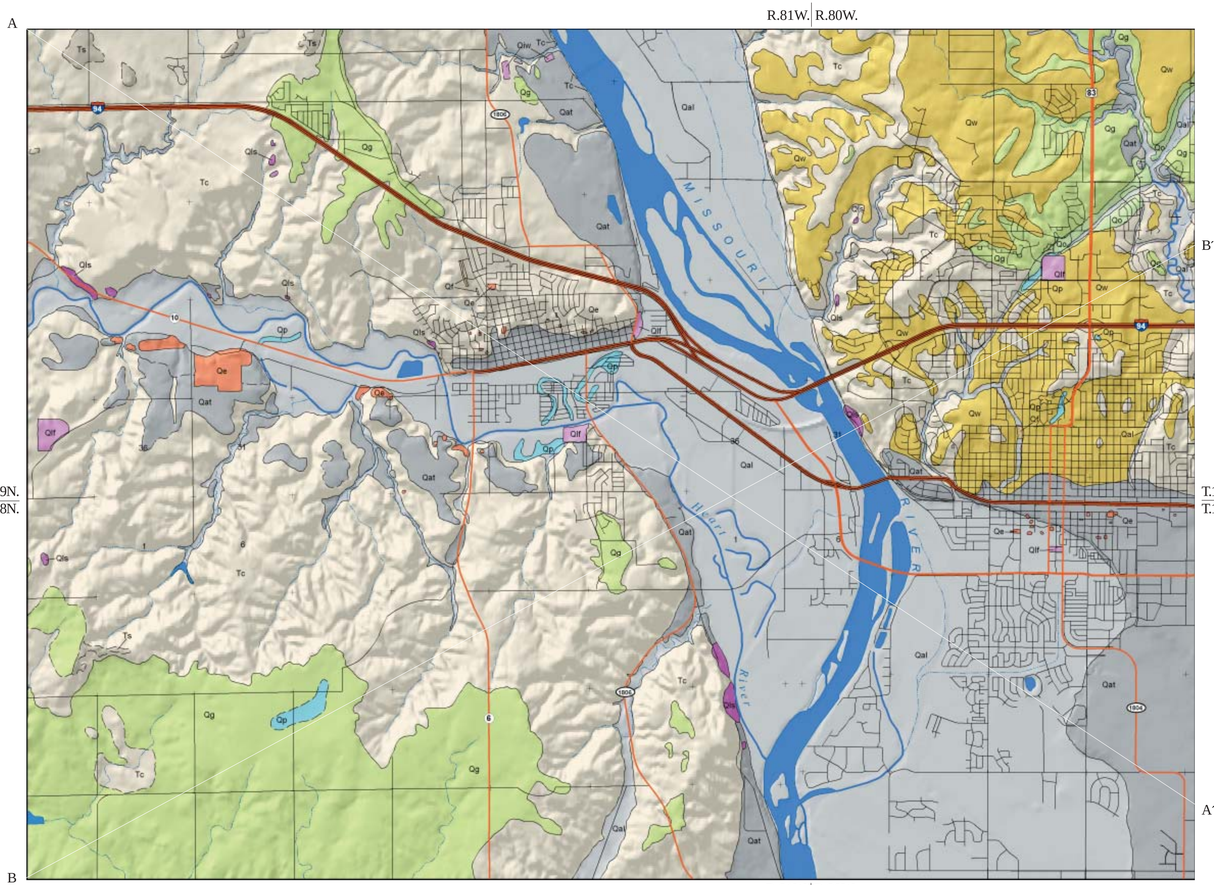
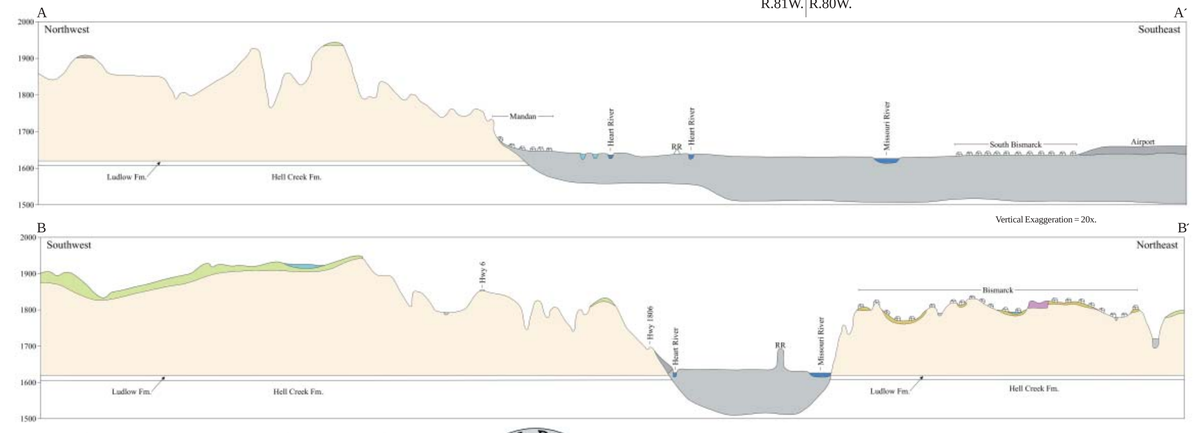
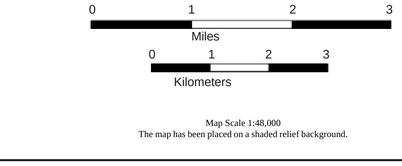
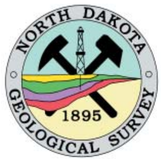






