X Marks the Spot #11

By Lorraine A. Manz

Although the original structure, the first "active" one of its kind in North Dakota, no longer exists. Its location is marked by a granite monument that was erected in October 1953 – two-and-a-half years after the discovery at this site of a valuable natural resource.

1. What location is marked by the X?
2. What was the official name of the now-defunct structure?

Respondents who provide the correct answers to these questions will be eligible for prizes. Two names will be randomly drawn from a winners' pool by DMR staff. One selected respondent will receive a copy of *The Face of North Dakota*, and another will receive a *Geologic Map of North Dakota*.

Please submit responses by September 8, 2006. Winners of our drawing and the correct answers will appear on our web site shortly thereafter and in the next issue of the *DMR Newsletter*.

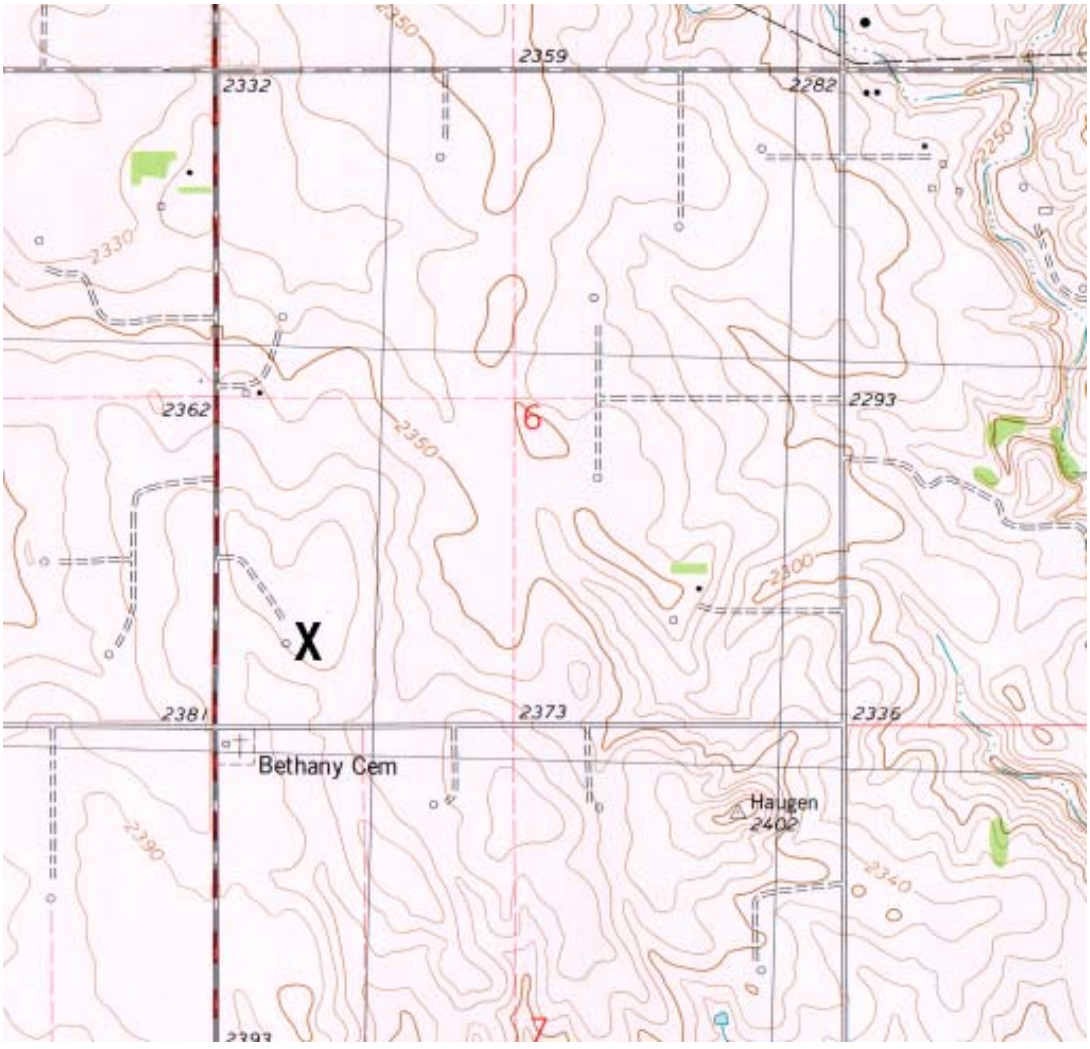
Answers submitted by mail should be sent to:

Editor, *DMR Newsletter*
Attn: Spot Contest
North Dakota Geological Survey
600 E. Boulevard Ave.
Bismarck, ND 58505-0840

Answers submitted by e-mail should be sent to:

ndgspubs@nd.gov

To submit answers via the web, visit our homepage at http://www.state.nd.us/ndgs and select the link labeled "X Marks the Spot." Only one answer permitted per person. The contest is not open to employees of the Industrial Commission or members of their families.



Answer to X Marks the Spot #10

Competition #10 proved to be one of the tougher ones in recent times. Most of the fifteen respondents correctly identified the pair of features as an ice-thrust block and its associated depression, but only seven also provided their official geographic names: the Grasshopper Hills and Medicine Lake – located about 20 miles north of Jamestown in Stutsman County (fig. 1). Some respondents suggested that the landform marked by the X was an esker, which was an interesting choice because many ice-thrust features are accompanied by eskers that originate in the source depression and trend downglacier around the thrust block. Others made reference to "Anamooses," a name for these hill/depression combinations that, sadly, was never adopted for the reasons discussed below.

Administrative Assistant Linda Johnson drew Gary Brekke and Dan Walker as the competition winners. Both will receive a copy of the Survey's very popular and excellent poster *Prehistoric Life of North Dakota*. Congratulations to the winners and thanks to everyone who participated in the competition.

Correct answers were submitted by:

Gary Brekke	**Fargo**
Ken Gardner	Drayton
Jay Gilbertson	Brookings, SD
Ray Greenwood	Jamestown
Greg Hagen	Minot
Ramsey Family*	Crystal
Dan Walker	**Victoria, BC**

* Ramsey family submitted one response as part of a collective effort.

Figure 1. Aerial photo of the Grasshopper Hills and Medicine Lake in Stutsman County. North is towards the top of the photo.

One of the most readable articles about the nature of ice-thrusting and the landforms it produces was written by former State Geologist John Bluemle as North Dakota Note #11 (Ice-Thrusting in North Dakota – Pop-Up Hills: North Dakota's Champagne Geology). The full text of this article is available online at http://www.state.nd.us/ndgs/NDNotes/ndn11.htm, but for the benefit of those of us who prefer paper to a computer screen a slightly shortened, but no less informative, version is provided here.

John writes:

"The landforms resulting from thrusting by glaciers are among the most unusual and interesting found in North Dakota. These are places where the glacier extracted – plucked – a large chunk of rock and sediment and moved it a short distance before setting it down again. Generally, the result was a hole, from the spot where the block was taken, along with a nearby hill, where the material was dropped. The ice-thrust features are most common in central North Dakota.

For example, Steele Lake at the town of Anamoose occupies a depression formed about 12,000 years ago when the glacier extracted – lifted or thrust – a chunk of material, moved it as a single piece, and then set it down a tenth of a mile to the southeast. The lake is straight south of Anamoose; the materials that were once where the lake is today form a hill on the southeast edge of the lake (figs. 2 and 3).

"In the late 1960's, when I first realized how hill-hole combinations like the one at Anamoose formed, I thought it would be appropriate to refer to such a feature as an "anamoose." However, the grammatical problems arising from that name were soon apparent. Are three such hills "anameece?" "anamooses?" or simply "anamoose?" (as in "I hit three moose on the road"). The name of the town

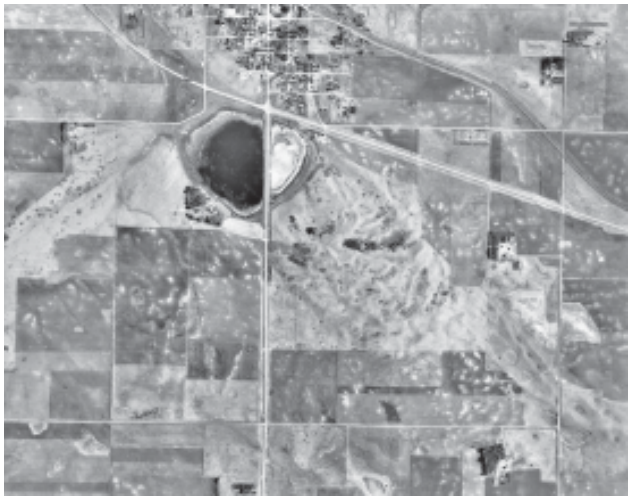


Figure 2. View from the air over the town of Anamoose in southeastern McHenry County. Steele Lake, on the south edge of town, is adjacent to an ice-thrust hill immediately to its southeast. The hill consists of material that was moved by the glacier, southeastward from where the lake is now.

