What a Long, Strange (S)Trip(e) It's Been!*

by Mark A. Gonzalez

Travel across central Colorado and you're bound to get a kink in your neck from rubber-necking at all the gorgeous mountains. They're obvious and spectacular. They take no formal training to understand or appreciate. Travel across south-central McHenry County, North Dakota, and your likely to stifle a great big yawn—unless of course, you're one of the special forces assigned to the "Till Commandos," a unit of highly trained glacial geologists who get kinks in their neck as they travel across undulating glacial landscapes. Till Commandos have the formal training and great appreciation to rubberneck as they traverse dead-ice moraine, washboard moraine, proglacial lakes, outwash aprons, recessional moraines, and all things glacial.

One of the most striking glacial landscapes in North Dakota is preserved in south-central McHenry County. To the untrained eye, it isn't much to look at, especially from the ground. But throw in a bird's-eye view from a low-flying plane and some information on the region's landforms, and this area rocks! It's glacial past is cool!

Undoubtedly the most astonishing feature in south-central McHenry County is a field of long, linear ridges. These ridges are all parallel, trending N 50° to 55° W (Fig. 1). The most spectacular of these ridges is the so-called Hogback Ridge, which extends for 16 miles from Verendrye at its northwest end to Balfour at the southeast end (See **X Marks the Spot** in this issue (page 17) and in the previous issue (Vol. 29, No. 2, page 23) of the *NDGS Newsletter*.

Hogback Ridge and other similar ridges in south-central McHenry County were formed when a thin glacier advanced rapidly over the area. The trend of the ridges indicates the direction of ice movement (to the southeast) during the Late Wisconsinan (approximately 10,000 to 12,000 years ago). Various geologists have applied different names to the ridges of this area. The most generic term to describe this landform is **subglacially molded topography**, meaning the landforms were molded or shaped by an overriding glacier. However, this term is fairly broad and can apply to a number of dissimilar looking landforms. Other investigators have referred to the long ridges as **drumlins, drumlinoid ridges, drumlinized ground moraine, flutes,** or **fluted moraines**. Others have applied the terms **crag-and-tail** or **knob and trail** to these ridges or similar ridges elsewhere (e.g., Chamberlin, 1888, p. 244-245).

Drumlins are typically cigar- or inverted spoon-shaped landforms with blunt, steeper slopes on their stoss (up-ice direction) sides and tapering, gentler slopes on their lee (down-ice direction) sides (Fig. 2). Also, drumlins typically have length:width ratios of 2:1 to 10:1. The ridges in southern McHenry County are not stereotypical drumlins. Most notably, they have a particularly amazing length:width ratio that averages 60:1 (Lemke, 1958) and in the case of the Hogback Ridge exceeds 250:1.

Various hypotheses exist to explain the formation of drumlins and related ridges. The hypothesis that I present here is based on observations made by John Bluemle, State Geologist of North Dakota, Don Schwert, Professor of Geology at North Dakota State University, and me. John Bluemle, who mapped McHenry County (Bluemle, 1982), and Don Schwert told me that the stoss, or up-ice, end of many ridges contains either an ice-thrust mass, or large glacial erratic. Ice-thrust masses were blocks of bedrock and/or frozen blocks of till that were plucked up by an advancing glacier and moved as an intact, coherent mass (see Fig. 3a). A frozen ice-thrust mass, once lodged in till, could be strong enough to resist erosion from a thin, warm, overlying glacier. Furthermore, instead of being eroded by a glacier, the frozen ice-thrust mass, or a large erratic, could erode and mold the bottom of an advancing, thin, warm glacier, creating a cavity beneath the glacier (Figs. 3b and 3c). As the glacier passed down-ice from the ice-thrust mass, its weight could cause soft, unfrozen, and saturated sand, gravel, and till, to be squeezed up, like toothpaste, into the basal cavity of the glacier (Fig. 3d). The

