Dunes on the Wind-Swept Prairie: North Dakota's Eolian Sands

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Introduction

The notion of sand dunes in North Dakota may at first sound rather misplaced. One may think that with both a climate and ever-changing weather conditions like ours - long cold winters with short, relatively hot and humid summers - the existence of sand dunes on the physical landscape would seem to be fairly unlikely. Images of more classical desert landscapes, such as the Eureka Dunes in Death Valley, California (fig. 1), or the Sahara in northwestern Africa (fig. 2), or perhaps even the gleaming white gypsum sands in New Mexico's White Sands National Monument area (fig. 3), probably come to mind; or maybe even the architecturally impressive sandstones of Zion National Park in Utah (fig. 4), which are the lithified remains of Jurassic-age eolian (wind-blown) dunes. But North Dakota does indeed have its share of sand dunes and other windswept landforms.

Figure 1. Eureka Dunes in Death Valley National Park, attributed to be the tallest in California at nearly 700 feet in height (National Park Service).

Figure 2. Dunes from the Sahara desert in northwestern Africa (Maienga Agency, Wikimedia Commons).

North Dakota's Dunes

Dunes are found in nearly every region of the state but tend to be concentrated in the east. This is due, in part, to glacial processes, which reworked and deposited younger, immature sediments that had been scoured from the underlying bedrock. One of the more visually impressive dunes is found in the southeastern part of the state in southwestern Sargent County (fig. 5) and is a part of the Riverdale Ridge Dunes west of the town of Brampton.

There are over 30 dune fields in North Dakota (fig. 6), the largest

Figure 3. Gypsum dunes with wind ripples in White Sands National Monument in New Mexico (National Park Service).

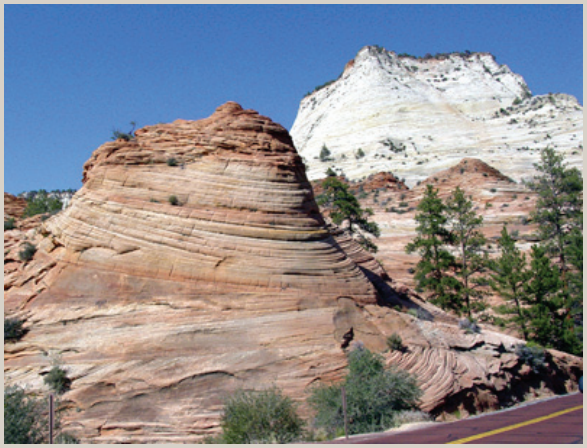

Figure 4. Spectacular sedimentary bedding structures exhibited in the Navajo Sandstone in Zion National Park, Utah. The Navajo Sandstone is a lithified eolian dune deposit of Jurassic age that crops out extensively throughout southern Utah. The dunes consist of reworked shallow marine deposits from Jurassic seas further to the west (National Park Service).

Figure 5. View to the east of a well-exposed dune in southeastern Sargent County. This dune is a part of the Riverdale Ridge Dunes located in southeastern North Dakota. Gently dipping bedforms are visible in the upper portions of the dune just below the surface vegetation that is currently stabilizing this dune. Telephone poles in the right foreground give an indication of scale. This particular dune is over 30 feet in height.

of which is near Denbigh, in central McHenry County (table 1). Dunes also developed on glaciofluvial-lacustrine deposits of the Sheyenne and Pembina Deltas that formed in Glacial Lake Agassiz between about 13,000 and 9,000 years ago (Bluemle, 2000).

Table 1. Location and extent of selected dune areas in North Dakota

Dune Area Name	County	Area (mi^2)
Denbigh Dunes	McHenry\Pierce\Bottineau	990
Sheyenne Dunes	Ransom\Sargent\Richland	687
Pembina Dunes	Cavalier\Pembina	208
Brampton Dunes	Dickey\Sargent	152
Hankinson Dunes	Richland	110
Dawson Dunes	Kidder	73

Dune Structure

As one might imagine, there are many types of dunes, each being formed from the ever-changing interactions of wind and sand. A basic sand dune (fig. 7) has the crest at its highest point and two sides, generally one longer than the other, which are named the stoss (windswept) and the lee (slipface) sides respectively. When multiple dunes are present, such as in a dune field, the distance between each successive dune crest, is called the dune wavelength.