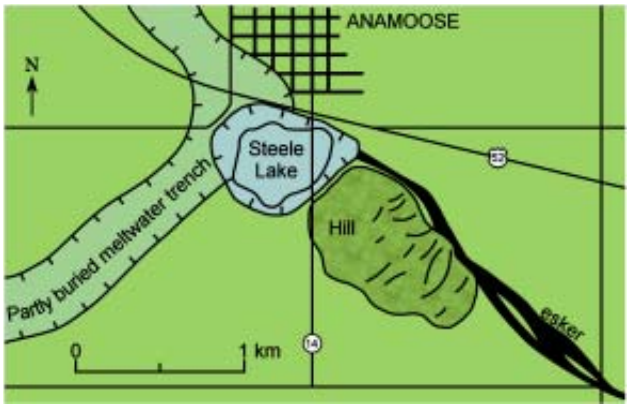


Figure 3. Map of the same area shown on Figure 2.

"*Anamoose*," incidentally, is apparently an adaptation of a Chippewa word, *uhnemoosh*, meaning female dog. Those people fascinated by unusual place names seem to be very happy with Anamoose. In any event, the difficulties with the word soon led me to switch, simply, to "ice-thrust hills" or "ice-thrust topography."

Areas of ice-thrust topography are found in many places on the plains of North Dakota and throughout the prairie provinces of southern Canada. Several other kinds of ice-thrust landforms have now been recognized in North Dakota, but the hill-hole combinations – roughly equidimensional hills containing thrust masses located downglacier from a source depression of similar size and shape (as at Anamoose) are the most striking.

Briefly, the theory NDGS geologists developed about 30 years ago to explain features like the one at Anamoose is as follows:

The features tend to be found overlying buried aquifers (figs. 4 and 5). Aquifers are rock or sediment layers that contain water. An aquifer might be contained in a bed of permeable sandstone, or it might be developed in gravel beds that had been deposited by water flowing from the melting ice ("permeable" means that the rock or sediment has

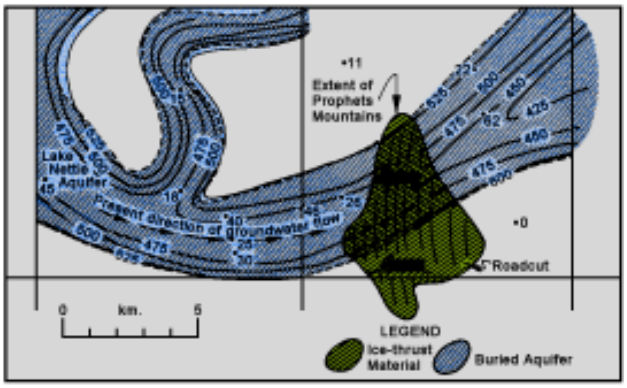


Figure 4. Extent of the Prophets Mountains in western Sheridan County, a few miles northwest of McClusky. The Prophets Mountains occur over a large aquifer which is contained within the valley of an ancient river.

interconnected holes so that water can seep or flow through it). In many cases, the aquifers are deeply buried, beneath impermeable layers of rock (impermeable means water can't flow through it). When the glacier advanced over such an aquifer, its weight sometimes caused elevated pore-water pressures to build up in the beds of sediment overlying the aquifer. When this happened, the pressure forced the materials upward, into the path of the advancing ice and, as a result, large, intact blocks of material were incorporated into the advancing glacier. The situation is kind of analogous to the action of a hydraulic jack. The "jack" pushed the material upward into the path of the glacier.