Map Scale 1:48,000
The map has been placed on a shaded relief background.



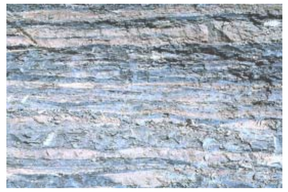
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program. Gerald Groenewold is the Director of The Energy and Environmental Research Center in Grand Forks, N.D. Gerry was a geologist with the ND Geological Survey from 1974 to 1984.

GEOLOGIC HAZARDS

SLOPE FAILURE

Slumping along the Heart River Valley in west Mandan.

A landslide closes North Dakota Highway 1806 in 1997.



Alternating lenses of sandstone and siltstone in mudstone of the Cannonball Formation.

Qls Seventeen landslides were identified in the Bismarck – Mandan area. Most of these slides likely predate settlement of the area and are hundreds, if not thousands, of years old. Typically, more recent landslides are reactivations of these older, much larger landslide complexes. Landslides may occur throughout the year but are most prevalent in the spring and early summer due to the availability of moisture from snowmelt and rainfall events. In addition, studies have shown that landslides are most active during a wet period that follows an extended dry period. For these reasons, water is often said to "lubricate a slide." Although this is an oversimplification of the mechanisms and rock properties, such as differential pore pressures, involved in slope failure, it is correct in its emphasis of the importance of water to slope movement. To a degree, landslides are self-perpetuating because more water seeps into the subsurface after a slide occurs due to the ponding of water in the newly formed surface depressions and infiltration of this water through numerous tension cracks.

Rivers and streams erode by undercutting the river banks on the outside of a meander or curve. This erosion creates oversteepened cliff faces that are highly susceptible to slope failure. Such is the case in west Mandan where landslides have occurred in the steep, tall cliffs overlooking the Heart River. A series of landslides in this area has displaced trees, a rock wall, and resulted in the abandonment of at least two lots due to safety concerns.

A landslide occurred during the spring of 1997 that displaced the roadway of ND Highway 1806 north of Fort Abraham Lincoln State Park. A four-foot scarp, the vertical rock wall exposed above a landslide, developed across the roadway leading to the permanent abandonment of this stretch of road. The dark patching material on the surface of the roadway indicates that cracks had developed in the road at this location as precursors to this larger mass movement. This most recent slide is part of a larger complex of ancient landslides that are present along the west wall of the Missouri River valley in this area. Features visible on aerial photographs of this area suggest that the toes of these ancient slides may have been cut by workers at the time they installed the old Northern Pacific spur line located below the roadway.