As sand particles are transported by the wind along the dune, from the stoss or windward side to the lee side, they are blown up and over the crest, whereupon gravity takes over, and they cascade downward along the slipface. Over time the sand builds up into individual bedforms on the leading edge of the dune as it proceeds in a downwind direction. The lee or downwind side of a dune is commonly steeper than the windward side but generally will not exceed an angle of 34°, which is the commonly accepted value for the angle of repose for loose dry sand (Tarbuck and Lutgens, 1990).

By looking at the orientation of the dune crests and individual dune characteristics, such as height, wavelength, and particle size and

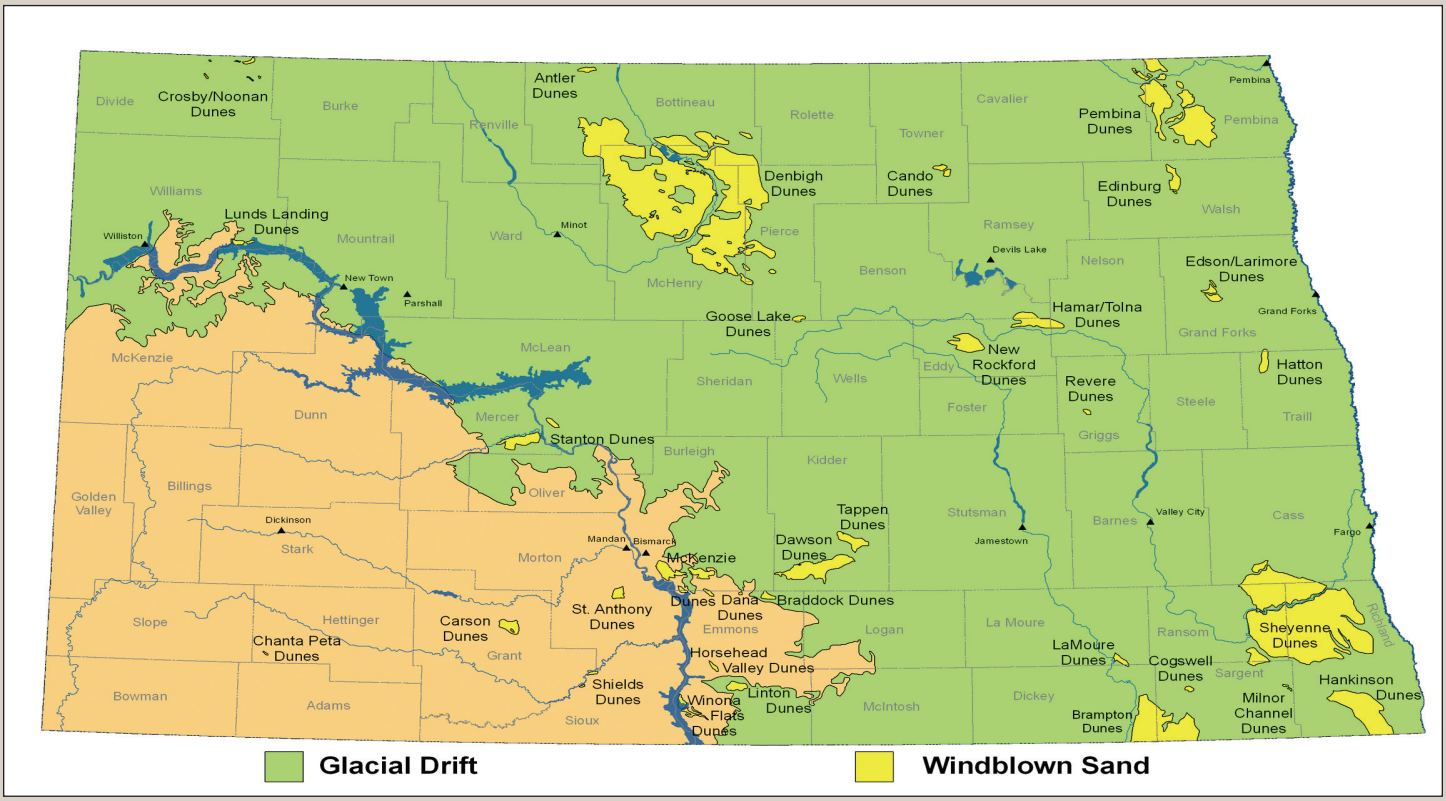

Figure 6. Location of windblown sands and dunes in North Dakota.

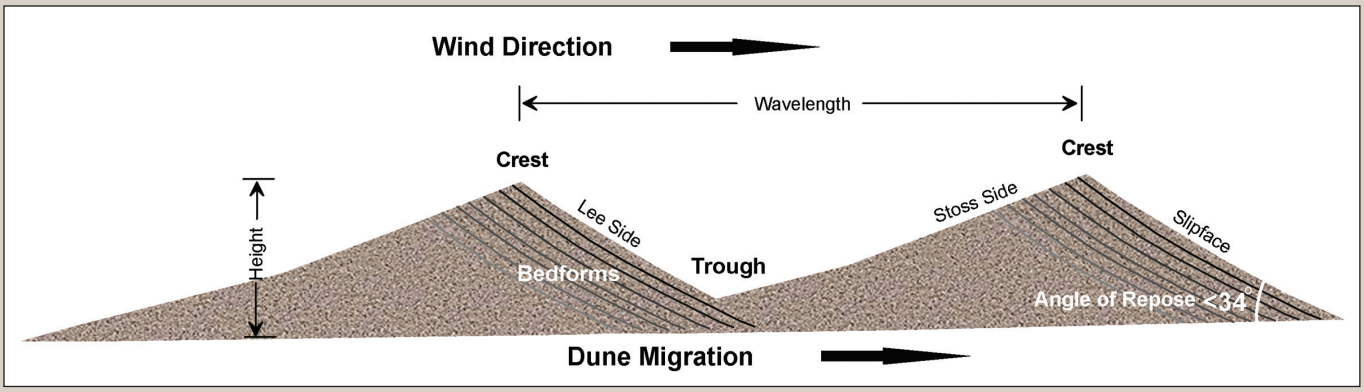

Figure 7. Schematic cross-section of a pair of dunes illustrating some of their basic descriptive characteristics.

mineralogy, clues to the eolian conditions responsible for dune creation can be determined and used to interpret the climatic and geologic environments at the time of dune formation, as well as the source (provenance) of the sand. For example, Muhs et al. (1997) deduced that the northwest-trending dunes of the Denbigh Dunes (Minot Dune Field) were most likely formed within the last 1,200 years or so, when the climate was similar to the present, rather than under older post-glacial conditions.

Dune Fields in North Dakota

A dune field is an area where many dunes have formed as a result of winds blowing the relatively finer fractions of sediment from a source area (commonly along a former river or stream) into localized accumulations of dunes (fig. 8). A dune field commonly contains several individual or complex dune types, which in North Dakota may be interspersed with interdune areas where local vegetation has become abundant, and may also be bounded by large accumulations of tabular-like sheet sand deposits. For the purposes of discussion here, a dune field or dune area is understood to contain all of the localized sand-sized deposits (both sheet sands and dune sands) that have been moved or modified by the wind.

