Surface Mapping of Sand & Gravel and LiDAR Applications

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Surface mapping is a fundamental aspect of the North Dakota Geological Survey (NDGS). The production of maps allows the community to understand the rocks, sediments, structures, and other geologic features in an area. Geologic maps further the scientific understanding of North Dakota geology and provide an added economic value for the knowledge of natural resources. The addition of LiDAR (light detection and ranging) imagery has allowed geologists to observe small-scale features that may not have been observed before. The NDGS is generating digital elevation models derived from the State Water Commission LiDAR Dataset to support its surficial mapping, landslide mapping, and other geological investigations.

The construction of high-resolution digital elevation model (DEM) maps from the LiDAR data is instrumental in the future of mapping at the NDGS. These maps are the building blocks for a variety of mapping projects. A distinct advantage of LiDAR is the three-dimensional visualization of topography allowing for clearer interpretations of landforms, which allows geologists to spatially analyze the surface and identify subtle glacial features. Approximately 75% percent of North Dakota is covered by glacial deposits; therefore, the identification of specific glacially-derived landforms is significant for geologists in the evaluation of potential sand and gravel deposits.

In particular, there are specific glacial landforms that contain commercial grade sand and gravel. Examples of these landforms are eskers, kames, beaches on the shorelines of former glacial meltwater lakes, and outwash plains. An esker is a long sinuous ridge with stratified drift containing identifiable cross-bedding that commonly formed within an ice-walled tunnel in or beneath a glacier (fig. 1). Gravel and sand were deposited within the tunnel as the glacier was retreating and deposited the sinuous ridge found on landscapes today (fig. 2). A kame contains stratified drift and looks like a hill on the modern landscape (fig. 3). A kame deposit originally formed within a depression on the top of a glacier, and as the glacier melted and retreated, the sediment was deposited on the landscape appearing as a hill, inverted from its original form (fig. 4). Beach ridges that formed along

Figure 2. This map displays an example of an esker viewed on LiDAR imagery. The esker pictured is the Dahlen esker located near Dahlen, North Dakota.

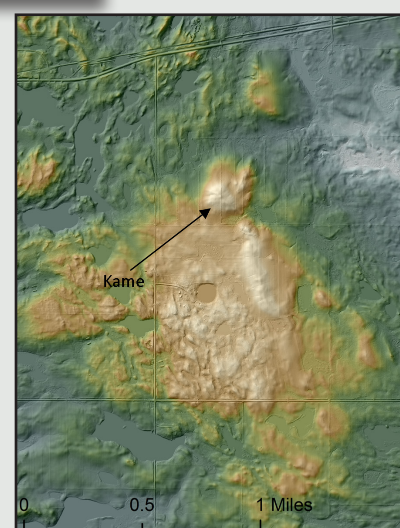

Figure 3. This map displays an example of a kame viewed on LiDAR imagery. The kame is located near Pickardville, North Dakota, approximately 6 miles east of McClusky.

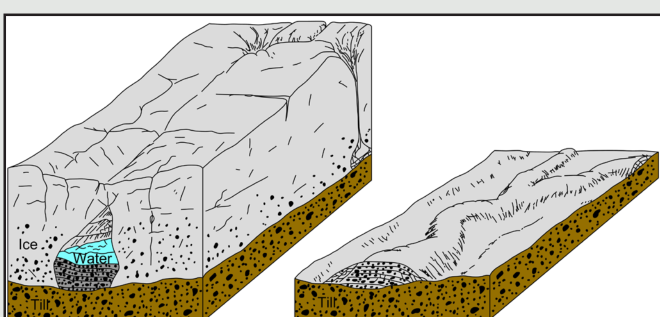

Figure 1. On the left: This illustration shows a meltwater channel within a glacier. The high energy of the water within the tunnel allows sand and gravel to be deposited. On the right: The deposited sand and gravel forms a ridge, called an esker, as the ice melts away.

Background Picture: *Twenty feet of sand and gravel overlain by five feet of till in Williams County, North Dakota.*

the shores of meltwater lakes are a rich source of sand for commercial use and can be found throughout the glaciated part of North Dakota. The largest of these are associated with glacial Lake Agassiz. The lake existed in North Dakota from approximately 11,700 years ago until 9,000 years ago and left behind its rich lake sediment for farming in the Red River Valley and an extensive complex of beach ridges along its western edge. Glacial meltwater transported sediment away from the ice margin forming plains referred to as outwash plains, which contain stratified and cross-bedded sand and gravel deposits. The high energy of the outwash causes smaller particles like clay and silt to remain in the water column and be washed downstream, resulting in the pristine deposition of sand and gravel.

NDGS geologists are able to identify potential sand and gravel deposits from the geomorphology within LiDAR data. Following this, a geologist will field check the data to make sure the interpretation is consistent. Techniques such as hand auguring, or using a soil probe to penetrate the subsurface, will be used to validate the sand or gravel deposit. If the geologist validates the deposit, the area of the landform can be delineated and the volume of sediment calculated from the LiDAR data. This gives landowners and mining companies valuable information for land management and natural resource evaluation. After a sand or gravel deposit is discovered there are many different lab techniques that are used to evaluate chemistry, grain size, roundness, and sphericity. This is an important step that helps companies determine the economic need of a particular sand and gravel deposit.

