Surficial Geology of the Norden 7.5 Minute Quadrangle, Nebraska

R.M. Joeckel[1], L.M. Howard[1], S.T. Tucker[2], G. Nuzzo[3], and
[1]Conservation and Survey Division, University of Nebraska-Lincoln
[2]Highway Paleontology Program, University of Nebraska State Museum, University of Nebraska-Lincoln
[3]Water Science Program, University of Nebraska-Lincoln

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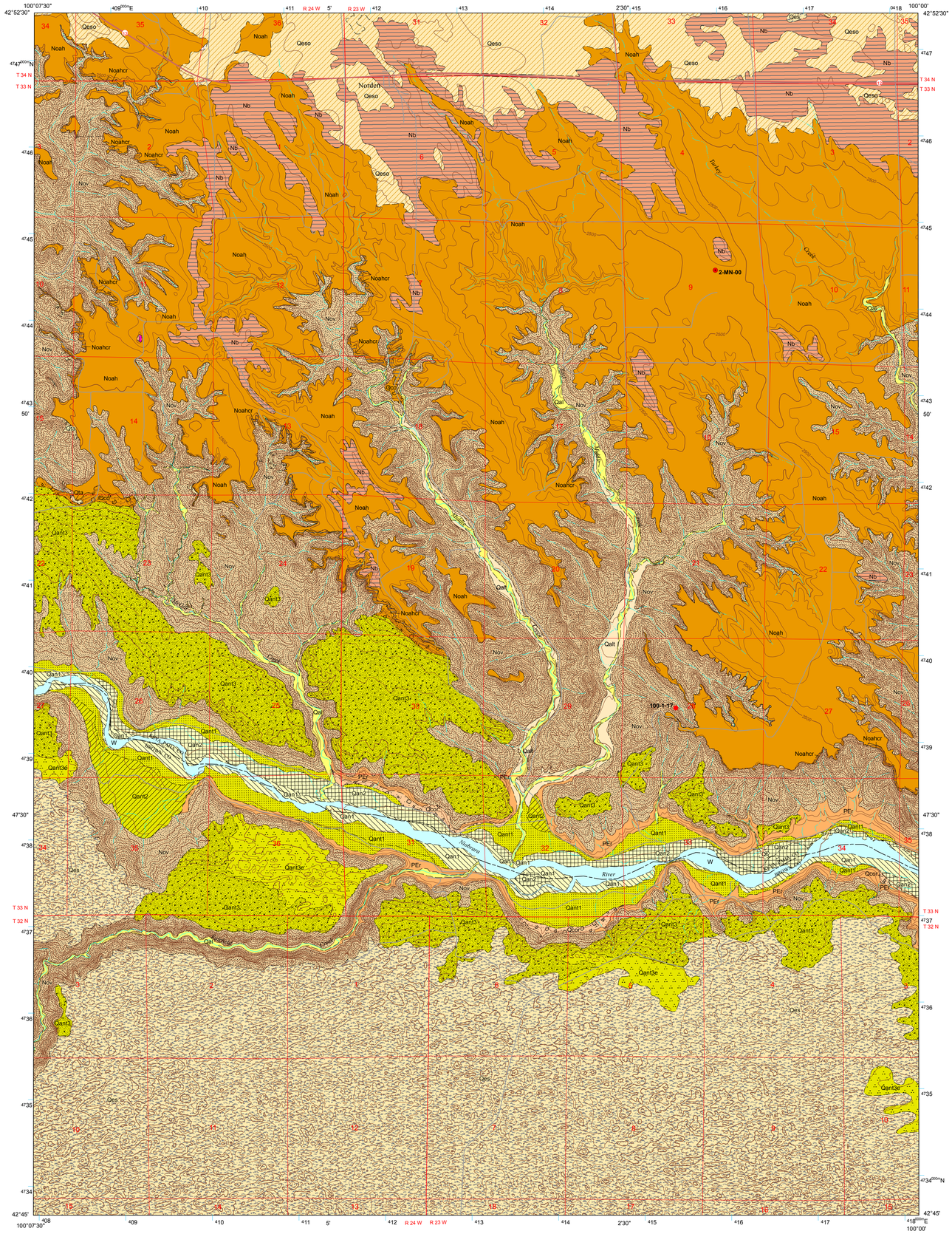


SCALE 1:24000

1 0.5 0 1 Miles

1,000 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 Feet

1 0.5 0 1 Kilometers

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Projection: Universal Transverse Mercator, zone 14 North, NAD83.
1,000-meter Universal Transverse Mercator grid ticks shown in blue.