Most of the dunes in North Dakota are either

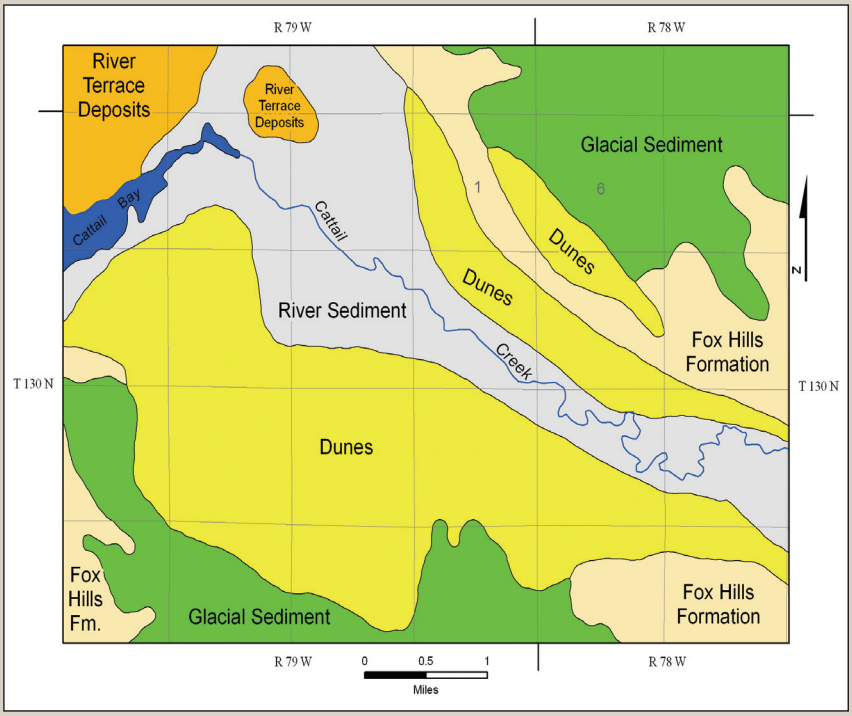

Figure 8. Map of bedrock and surface geologic units in the southeastern Cattail Bay-Winona Flats area in southwestern Emmons County along the Missouri River. Dunes are present on both the north and south sides of Cattail Creek and are examples of windswept landforms sourced from the finer portions of these initially water-deposited sediments.

Figure 9. View to the northwest into the Missouri River Valley at Cattail Bay (south of Winona Flats) from ND Highway 1804 across the dune field south of Cattail Creek in southwestern Emmons County. The low-relief undulating topography of these grass-covered dunes is characteristic of many of the wind-swept areas where longitudinal dunes are present in North Dakota.