These large blocks of material were moved a short distance – they were "thrust" – by the glacier. The result was a hill (the ice-thrust block) and a hole (the place the block came from) (fig. 6). Some of the blocks that were moved by this process are truly huge, on the order of a few hundred feet thick and several square miles in area.

Pressurized groundwater is necessary for thrusting to occur and in order to build up pressure, something had to confine the water. If the groundwater was able to escape ahead of an advancing glacier, thrusting did not occur. If it could not escape, for whatever reason, thrusting was possible. In some cases, it's likely that a surface layer of frozen ground – permafrost – contributed to thrusting by acting as a confining layer for the groundwater.

We have identified several kinds of ice-thrust features, but the most striking and obvious of those found in North Dakota are the hill-hole combinations like the one at Anamoose – discrete hills of ice-thrust material, often slightly crumpled, situated a short distance downglacier from source depressions of similar size and shape. The source depressions commonly contain lakes or ponds. A typical ice-thrust hill of this type is about 100 feet high and less than a mile across. It may be

Figure 5. Air view of the Prophets Mountains. These ice-thrust hills consist of slabs of material that were pushed up by the ice from east to west. The snow marks troughs between ice-thrust ridges.

Figure 6. View over a lake, toward the Binford Hills in Griggs County. The lake is contained in the hole that formed when the Binford Hills were thrust by the glacier into their present location.

located immediately adjacent to the hole from which it came or it may be as far as three miles away from it. If the glacier continued to advance over an area after it had thrust the material, the feature tended to become smeared out; many ice-thrust features are buried beneath younger glacial sediment. The best ice-thrust hills are found in places where the glacier stopped advancing almost as soon as it completed the job of thrusting the materials.

The formation of thrust features like the one near Anamoose might be likened to popping the cork from a bottle of champagne; after the initial release when the thrusting occurred, the groundwater gushed out of the resulting hole and the pressure dissipated. To draw an analogy: the pressure in the bottle (aquifer) was released when the cork (hill) was removed from the bottle.

Just a few more examples of thrust features like the one at Anamoose: Egg Lake and Egg Lake Hill southeast of Harvey in Wells County; Medicine Lake and the adjacent Grasshopper Hills north of Jamestown in Stutsman County; Rugh Lake and the adjacent hill in eastern Nelson County; Blue Mountain and the adjacent depression west of Stump Lake in Nelson County – dozens of the features are found in North Dakota. The granddaddy of all ice thrusts is Devils Lake. The materials from the ice-thrust hole that today contains Devils Lake are all piled up along the south side of the lake.

A lot of these kinds of ice thrust features are found in North Dakota, but the features are not common in other states. Why? A partial answer to this question relates to the fact that regional drainage in North Dakota was northward and the glaciers were advancing southward. Thus, the glaciers were advancing against the direction of groundwater flow. The rivers were simply diverted east and south, around the edge of the glacier, but the groundwater couldn't go anywhere.

In any situation in which the groundwater could not easily escape, there was the potential for pressures to build up. For example, if the surface of the ground ahead of an advancing glacier was frozen, this could form an impermeable seal on the surface of the ground. In many parts of central and northern North Dakota, water probably simply became trapped in the bedrock or glacial sediments beneath the ice, increasing the likelihood of thrusting.

Thrusting also occurred in northern Europe, where glaciers advanced southward against the regional groundwater flow systems. On the other hand, in areas where the glaciers advanced in the same direction as the regional groundwater flow systems, as in Scandinavia and the British Isles, very little thrusting occurred. The groundwater was able to escape ahead of the advancing ice.

And the eskers? When thrusting occurs, enormous quantities of pressurized, sediment-laden groundwater are released from the confined aquifer beneath the glacier. Eskers form where this material flows through subglacial channels towards the glacier margin. Thereafter they are transformed into outwash plains or meltwater valleys where they enter the proglacial environment.

More recommended reading

Bluemle, J.P., 1992, Ice-thrust topography in North Dakota: NDGS Newsletter, 1992, Vol. 19, Issue 2, pp.16-21.

Bluemle, J.P. and Clayton, L., 1984, Large-scale glacial thrusting and related processes in North Dakota: Boreas, Vol. 13, pp. 279-299.

Surface appearances are only that; topography grows, shrinks, compresses, spreads, disintegrates, and disappears; every scene is temporary, and is composed of fragments from other scenes.
John McPhee