Surficial Geology of the Fairmont 7.5 Minute Quadrangle, Nebraska

P.R. Hanson, A.R. Young, A.K. Larsen, L.M. Howard, J.S. Dillon, Conservation and Survey Division
(Nebraska Geological Survey), School of Natural Resources, University of Nebraska-Lincoln

Surficial Geology Overview

The Fairmont Quadrangle is located in east-central Nebraska south of the Platte River valley and along the western boundary of the glacial limit. The region is characterized as low-relief hills and plains that were historically covered in tallgrass prairie. The surficial geology of the local landscape is dominated by loess that overlies glacial sediments and abandoned alluvium that was deposited by the Platte River. These alluvial sediments were likely deposited around ~200,000 years ago (Swinehart et al., 1994) when the Platte River flowed south of its current valley. The region contains multiple ephemeral lakes and wetlands that are locally called 'Rainwater Basins'. These enigmatic features formed prior to Peoria Loess deposition (>25,000 years ago) and are described below. The low relief of this landscape is due to the fact that loess deposition filled in features on the underlying broad and relatively flat alluvial plain that was deposited by the Platte River. These unconsolidated sediments overlie Cretaceous Carlile Shale in the study area.

Platte River Alluvium

The entirety of the mapping area has eolian deposits at the ground surface, but these overlie alluvium deposited by the Platte River. These alluvial sediments would have initially been deposited as broad, low relief braid plains that are predominantly sand and gravel. The alluvial sand and gravel is capped with eolian sand in the form of dunes or sand sheets that are up to 8 m (25 ft) thick in the northern portion of the map. Late Quaternary loess deposits that are up to 14 m (45 ft) thick cover the Platte alluvium in the south. The fills also locally include (and in some cases directly overlie) undifferentiated silt deposits, which may be of either alluvial or eolian origin. The Pleistocene-age sediments range from 26 to 72 m (85 to 235 ft) in total thickness. This package of sediments directly overlies the Miocene Ogallala Group which varies from 11 to 58 m (37 to 190 ft), and lies on the Cretaceous Pierre Shale.

Glacial Sediments

The Fairmont quadrangle lies at the western edge of the glacial limit in Nebraska. These glacial deposits date from approximately 2,500,000 to 600,000 years ago (Boellstorff, 1978a; 1978b; Roy et al., 2004). These sediments include till, glaciolacustrine, glaciofluvial and related materials. Historic CSD Test Holes 60-B-49, 61-B-49, and 62-B-49 encountered moderately to very calcareous glacial till along the western edge of the F airmont quadrangle (Burchett and Summerside, 1995; Smith, 2000). Test holes showed the till lies between approximately 457 to 433 meters (1500 to 1420 feet) in elevation, and was encountered between 19 to 46 meters (65 to 152 feet) below the ground surface.

Loess

Late-Pleistocene Peoria loess (**Qp**) is exposed at the ground surface over much of the quadrangle. The Peoria Loess is composed of wind-blown silt that was deposited between approximately 25,000 and 14,000 years ago (Bettis et al., 2003; Mason et al., 2011; Muhs et al., 2013). In the mapping area, the Peoria Loess ranges from 3.5 and up to about 6 meters (12-20 ft) in thickness. The Peoria is directly underlain by eolian dunes locally on the map. The dunes are particularly well developed and central and northeastern portion of the map. Peoria also is found overlying alluvium in the West Fork of the Big Blue River valley (**Qp/Qal**). In this case the alluvium directly underlying the loess was deposited by this stream rather than by the Platte River.

The Gilman Canyon Formation underlies the Peoria loess locally within the mapping area. The Gilman Canyon Formation, where present, is a thin (~1-2 meter) loess with a thick, dark-colored, cumulic pedocomplex formed in its upper portions. Loveland loess (**Ql**) is present in the region from historic and recent CSD test holes, but also is exposed along the West Fork of the Big Blue River valley. Loveland exposures in the mapping area are limited to the southern and eastern edge of the valley. The Loveland directly underlies the Gilman Canyon formation, and was deposited between about 165 ka and 125 ka (Maat and Johnson, 1996; Bettis et al., 2003). It is generally brown to pale brown, but a prominent soil complex formed in its upper portions exhibits reddish (7.5YR Hue) colors. The soil exhibits strong pedogenic structure, including well-developed clay coatings, iron-manganese oxide accumulations, and secondary carbonate accumulations at greater depths.