Contours from the Nebraska Department of Natural Resources, Compiled from USGS 7.5 minute topographic quadrangles.

Additional base data derived from the 2010 TIGER line files.

5½° TRUE NORTH MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2017

Norden NW	Hayford Lake	Meadville NW
Muleshoe Creek	Norden	Huddle Table
Wood Lake	Wood Lake NE	Ainsworth NW

NEBRASKA
MAP LOCATION

Description of Mapping Units

Qaf **Quaternary alluvial fan (Holocene; early 21st cenruty)**

Very fine to fine sand and silty very fine to fine sand.

There are a few, very small alluvial fans on the lowest alluvial terrace and on the floodplain along the north side of the Niobrara River in sections 33 and 34 of T. 33 N., R. 23 W. These very small fans appear to have been formed because from enhanced erosion and local deposition in the aftermath of the extensive July 2012 wildfires in the Niobrara River Valley.

Qal **Quaternary alluvium of smaller streams (Holocene, including modern)**

Very fine to fine sand with minor silt, silty sand, and gravel.

Alluvium of lower-order streams is mapped as Qal. In the mapped area, these deposits are overwhelmingly dominated by sand.

Qalt **Quaternary alluvium of terraces of smaller streams (Holocene, including modern)**

Very fine to fine sand with minor silt, silty sand, and gravel.

This mapping unit is texturally the same as mapping unit Qal and genetically related to it. Qalt represents young terraces of lower-order streams produced by entrenchment in very recent geologic times, including the 20th century.

Qco **Colluvium derived from strata of the Ogallala Group (Quaternary)**

Very fine to fine sand and pebbles to boulders of carbonate-cemented sandstone.

This mapping unit is colluvium eroded locally from the sandstone of the Cap Rock Member of the Ash Hollow Formation, the overlying Merritt Dam Member, and the underlying Valentine Formation. It may interfinger with Quaternary terrace deposits of the Niobrara River downslope.

Qcor **Colluvium and residuum (Quaternary)**

Very fine to fine sand, or sand with locally derived calcareous sandstone and/or siltstone fragments; may also contain coarser sand and gravel clasts.

This mapping unit is thin regolith derived from the weathering and erosion of the Rosebud Formation and from the erosion of the overlying Ogallala Group. It may also contain material eroded from Quaternary terrace fills in some places.

Qta **Sandstone talus (Holocene)**

Discontinuous accumulations of subangular to angular cobbles to large boulders of friable sandstone.

This mapping unit includes the more prominent accumulations of talus blocks (as much as several meters in length) from the erosional retreat of the canyon-rim escarpment formed by the Cap Rock Member of the Ash Hollow Formation. These talus blocks lie atop unconsolidated sands of the Valentine Formation and/or sandy colluvium.

Qan1 **Historical alluvium of present Niobrara River (modern; 20th century)**

Light gray to very pale brown, very fine to fine sand with minor, fine gravel.

This mapping unit encompasses recent historical alluvium of the present Niobrara River. Areas mapped as Qan1 have a risk of flooding during the river's rare high-stage flows. Essential all of the areas areas mapped as Qan1 are within the channel belt of the Niobrara River as it was roughly delineated in the original General Land Office surveys of 1875. This observation, together with the examination of historical aerial photographs, suggests appreciable narrowing of the channel belt and the accretion of former distal braid channels and bars during the past 140+ years, and chiefly after the 1930s.

Qan2 **Older (distal) alluvium of present Niobrara River (Holocene; post- 1875)**

Light gray to very pale brown, very fine to fine sand with minor, fine gravel.

This mapping unit encompasses alluvium of the present Niobrara River that is older and more distal from the river than is mapping unit Qan1, and also higher in elevation than the latter mapping unit. Most of the total area mapped as Qan2 lies inside of the limits of the channel belt of the Niobrara River as it was delineated in the original General Land Office surveys of 1875. We urge caution in the interpretation of age relationships on the basis of the 1875 surveys, however, because the course of the Niobrara River appears to be highly approximated. Areas mapped as Qan2 have a very minor risk of flooding during the rare high-stage flows on the Niobrara River, if there is any flood risk at all.

