EARTH

GLACIERS IN SOUTH DAKOTA

What Are Glaciers And How Do They Form?

A glacier is a large, long-lasting mass of ice that moves as a result of its weight. A glacier can develop in any area where, over a period of years, more snow accumulates than melts. Ice forms by the compaction and recrystallization of the snow. When the mass of ice reaches a certain thickness, it starts to spread out (move) away from the area of accumulation. At this point, the ice mass is called a glacier.

The ice within an active glacier is always on the move (see Figure 1). Individual ice particles enter the glacier in the *accumulation zone* and are transported over time to areas where the ice is lost through melting or other processes (the *ablation zone*). The margin of a glacier will advance when the accumulation of ice exceeds *ablation*. Conversely, the glacier's margin will retreat when more ice is lost to *ablation* than is replaced. A stable ice margin indicates a balance between gain and loss.

What Types Of Materials Do Glaciers Deposit?

Glaciers are very effective at rearranging earth materials. Rocks ranging in size from the finest powder to boxcar-sized boulders have been eroded, transported, and deposited by glaciers. Even larger slabs of rock, up to 1 mile (1.6 km) in length, can be shown to have moved under the influence of glaciers. Sediment is released from the ice when the glacier melts.

A variety of sediment types are deposited by, or are the result of, glaciers. *Till* is the term used to describe unsorted glacial sediment. In South Dakota, *tills* contain a large amount of clay- and silt-sized particles (roughly 65 percent by weight), as well as sand and scattered larger rock fragments. When water from melting ice interacts with the sediment, a number of "sorted" sediments result. Sand and gravel deposits (*outwash*) result when meltwater removes finer silts and clays. Fine-grained sediments are deposited when meltwater becomes

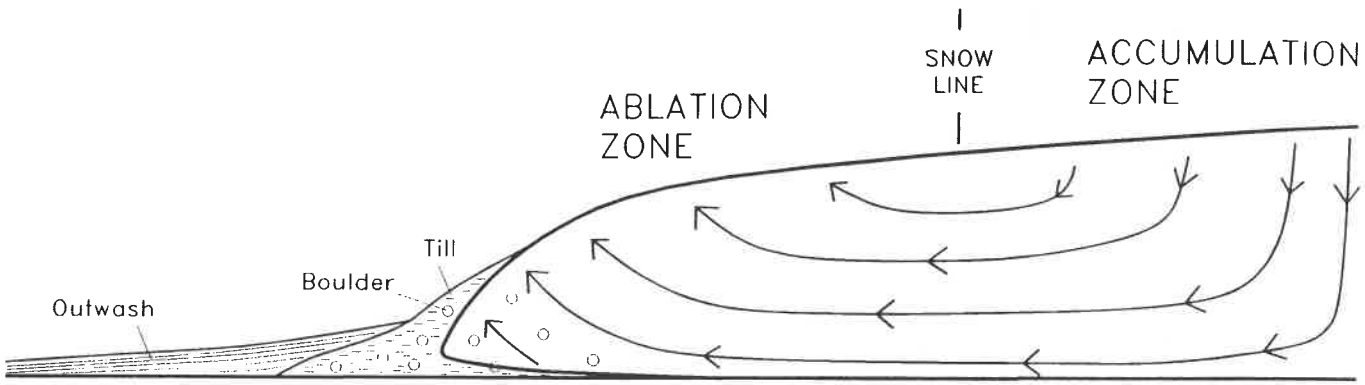

Figure 1. Cross Section Of An Idealized Glacier Showing Internal Movement Of Ice And Distribution Of Sediments.

ponded in lakes or slower moving sections of meltwater streams. *Loess* is the term used to describe sorted fine-grained glacial sediment deposited by wind action.

What Evidence Is There That South Dakota Was Glaciated?

Evidence of glacial activity in South Dakota can be seen throughout the eastern half of the state. Glacial features can be divided into two basic types, erosional or depositional, and range in size from very small scratches on rocks to features as large as the Coteau des Prairies and the Missouri River. Accumulations of up to 875 feet of glacial sediments are found in parts of the state, while in other areas glacial erosion has laid bare the underlying bedrock.