The mudstone of the Cannonball Formation contains interbedded lenses of sandstone and siltstone (grayish brown) and claystone (dark gray). The lenses of sand and clay in this photo range from 0.5 to 2 inches thick but can be as much as eight inches thick. The sand and clay content of the Cannonball mudstones is also variable, some mudstones are dominated by clay and others by sand and silt. Most of the mudstones in the Bismarck-Mandan area are dominated by claystone. The clays in the mudstone are mixed and contain varying percentages of swelling clays. Differential pore pressures within lenses in the mudstone and the presence of swelling clays may potentially damage building foundations.

All of the landslides identified in the Bismarck-Mandan area involve mudstones in the Cannonball Formation. Not only are these mudstones involved, but most of the slope failures appear to have originated within these rocks.

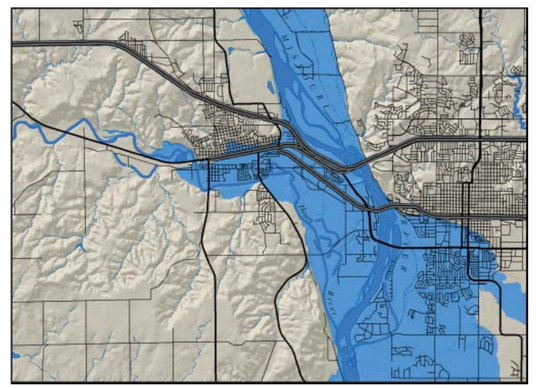
MUNICIPAL SOLID WASTE

Municipal garbage, more than 30 years old, unearthed while installing buried cable along Century Avenue in 1998.

Qlf A 1938 aerial photograph shows a small gravel pit was operating near the soccer and football fields at Century High School in Bismarck. Within the next ten years, garbage was being dumped into the old gravel pit. Burning garbage is visible on an aerial photograph of the site taken in May, 1948. In addition, garbage can be seen in standing water in the ravine adjacent to the site. By the late 1950s, garbage was being dumped into east-west trending trenches as the dump expanded towards the south. The site closed in 1964. This site was about one mile north of town when it was first used as a garbage dump. As a result of urban sprawl, the 40 acres of buried ash and garbage is surrounded by homes, businesses, and a school and is overlain by a softball complex, athletic fields, and the Century High School parking lot.

At least three other garbage dumps are present in this area. A garbage dump operated near the Law Enforcement Center in south Bismarck prior to 1938 and closed in 1950. Another dump that was in operation prior to 1938 was located east of the corner of Third Street and Main Avenue in Mandan. This dump was closed by 1964. A third garbage dump eventually became a sanitary landfill. It was in operation from 1950 to 1986 along the southern edge of the Heart River Valley in south Mandan. A municipal solid waste landfill is currently operating southwest of Mandan.

FLOODING AND SEEPAGE



Area inundated (in blue) by the historic flood of March 31, 1881.

The highest recorded level of the Missouri River (1,649.88 feet) occurred on March 31, 1881. At this elevation, most of the area now occupied by the southern portions of Bismarck and Mandan would have been under 10 feet of water (see adjacent map.) The Missouri River has exceeded the 1,632 foot mark three times since Garrison Dam was constructed (July, 1975; December, 1979; and July, 1997). The last occurrence (1,632.38) caused bank erosion and forced some river-front homeowners to shore up the riverbanks in the Bismarck area to protect their property.

Overland flooding from unusually large rainfall events is a potential problem for homeowners in the area. Overland flow is focused into ravines and coulees that lead into the Heart and Missouri rivers. These ravines formed over the last 10,000 years, since the last glacier receded from this area. Development, particularly in north Bismarck, has partially or completely filled portions of these drainages with construction fill. Surface water and shallow groundwater still tend to concentrate along these courses. One of these, a four-mile long ravine, runs from Hay Creek to Zonta Park via the Tom O'Leary golf course. Perched groundwater can be concentrated at a number of stratigraphic horizons including: the base of construction fill, the contact between Cannonball sandstone and underling mudstone, as well as the upper surface of thin, well cemented sandstone layers in the Cannonball Formation. Seepage is a potential problem for basement slabs that are in close proximity to any of these settings.