Qes **Eolian sands of the Nebraska Sand Hills (late Pleistocene and Holocene)**

Light brownish gray, very pale brown, pale brown, and brown, well-sorted, very fine to fine sand.

This mapping unit represents eolian sands at the northern margin of the Nebraska Sand Hills. Barchanoid ridge dunes gradually decrease in width and height southwestward across Cherry County, west of the present mapped area. Although the dunes mapped within Qes are the largest ones in the quadrangle, they are still smaller and less distinct than the larger dunes south and southwest of the mapped area.

Qeso **Eolian sands (Holocene) atop shallow strata of the Broadwater Formation and the Ash Hollow Formation of Ogallala Group (Holocene)**

Light grayish brown to grayish brown, very well-sorted, very fine to fine sand atop much lighter-colored sands and friable siltstones and sandstones of the Ash Hollow Formation.

Coppice and indistinct dome dunes are common in areas mapped as Qeso, but eolian sands in these areas are very thin in comparison with those of mapping unit Qes. Interdune areas may be eroded into the underlying Broadwater and Ash Hollow formations. Sands of mapping unit Qeso are finer than those of the Broadwater Formation and lack pebbles. They are also very well-sorted and distinctly browner in color than are the sands and sandstones of the underlying Ash Hollow Formation.

Qant3e **Topographically high alluvial terrace fills of Niobrara River (late Pleistocene)**

Light gray, pale yellow, grayish brown, and very pale brown, very fine to fine sand and silty sand with minor gravel consisting of clasts of white, carbonate-cemented, very fine to medium sandstone (derived from the erosion of the Ash Hollow Formation), as well as crystalline lithologies. Qant3 may overlie thin sands of the Valentine Formation or siltstones of the Rosebud Formation.

This mapping unit represents the fill of the prominent high terrace on the south side of the Niobrara River. These sediments have been referred to as the "Connely Flat Beds" by Larson (2001) and Jacobs et al. (2007), and fossils from them are assigned to the Rancholabrean North American Land Mammal Age (NALMA).

Qant1 **Topographically low alluvial terrace fills of Niobrara River (Holocene?)**

Light gray, grayish brown, and very pale brown, very fine to fine sand with minor gravel consisting of white sandstone clasts (see forthcoming description) and crystalline lithologies. Contains localized pebble to cobble gravels dominated by clasts of white, carbonate-cemented, very fine to medium sandstone (derived from the erosion of the Ash Hollow Formation), cobbles and boulders of opaline-silica-cemented sandstone (derived from the erosion of the Valentine Formation), and carbonate nodules and siltstone clasts eroded from the Rosebud Formation.

This mapping unit covers the lowest terraces of the Niobrara River, which lie well above the level of mapping units Qan1 and Qan2. Deposits of mapping unit Qant1 deposits probably overlie the eroded Rosebud Formation or the basal Valentine Formation. They exceed 3 m in thickness in many places.

Qant2 **Topographically intermediate alluvial terrace fills of Niobrara River (late Pleistocene)**

Light gray, pale yellow, grayish brown, and very pale brown, very fine to fine sand and silty sand with minor gravel consisting of clasts of white, carbonate-cemented, very fine to medium sandstone (derived from the erosion of the Ash Hollow Formation), as well as crystalline lithologies. This mapping unit includes a prominent, very dark brown, clay-rich paleosol with prominent blocky structure and filaments of white carbonate. Qant2 deposits may exceed 7 m in thickness and they are heavily dissected, mak ing the fill terrace they compose less prominent than lower and higher terraces of the Niobrara River.

This mapping unit encompasses fill terraces of the Niobrara River at intermediate levels between the highest and lowest terraces thereof (i.e., mapping units Qant1 and Qant3).

Qant3 **Topographically high alluvial terrace fills of Niobrara River (late Pleistocene)**

Light gray, pale yellow, grayish brown, and very pale brown, very fine to fine sand and silty sand with minor gravel consisting of clasts of white, carbonate-cemented, very fine to medium sandstone (derived from the erosion of the Ash Hollow Formation), as well as crystalline lithologies. Qant3 may overlie thin sands of the Valentine Formation or siltstones of the Rosebud Formation.

