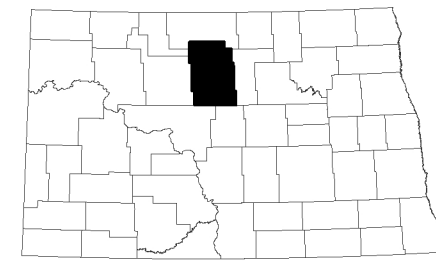
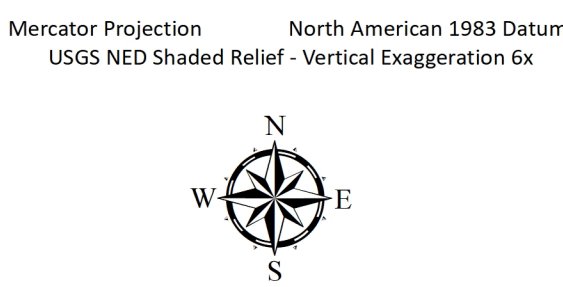
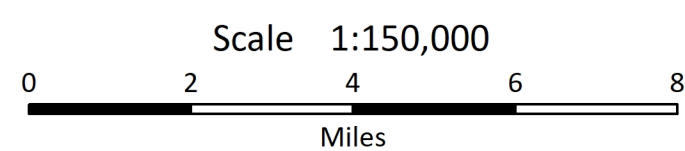


Windblown Sand Deposits

- Qodh** Windblown sand in dune fields of high relief commonly greater than 30 feet (10 m) and up to 60 feet (18.3 m).
- Qodl** Windblown sand in low-relief dunes with relief typically less than 10 feet (3 m).
- Qoet** Windblown sand as thin undulating tabular sheet sands with scattered low-relief dunes mantling glaciolacustrine sands.
- Quaternary Geology Undifferentiated.



Bulk Sand Mineralogy (weight %)

- Sample Location 18
- 66 — Quartz
- 25 — Feldspar
- 3 — Clay

Other Features

- ▲ Historic Site
- City
- Water
- River/Stream
- U. S. Highway
- Paved Road
- Unpaved Road

MINERALOGY OF WINDBLOWN SAND DEPOSITS IN McHENRY COUNTY

Fred J. Anderson

2020

Table 1. Detailed XRD Mineralogy of Windblown Sand in McHenry County, North Dakota.

| Sample No. | Quartz | Plagioclase | Potassium Feldspar | Feldspars (Total) | Calcite | Dolomite | Carbonates (Total) | Illite | Illite/Smectite | Chlorite | Kaolinite | Clays (Total) | Micas | Hornblende | Pyrite | Iron Oxides |
|------------|--------|-------------|--------------------|-------------------|---------|----------|--------------------|--------|-----------------|----------|-----------|---------------|-------|------------|--------|-------------|
| 1 | 70 | 14 | 8 | 22 | -- | -- | -- | 2 | 1 | 1 | tr. | 4 | 3 | 1 | -- | -- |
| 2 | 71 | 10 | 11 | 21 | -- | -- | -- | 1 | 1 | tr. | 1 | 3 | 4 | 1 | -- | -- |
| 3 | 70 | 11 | 13 | 24 | -- | -- | -- | 1 | tr. | tr. | 1 | 2 | 3 | 1 | -- | -- |
| 4 | 71 | 11 | 12 | 23 | -- | -- | -- | 2 | tr. | tr. | tr. | 2 | 3 | 1 | -- | -- |
| 5 | 68 | 13 | 11 | 24 | -- | -- | -- | 2 | tr. | tr. | 1 | 3 | 3 | 2 | -- | -- |
| 6 | 71 | 10 | 10 | 20 | tr. | -- | tr. | 2 | 1 | tr. | 1 | 4 | 3 | 2 | -- | -- |
| 7 | 68 | 16 | 7 | 23 | -- | -- | -- | 3 | 1 | tr. | 1 | 5 | 3 | 1 | -- | -- |
| 8 | 66 | 13 | 13 | 26 | -- | -- | -- | 2 | tr. | tr. | 1 | 3 | 4 | 1 | -- | -- |
| 9 | 70 | 12 | 10 | 22 | -- | -- | -- | 2 | tr. | tr. | 1 | 3 | 3 | 2 | -- | -- |
| 10 | 71 | 12 | 11 | 23 | -- | -- | -- | 1 | tr. | tr. | 1 | 2 | 2 | 2 | tr. | -- |
| 11 | 73 | 10 | 7 | 17 | tr. | -- | tr. | 3 | tr. | 1 | 1 | 5 | 3 | 2 | -- | -- |
| 12 | 74 | 10 | 10 | 20 | -- | -- | -- | 1 | tr. | tr. | 1 | 2 | 3 | 1 | -- | -- |
| 13 | 76 | 8 | 8 | 16 | -- | -- | -- | 2 | tr. | tr. | 1 | 3 | 5 | -- | -- | -- |
| 14 | 69 | 14 | 9 | 23 | tr. | -- | tr. | 2 | tr. | tr. | 1 | 3 | 4 | 1 | -- | -- |
| 15 | 74 | 8 | 7 | 15 | -- | -- | -- | 1 | tr. | tr. | 1 | 2 | 3 | 6 | -- | -- |
| 16 | 64 | 17 | 9 | 26 | -- | -- | -- | 3 | 1 | tr. | 2 | 6 | 3 | 1 | -- | -- |
| 17 | 67 | 9 | 17 | 26 | tr. | -- | tr. | 1 | tr. | tr. | 1 | 2 | 4 | 1 | -- | -- |
| 18 | 66 | 11 | 14 | 25 | tr. | -- | tr. | 2 | tr. | tr. | 1 | 3 | 3 | 3 | -- | -- |
| 19 | 64 | 17 | 10 | 27 | -- | -- | -- | 3 | tr. | tr. | 1 | 4 | 4 | tr. | -- | 1 |
| 20 | 69 | 13 | 8 | 21 | 1 | -- | 1 | 2 | 1 | tr. | 1 | 4 | 3 | 2 | -- | -- |
| 21 | 72 | 9 | 12 | 21 | -- | -- | -- | 1 | tr. | tr. | 1 | 2 | 3 | 2 | -- | -- |
| 22 | 72 | 11 | 9 | 20 | -- | -- | -- | 1 | 1 | tr. | 1 | 3 | 4 | 1 | -- | -- |

-- mineral phase not detected.
tr. = trace.