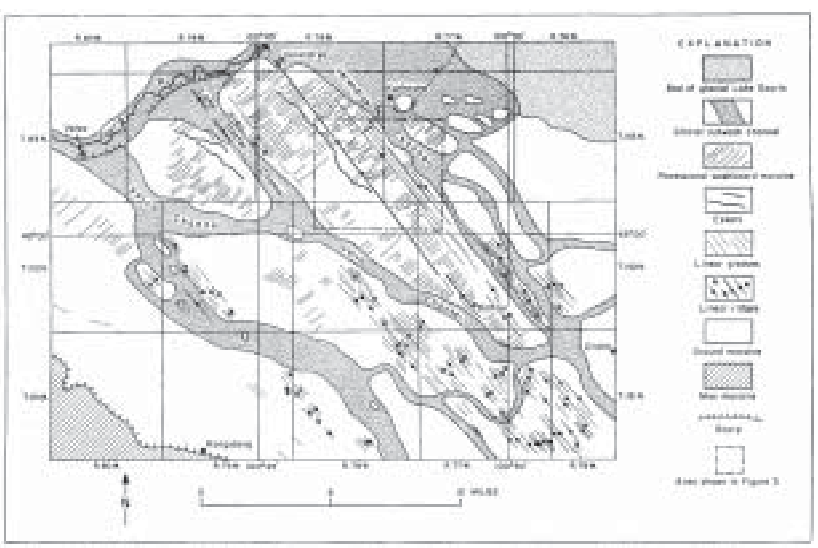


Fig. 1. Generalized geologic map of surface deposits and landforms near Velva, North Dakota (from Lemke, 1958).

*—Paraphrase from "Truckin'" by Robert Hunter, the Grateful Dead (1977)

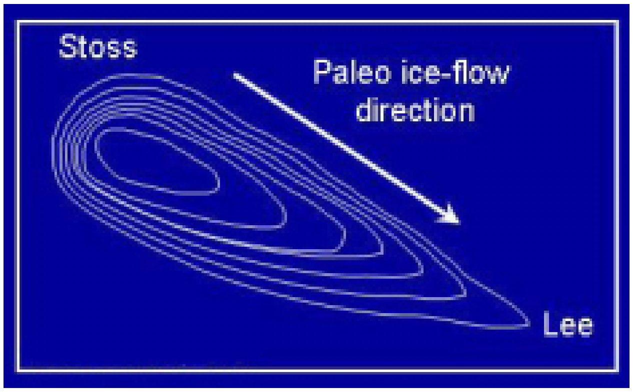
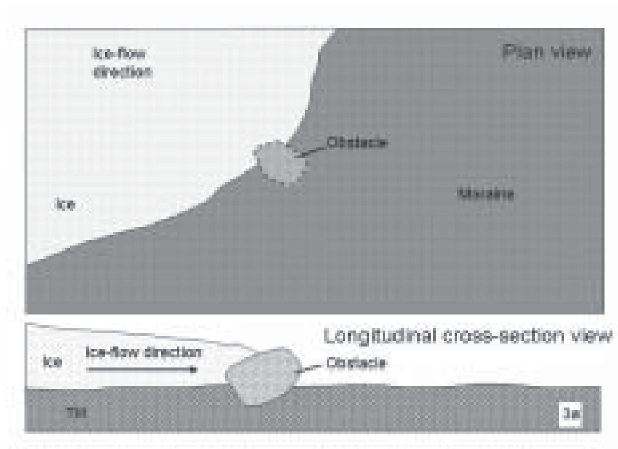
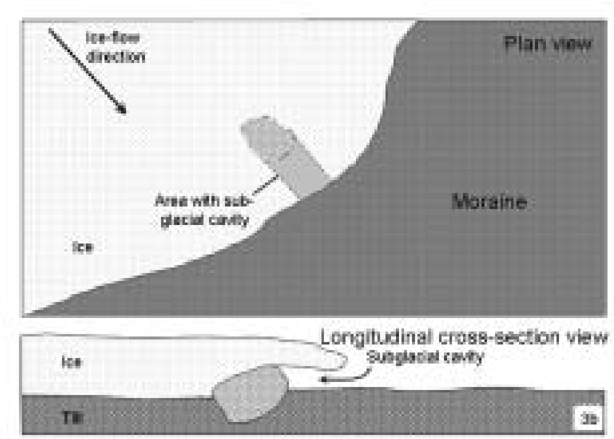
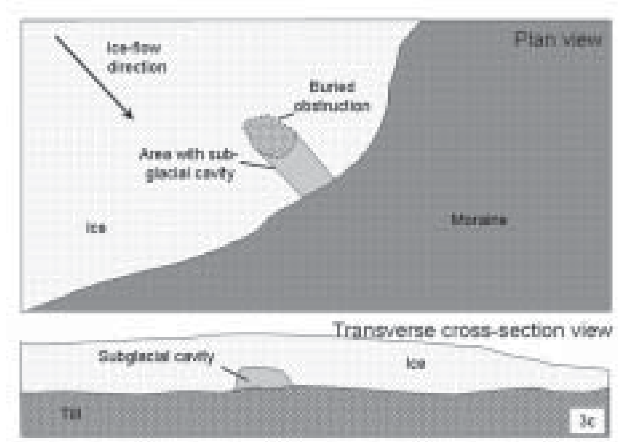