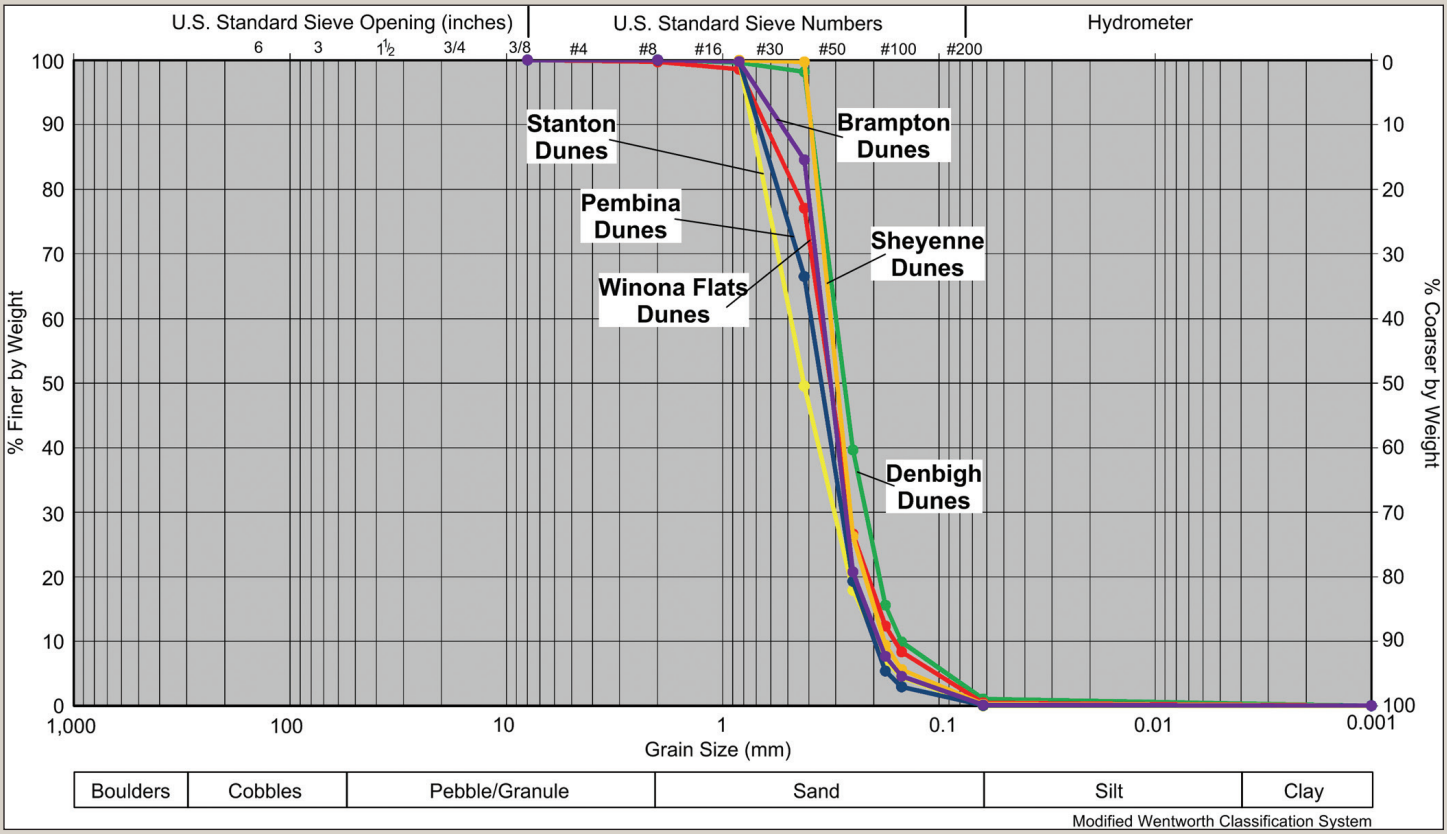

Figure 10. Distribution of sediment grain sizes of selected dune sands from North Dakota. These eolian sediments can be classified as well sorted, fine-grained sands. Grain size distribution diagrams like this can be used to determine the amount of sand in a sample that is of a particular grain size.

crescentic (parabolic) or longitudinal (linear) (fig. 9). Areas dominated by linear dunes tend to be larger in expanse with relatively low localized relief. Conversely, areas of parabolic or crescentic dunes tend to be clustered closer together with higher local relief (fig. 6).

Sedimentary Characteristics

Dune sand is commonly well-sorted, meaning that the majority of individual sand grains are of a similar size (fig. 10). This is due, in part, to the velocity and duration of winds that eroded, transported, and deposited the individual sand grains into the dunes themselves (Boggs, 1995).

During the drought period of the 1930s, when climatic conditions in the Upper Midwest were much drier, several dune fields in North Dakota were reactivated. Also, new dunes were created from freshly exposed sediment sources, and in many rural areas were found encroaching on farm buildings and other structures (fig. 11).

Denbigh Dunes

Arguably the most familiar sand dunes in North Dakota are the ones near the town of Denbigh in McHenry County. Also referred to by some (e.g. Muhs et al., 1997) as the Minot Dune Field, the Denbigh Dunes cover an area of 990 square miles (2,564 km^2) or about 28 standard townships. Local relief is as high as 100 feet (30 m) with dunes commonly around 5 to 20 feet (1.5-6 m) in height. Dunes are northwest trending parabolic types (crescentic shaped) that are currently classified as being inactive because they are stabilized by a well-developed cover of prairie vegetation.