This mapping unit represents the fill of the prominent high terrace on the south side of the Niobrara River. These sediments have been referred to as the "Connely Flat Beds" by Larson (2001) and Jacobs et al. (2007), and fossils from them are assigned to the Rancholabrean North American Land Mammal Age (NALMA).

Nb **Broadwater Formation (Pliocene-?early Pleistocene)**

Pale brown to yellowish brown, fine- to coarse-grained, crystalline pebble gravels, and fine- to very coarse-grained sands and pebbly sands.

Skinner and Hibberd (1972) described sands and gravels at high elevations in the general vicinity of the mapped area as the "Long Pine Formation." These sediments are now considered in Nebraska to be the Broadwater Formation, a deposit produced by major bedload rivers (the ancestral Platte River system) draining the Rocky Mountains to the west. It is very likely that the Broadwater Formation was much more continuous and sheetlike in its geometry prior to the late Pleistocene. Eolian and stream erosion in the uplands north of the Niobrara River have left mere remnants of the unit, many of which tend to be elongate from northwest to southeast. This orientation is parallel to the direction of strong winds during the Late Pleistocene, suggesting that wind played a major erosive role.

Noahcr **Cap Rock Member of Ash Hollow Formation of Ogallala Group (late Miocene)**

White to pale yellow, weakly to moderately indurated, carbonate-cemented, very fine to medium sandstone and silty sandstone, with a distinct "salt and pepper" aspect; contains rhizoliths in many places.

The Cap Rock Member (Skinner et al., 1968; Skinner and Johnson, 1984) of the Ash Hollow Formation is mapped as a separate unit only where it can be distinguished in aerial imagery. Thus, it is mapped chiefly on the south- and west-facing edges of the rolling uplands north of the Niobrara River and at the rim of the river's deep canyon. The Cap Rock member is thicker in the Norden Quadrangle than it is in the vicinity of Valentine, Nebraska to the west.

Noah **Ash Hollow Formation of Ogallala Group, undifferentiated (late Miocene)**

Mostly unconsolidated, well-sorted, white, light gray, very pale brown, light brown, and pale yellow, fine to medium sand with a distinct "salt and pepper" aspect due to the presence of dark mineral grains. Thin, white, carbonate-cemented sandstones exist within the unit, as well as the much thicker, basal member of the formation (Cap Rock Member), which is mapped as a separate unit only where it is discernible in aerial imagery. White, light gray, very pale brown, and pale yellow, soft, calcareous siltstones and sandy siltstones are common, but volumetrically subordinate components of the Ash Hollow Formation. This mapping unit may also include thin residuum and colluvium derived from the weathering of the Ash Hollow Formation.

The fluvial sediments of the Ash Hollow Formation (Figs. 1, 6-8) were subdivided by Skinner and Johnson (1984) into a lower member (Cap Rock Member, which mapped separately where discernible in aerial photographs) and a thicker, overlying member (Merritt Dam Member) in the Niobrara River Valley. Where the Cap Rock Member is mapped as a separate unit, overlying strata are those of the Merrit t Dam Member. The total thickness of the Ash Hollow Formation is approximately 100 ft or 30.5 m in the mapped area. Fossil remains from the Ash Hollow Formation belong to the medial to late Clarendonian NALMA (Cl2 and Cl3 of Tedford, et al., 2004) ranging in age from 9.5-12.0 Ma. In much of the northern half of the map, the Ash Hollow Formation appears to have undergone extensive eolian erosion during the Late Pleistocene and Holocene.

Nov **Valentine Formation of Ogallala Group (late Miocene)**

Dominantly unconsolidated, well-sorted, white, light gray, very pale brown, light brown, and pale yellow, very fine to medium sand with a distinct "salt and pepper" aspect due to the presence of dark mineral grains. A distinct unit of light gray to pale yellow sandy siltstone (Cornell Dam Member of Skinner and Johnson, 1984) is present regionally in the lower Valentine Formation. Local carbonate-cemented sandstone strata or masses appear in the Valentine Formation in the Norden Quadrangle. Rounded, irregular masses or larger lenses of gray to greenish gray, opaline-silica-cemented sandstone also appear locally in the basal Valentine Formation (Crookston Bridge Member of Skinner et al., 1968). This mapping unit may also include thin, sandy colluvium derived from the Valentine Formation, which may be difficult to distinguish from the formation itself.