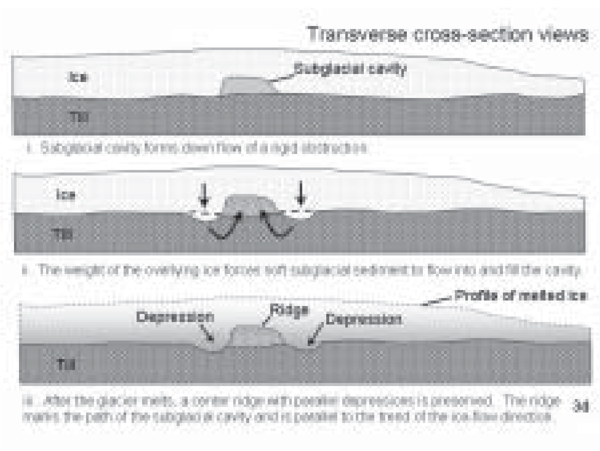
Fig. 2. Drumlins are typically cigar-shaped landforms or resemble the inverted bowl of a spoon. The length:width ratio is generally 2:1 to 10:1, though in extreme examples it is as great as 1000:1. This illustration uses contour lines (10-foot or 3-meter intervals) to depict the planimetric shape of a drumlin. The stoss, or up-ice, side of a drumlin is generally steeper and blunter than the lee, or down-ice, side, which is more gently sloped and tapered.

displacement of subglacial material into ridges creates linear depressions along the flanks of the ridges (Figs. 3d and 3e). The orientation of the ridge would indicate the direction of ice movement too (Fig. 3e).









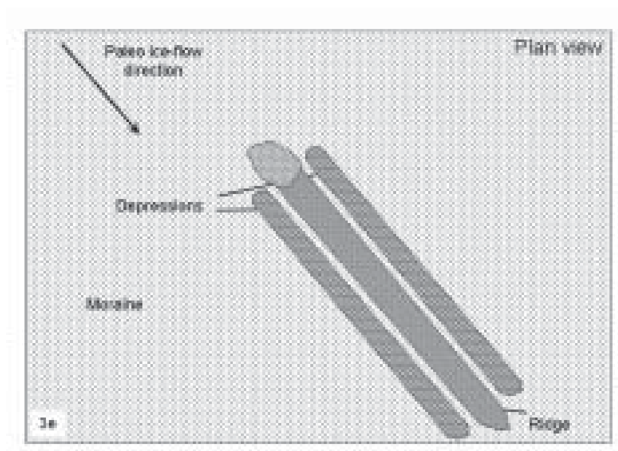


Fig. 3. Schematic illustrations, both in plan view and cross-sectional view, illustrating the hypothesized formation of the Hogback Ridge and other ridges in south-central McHenry County. (a) In nearly all cases, a large obstacle is found in the up-ice end of the ridges. The obstacle is commonly either a large erratic or an ice-thrust mass. (b) As ice passes over the obstacle, the obstacle molds the bottom surface of the glacier. To preserve the mold, the ice must be relatively thin and warm so that it is deformed readily by the obstacle. (c) As the ice advances past the obstacle, a subglacial cavity forms on the lee side of the obstacle. (d) The weight of overlying ice forces soft, water-saturated subglacial sediment into the subglacial cavity. (d and e) When the ice melts, the material squeezed into the subglacial cavity is preserved as a long, linear, narrow ridge. Commonly, the ridge is flanked on one or both sides by depressions.