Sand from the Denbigh Dunes can and has been described as a quartz common, yellow-brown (on outcrop), well-sorted, fine- to medium-grained sand, with dominantly angular to subrounded grains, that is generally devoid of carbonates (Lemke, 1960; Lord, 1988.) However, recent analytical work has suggested that these

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Figure 11. Sand dunes encroaching on the side of a barn in Kidder County during the 1930's drought. Sand ripples can be seen on the surface of the dune indicating that the direction of sediment transport was parallel to the face of the roof (SHSND, ca. 1930).

Figure 12: (a) Aerial oblique view to the southeast of a high-relief portion of the Denbigh Dunes just south of Denbigh along ND Highway 2, McHenry County (modified from Bluemle, 1987). (b) View to the north of grass-covered, high-relief dunes located just to the northwest of Denbigh. (c) Photomicrograph of dune sand collected from a road-cut in the northern Denbigh Dunes area (25X magnification).

sands may have higher overall acid solubilities (around 17%) than other sands found in North Dakota by a factor of two (Anderson, unpub. data), which could be explained by glaciolacustrine processes associated with the existence of Glacial Lake Souris (Lord, 1988).

North Dakota's diverse eolian landscapes are very scenic with an interesting assemblage of flora and local wildlife that can make even a short visit to these areas both interesting and enjoyable.

Selected References

Bluemle, J.P., 1987, Dunes: North Dakota Geological Survey Newsletter, December 1987, p. 36-41.

Bluemle, J.P., 2000, The Face of North Dakota: North Dakota Geological Survey Educational Series 26, 210 p.

Boggs, S., Jr., 1995, Principles of Sedimentology and Stratigraphy (2nd ed): Prentice-Hall, 774 p.

Lemke, R.W., 1960, Geology of the Souris River Area, North Dakota: U.S. Geological Survey Professional Paper 325, 138 p.

Lord, M.L., 1988, Sedimentology and stratigraphy of Glacial Lake Souris, North Dakota; effects of a glacial-lake outburst: Grand Forks, University of North Dakota, PhD dissertation, 221 p.

Muhs, D.R., Stafford, T.W., Jr., Been, J., Mahan, S.A., Burdett, J., Skipp, G., and Muhs, R.Z. 1997, Holocene eolian activity in the Minot dune field, North Dakota: Canadian Journal of Earth Sciences, v. 34, no. 11, p. 1442-1459.

Tarbuck, E.J., and Lutgens, F.K., 1990, Earth - An Introduction to Physical Geology (3rd ed): Princeton, N.C., Merrill Publishing, 330 p.

Further Reading

McKee, E.D., 1979, A Study of Global Sand Seas: U.S. Geological Survey Professional Paper 1052, 429 p.

Kickoff to Summer Reading Day, 2011

When was the last time you were able to sit down with a good book? This is just the thing that the annual Kickoff to Summer Reading day is trying to encourage in children of all ages. The theme this year was "One World, Many Stories" and participants were encouraged to use that topic to relate to children and inspire them to read. The North Dakota Geological Survey was one of more than 20 sponsors of the event.

The event is held annually on the capital grounds, in the Heritage Center, and at the State Library, and attracts many area residents. This year more than 3,000 people walked through the doors of the Heritage Center during the event.

The North Dakota Geological Survey paleontology department has participated in these activities for many years and we show off various fossils pulled from the North Dakota State Fossil Collection. The paleontology department had a table set up and answered many questions about the fossils of North Dakota, and encouraged people to think of their own stories about the fossils. A "pin-the-tail-on-the-dinosaur" activity was available, as well as the recently published NDGS coloring book by Hoganson and Gould (ND Ed series 32, 2011).