References

Bettis, E.A., III, Mason, J.A., Swinehart, J.B., Miao, X.D., Hanson, P.R., Goble, R.J., Loope, D.B., Jacobs, P.M., Roberts, H.M., 2003, Cenozoic eolian sedimentary systems of the USA midcontinent, In: Easterbrook, D.J. (Ed.), Quaternary geology of the United States. Geological Society of America, Boulder, Colorado, pp. 195-218.

Boellstorff, J., 1978a, Chronology of some late Cenozoic deposits from the central United States and the Ice Ages, Transactions of the Nebraska Academy of Sciences 6, 35-49.

Boellstorff, J., 1978b, North American Pleistocene stages reconsidered in light of probable Pliocene-Pleistocene glaciation, Science 202, 305-307.

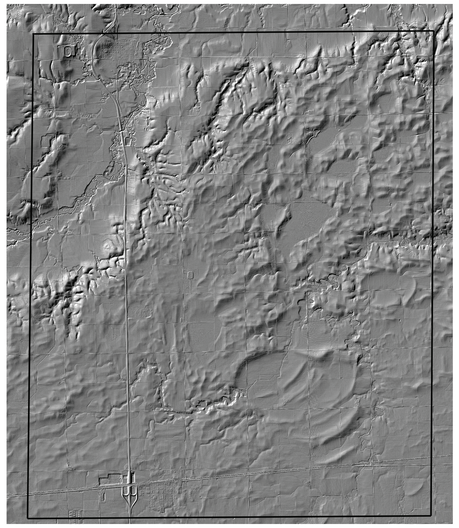


Fig. 1. Hillshade generated from LiDAR data for the Fairmont 7.5 minute quadrangle. Shown are Rainwater Basins with rims, particularly in the south-central and and northeastern portions of the quadrangle, and dunes buried under loess.

Rainwater Basin Formation

Rainwater basins cover significant portions of south-central Nebraska, and the majority of them lie to the south of the Platte River. The depressions vary in size, but most measure ~ 0.7-1.5 km x 1.5-2.5 km with long axes that are oriented northeast-southwest. A distinctive ridge (~ 9-15 m in relief) is found along the southeastern edge of these features. Rainwater Basins are found on landscapes that have buried Platte River alluvium at depth that are overlain by late Quaternary loess units. The basins formed due to deflation of sandy sediment in Platte River braidplains. The basins presumably formed from northerly or northwesterly winds given that the ridge is consistently found on their southeastern edge. The basins and ridges were subsequently buried by varying thicknesses and ages of loess (e.g., Kuzila, 1994). Basin fills are primarily loess and re-worked loess, that is slightly thicker than loess deposits in the surrounding terrain. The thickness of the eolian sand within the ridges is on the order of 3-5 m (10-15 ft) thick, but this thickness varires. In some cores it can be very difficult to distinguish between eolain and alluvial sand.

Burchett, R.R., Summerside, S.E., 1995. Fillmore County Test-Hole Logs. Nebraska Water Survey Test-Hole Report No. 30, Conservation and Survey Division, University of Nebraska-Lincoln, 28 p.

Kuzila, M.S., 1994, Inherited morphologies of two large basins in Clay County, Nebraska: Great Plains Research, v. 4, p. 51-63.

Maat, P.B., and Johnson, W.C., 1996, Thermoluminescence and new 14C age estimates for late Quaternary loesses in southwestern Nebraska: Geomorphology, v. 17, p. 115-128.

Mason, J.A., Swinehart, J.B., Hanson, P.R., Loope, D.B., Goble, R.J., Miao, X., Schmeisser, R., 2011, Late Pleistocene dune activity in the central Great Plains, USA, Quaternary Science Reviews 30, 3858-3870.

Miao, X., Mason, J.A., Swinehart, J.B., Loope, D.B., Hanson, P.R., Goble, R.J., Liu, X., 2007. A 10,000-year record of dune activity, dust storms, and drought in the central Great Plains, Geology 35, 119-122.

Muhs, D. R. Bettis, E. A., III, Aleinikoff, J.N., McGeehin, J.P., Beann, J., Skipp, G., Marshall, B.D., Roberts, H. M., Johnson, W.C., Benton, R., 2008, Origin and paleoclimatic significance of l ate Quaternary loess in Nebraska: Evidence from stratigraphy, chronology, sedimentology, and geochemistry: Geological Society of America Bulletin, v. 120, p. 1378 - 1407.

Roy, M., Clark, P.U., Barendregt, R.W., Glasmann, J.R., Enkin, R.J., 2004, Glacial stratigraphy and paleomagnetism of late Cenozoic deposits of the north-central United States, Geological Society of America Bulletin 116, 30-41.