In the fall of 2001, Trent Hubbard, a doctoral candidate at the University of North Dakota, contracted to have backhoe trenches excavated across the Hogback Ridge. I had the opportunity to examine the internal stratigraphy of Hogback Ridge when the trenches were open. Soft-sediment flow structures were visible in the trench, indicating that pockets of fluvial sand and gravel and till deformed plastically and flowed into their position within the ridge. These soft-sediment structures are consistent with the hypothesis advanced by Bluemle et al. (1993) that subglacial sediments were squeezed up into the ridge. Small normal faults truncate the deformed soft-sediment structures and indicate that the drumlinoid ridges partially collapsed after the overriding ice melted.

The great length of the ridges in this area is one argument for rapid glacial advance. If the glaciers were advancing slowly, then the subglacial mold formed by an ice-thrust mass or boulder, would begin to melt, collapse, or deform, and the linear ridges would cease to be formed by the advancing glacier. In contrast, with rapid ice movement, the subglacial cavity would persist for one or two years and a long linear ridge would form as the glacier, along with its subglacial cavity, moved across the land. Also, the subglacial sediment must be warm (i.e., unfrozen), water-saturated, and readily deformed, or it will not readily flow into the subglacial cavity.

The ridges rise from a couple meters to 20 meters above the landscape (Fig. 4a). In many places, this rise is so subtle that the ridged or fluted surface is undetected from the ground. The flutes are generally best observed on stereographic aerial photographs (Fig. 4b).

Several of the respondents (Dwain Zodrow, Tony Alkofer, Kay Adele Buri) to the **X Marks the Spot** contest (see page 17 of this issue) provided some historical information regarding Hogback Ridge. Each noted that the ridge served as a convenient natural road for early pioneers of the Balfour/Verendrye area. It was a raised surface, which kept it relatively free of snow in the winter and well-drained in the summer. Locals referred to it as "Railroad Grade" because of its straight and level surface. Buri adds that early aviators used Hogback Ridge as a landmark for navigation, back in the time before modern technological instruments took much of the visual navigating out of flying.

References and Suggested Readings

Interested readers can find more information on the drumlins, subglacial molded topography, and the Hogback Ridge in:

Aario, R., and Heikkinen, O. (eds.), 1992. Proceedings of the third International Drumlin Symposium: Geomorphology 6(1):1-97.

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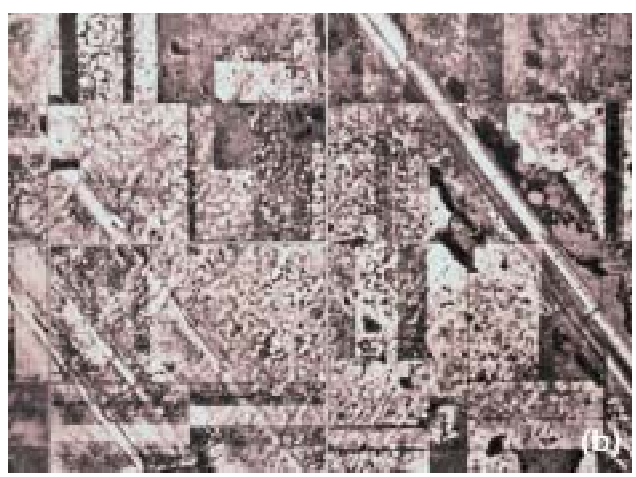

Fig. 4. (a) Subglacially-molded ridges rise from two to 20 meters above the surrounding till plain. In this view, note the lighter-colored, better-drained soils marking the crest of Hogback Ridge. Also note, on the left side of the view, the standing water in the depression that flanks the ridge (photograph by John P. Bluemle). (b) The ridges are easily seen on aerial photographs. Hogback Ridge is the prominent ridge on the right side of the view.