MINERALOGY OF WINDBLOWN SAND DEPOSITS

The mineralogy of windblown sand deposits in McHenry County was evaluated in late 2019 in support of the exploration for potential sources of in-basin proppant sand in North Dakota. A total of 22 unwashed bulk sand samples, 21 from McHenry County and one from southeastern Bottineau County, were analyzed by X-ray diffraction (XRD) mineralogical analysis. Eleven samples each were collected from high-relief (i.e. dunes with relief >10-ft or 3-m) dune fields and areas of gently undulating sheet sands with occasional low-relief dunes (i.e. dunes with relief <10-ft or 3-m). In this investigation, unwashed samples, as opposed to washed and sized sand, were selected for analysis in order to more fully characterize the mineralogy of these in-situ sand deposits.

Sand mineralogy was generally consistent across all the samples collected from both high and low-relief dune settings and within general mineralogical groups (Fig. 1.). Quartz content (weight %) ranged from 64 to 76% with an average of 70%. Feldspar (as plagioclase and potassium feldspar) content ranged from 15 to 27% with an average of 22%. Clay content (as illite and kaolinite) was low, ranging from 2 to 6% with an average of 3% (Fig. 2.). Trace (≤1%) amounts of carbonate (as calcite) was reported in only six of the 22 samples. Other minor minerals consisting of micas and hornblende were also reported in small amounts of around 3% and <2%, respectively (Table 1.).

Overall, quartz amounts tend to be somewhat higher in the southern and eastern portions of these windblown deposits, presumably due to their locations in downwind settings where overall transport distances were highest. Sample locations shown on this map are as previously described in Anderson (2020).

Figure 1. Ternary diagram of windblown sand mineralogy found in dune deposits in McHenry County, North Dakota. Samples from low and high-relief dunes all fall within a tight group suggesting similar overall mineral compositions and sedimentological origin.

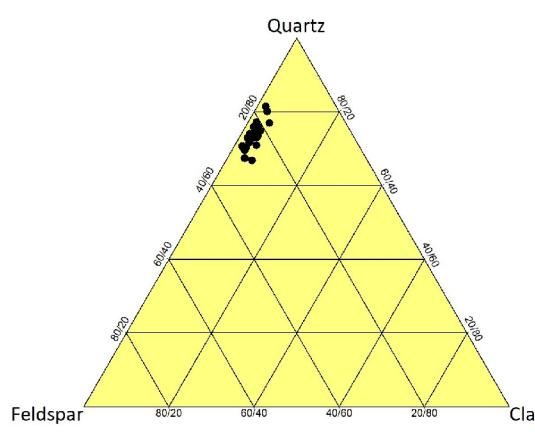
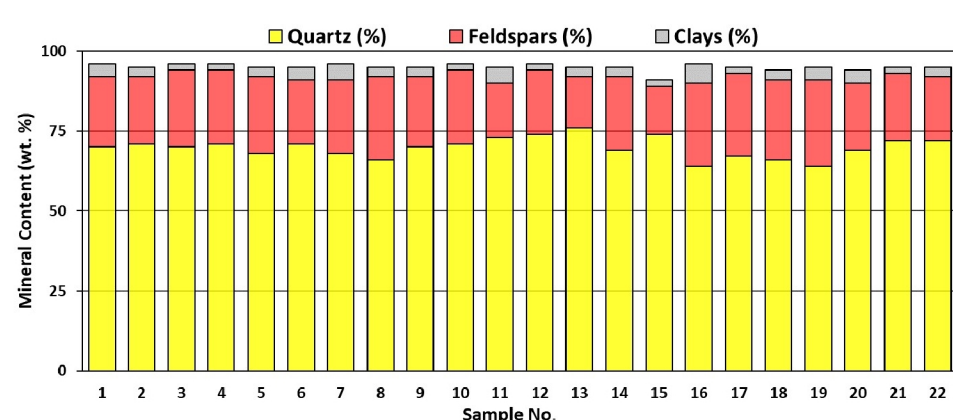


Figure 2. Major mineral group composition of windblown sand in McHenry County, North Dakota.



MAP COMPILATION REFERENCES

- Anderson, F.J., 2020, Evaluation of Windblown Sand Deposits in North-Central North Dakota for Potential Use as Proppant, North Dakota Geological Survey, Report of Investigation No. 124, 109 p.
- Bluemle, J.P., 1982, Geology of McHenry County, North Dakota, North Dakota Geological Survey, Bulletin 74, Part 1, Plate I.
- Clayton, L., Moran, S.R., Bluemle, J.P., and Carlson, C.G., 1980, Geologic Map of North Dakota, U.S. Geological Survey-N.D. Geological Survey, 1:500,000 scale map.
- Lord, M.L., 1988, Surface Geology of the Souris River Map Area, North Dakota Geological Survey, Atlas Series Map AS-4-A1, 1:250,000 scale map.