Skinner et al. (1968) and Skinner and Johnson (1984) subdivided the fluvial sediments of the Valentine Formation into the following members, in ascending stratigraphic order: Cornell Dam, Crookston Bridge, Devil's Gulch, and Burge members. Almost all of the Valentine Formation is unconsolidated sediments. The maximum thickness of the Valentine Formation exceeds 200 ft or 61 m in the mapped area. Fossils remains from the lower three members of the Valentine Formation fall within the late Barstovian NALMA (Ba2 of Tedford, et al. 2004) ranging from approximately 12.6-14.0 Ma. The Burge Member lies within the early Clarendonian NALMA (Cl1 of Tedford, et al., 2004) roughly 12.0-12.5 Ma.

PEr **Rosebud Formation (late Oligocene)**

Dominantly massive and prismatic- to subangular-blocky-weathering siltstone, very pale brown, light brown, yellowish brown, or brown when dry, and in commonly appearing reddish brown and dark reddish brown when wet. The uppermost 1-3 m of siltstone below the formation's upper contact may be pale yellow or white when dry. Wavy, horizontal to slightly inclined, irregular, white to pale yellow bands = 5 cm in thickness and spaced at vertical distances of a few centimeters to a few decimeters, are common in the massive to blocky- and prismatic-weathering siltstones in the upper part of this formation and render it readily identifiable in outcrop. Prismatic and blocky structure, as well as other features, identify a pervasive pedogenic overprint in Rosebud Formation siltstones. In addition to the dominant, banded siltstones lithofacies, subordinate lithofacies include: (1) massive very pale brown; light yellowish brown, and brown siltstones that do not exhibit blocky weathering, (2) burrowed siltstones exhibiting the same range of colors (Fig. 4); (3) lenticular to sheetlike friable sandstones of varying thickness; and (4) lenticular, intraformational, and typically clast-supported, granule to cobble breccias and conglomerates consisting of subangular to subrounded siltstone clasts (Fig. 5). Large, sheetlike sand bodies are very rare in the Rosebud Formation in the region.

The strata mapped herein as the Rosebud Formation have long been recognized as a distinct unit within the Arikaree Group (e.g., Skinner et al., 1968; Skinner and Johnson, 1984). The exact identity and age of all of the strata grouped under the name "Rosebud" in Nebraska and South Dakota, however, have been debated for some time (Martin, 2011). The strata mapped as Rosebud Formation in the Cornell Dam Quadrangle are a coherent set of distinctive lithofacies that, in the context of evolving regional stratigraphic schemes, are almost certainly of late Oligocene age (Martin, 2011). Future work may better constrain the age of this formation. The Rosebud Formation is indisputably terrestrial in origin, but exceedingly little interpretation of its depositional environments has yet been made. Sheer cliff-face exposures of the Rosebud Formation in the mapped area are difficult to examine in detail, but they are clearly dominated by siltstones, which may be floodplain fines, loessic deposits, or a combination of both. Cut-and-fill within sequences of thin siltstones and siltstone-clast conglomerates are prominent in a few exposures. These sequences are interpreted to be gully-fill deposits or the deposits of small streams. One exposure of the upper Rosebud Formation exhibits a comparatively thick (> 3 m) sheetlike sand body with macroform accretion surfaces indicates bar accretion within a fluvial channel of modest depth. There is a prominent break in slope at the contact between the Valentine and Rosebud formations, the latter unit forming prominent cliffs and benches along the Niobrara River. Stream knickpoints, particularly in the form of waterfalls have developed in many places within the Niobrara River Valley at the upper contact of the Rosebud Formation.

P **Pit**

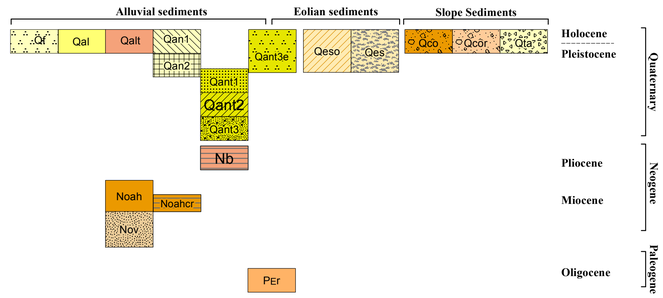
W **Water**

New core hole (drilled during this study)

Historic test hole

Map unit contact, certain

Map unit contact, approximate



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IANR University of Nebraska Lincoln