Smith, F.A., 2000. York County Test-Hole Logs, Nebraska Water Survey Test-Hole Report No. 93, Conservation and Survey Divsion, University of Nebraska-Lincoln, 60 p.

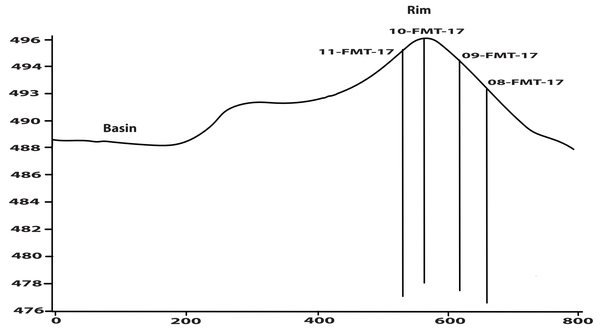


Fig. 2. Topographic cross section through a Rainwater Basin and adjacent rim. Locations and depths of boreholes shown in Fig. 3.

Boreholes Drilled along a Rainwater Basin Rim, Fairmont Quadrangle

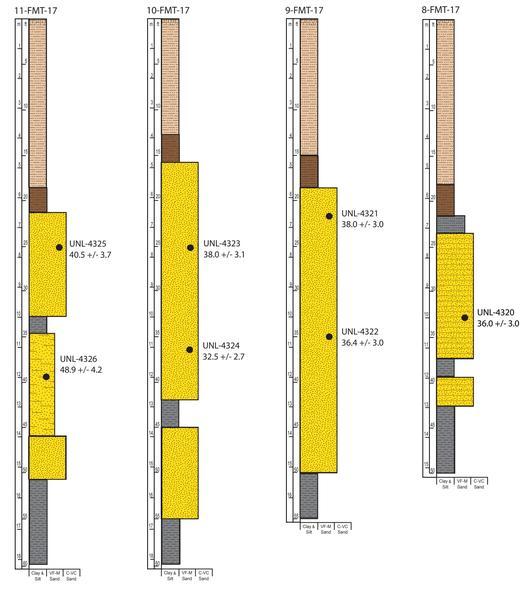
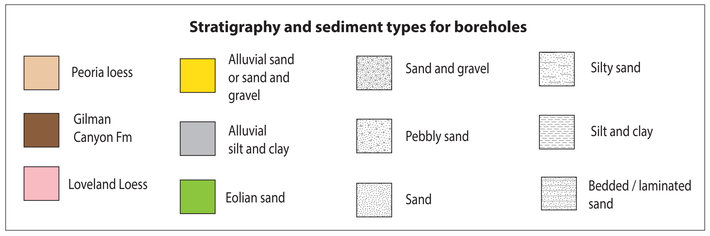


Fig. 3. Boreholes drilled along a Rainwater Basin rim in the Fairmont quadrangle. OSL ages are given in thousands of years ago.



CSD Mud Rotarty Test Holes Drilled in 2017

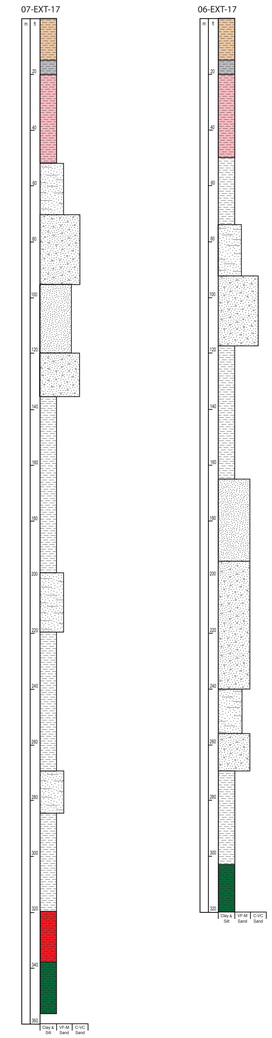
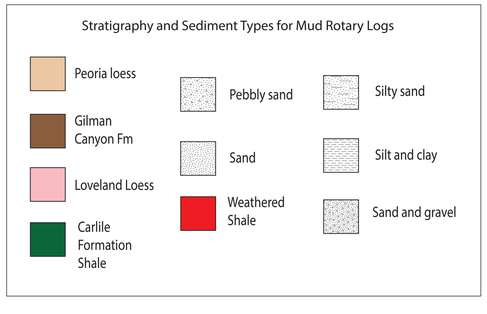


Fig. 4. Logs for mud rotary test holes drilled for geologic mapping of the Fairmont quadrangle.



IANR University of Nebraska Lincoln