In addition to glacial deposits, wind-blown (eolian) deposits are significant sources for sand. Dunes that may be too subtle to see on a conventional aerial photograph or topographic maps are easily identified on LiDAR. Their distinctive morphology is clearly evident on the landscape as the oblique view in figure 5 displays so effectively.

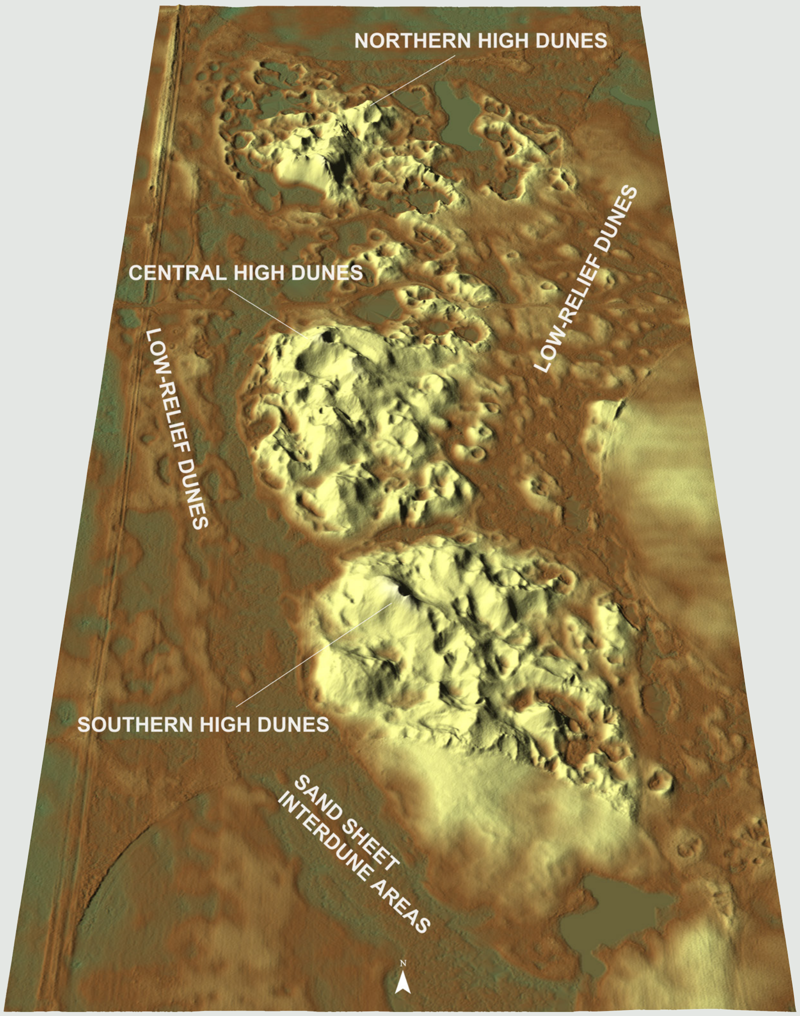

Figure 5. Oblique LiDAR image showing dune morphology in southwest Sargent County, North Dakota. The three-dimensional image displays the surface expression and varying relief of the eolian system. This deposit would be an exceptional resource for future sand use (Anderson, 2016).

LiDAR has become a very important tool for mapping at the NDGS. It has made great advancements in the identification of sand and gravel deposits and has simplified the calculations for quantifying the volume of these deposits. For more information on the technical details of LiDAR, there is an article in the July 2016 issue of the NDGS Geo News (Maike, 2016).

References:

Anderson, F.J., 2016, Geomorphology of Dune Sand Resources in Southwestern Sargent County: North Dakota Geological Survey Geologic Investigation No. 190.

Maike, C.A., 2016, LiDAR: What is it and how do we use it?: North Dakota Geological Survey Geo News, July 2016.

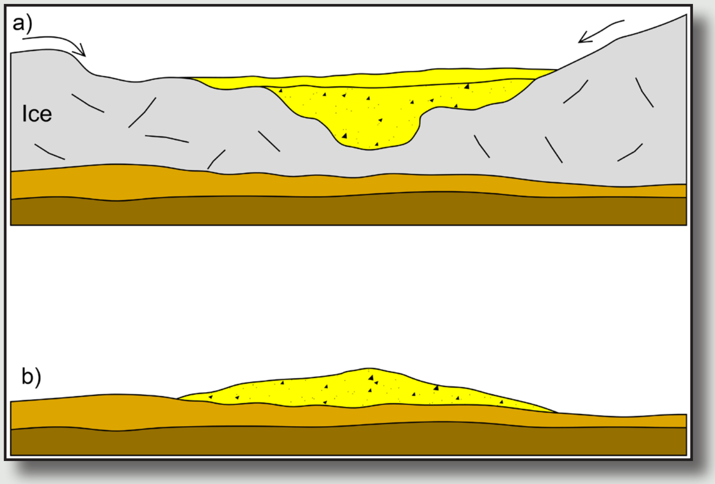

Figure 4. This illustration shows the formation of a kame. Above: sediment begins to accumulate within a depression on the surface of a glacier. Below: as the ice melts the sediment slumps onto the ground and forms a hill-like shape.