Erosional evidence of glacial activity is best illustrated by the many small scratches (*striations*) found on boulders and rock outcrops that were overridden by the glaciers. Most of the major streams and rivers in eastern South Dakota occupy channels originally cut by meltwater streams originating from melting glaciers. In addition, the broad valleys of the James and Minnesota Rivers owe their shape to the erosive power of glaciers that once occupied these lowlands.

Features that result from the deposition of glacial sediments include nearly all of the hills and ridges in eastern South Dakota. The term *moraine* refers to any accumulation of glacial sediment deposited by the ice, and occurs in many forms (see Glossary). Large blocks of ice are often trapped within glacial deposits. When they eventually melt, a depression is formed in the deposit. Lakes are formed when these depressions (*kettles*) fill with water.

The greatest accumulation of glacial sediments in South Dakota is found in the highland known as the Coteau des Prairies (see Figure 2). The Coteau des Prairies rises as much as 1,200 feet (365.8 m) above the adjacent Minnesota and James River valleys in the northeastern corner of the state, but merges with generally higher landscapes in the south. Glacial sediments average

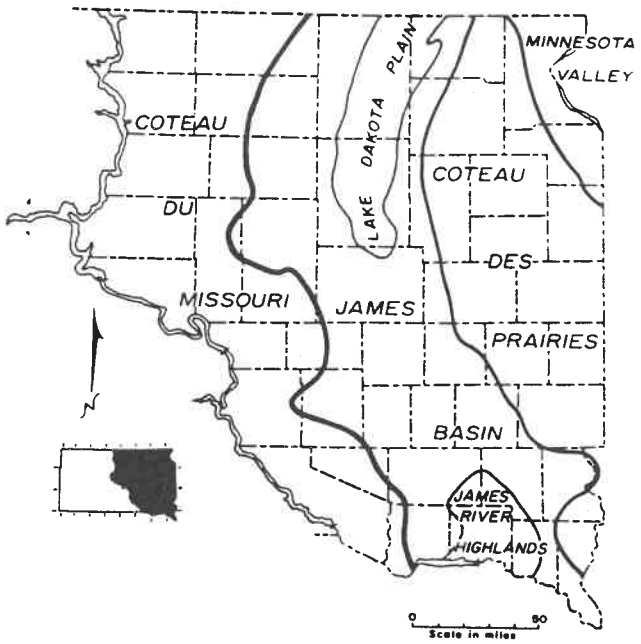

Figure 2. Major Physiographic Features in Eastern South Dakota

about 450 feet (136.5 m) thick throughout the Coteau, however, a test hole drilled by the South Dakota Geological Survey encountered 875 feet (265.4 m) of *till* and *outwash* near Troy in Grant County. The Coteau du Missouri (Fig. 2) is a similar accumulation of glacial sediments, although the thicknesses are not as great. Both highlands influenced the movement of the recent glaciers in the state.

The most spectacular indication of glacial activity in South Dakota is the Missouri River. Whenever ice covered the eastern part of the state, it blocked northeast-flowing rivers like the Cheyenne and Bad Rivers. Their waters ponded up in the valleys, then flowed along the edge of the ice until finding an outlet to the south. When the ice retreated, the water continued to follow the diverted course, creating the Missouri River as we know it today (see also the fact sheet on the Missouri River in the Habitats section).

How Are The Ages of Glaciers Determined?

Determining the age of glacial sediments is often difficult. The most common method involves *carbon-14 age dating* of organic matter (mostly wood) found in glacial sediments. This method works well for deposits that are less than 50,000 years old. Unfortunately, glaciers tend to be rather hostile environments and material suitable for dating is quite rare.

Material suitable for dating by other techniques is extremely rare in older glacial sediments. Near Milbank, in the northeastern part of the state, sediment between two *tills* has been dated at approximately 120,000 years before present. Just west of Sioux Falls, a volcanic ash (the Hartford Ash) separating two *tills* is approximately 610,000 years old. In most cases, however, only relative ages, based on correlation and physical properties, can be determined.

When Was South Dakota Glaciated?

Periods of wide-spread glaciation occurred throughout all of geologic time. The most recent interval of extensive glaciation is called the Pleistocene Epoch, which began roughly 2 million years ago and ended about 10,000 years ago.

Glaciers repeatedly advanced into South Dakota during the Pleistocene Epoch. The most recent episode of glacial activity (called the late Wisconsin stage) started about 30,000 years ago, and peaked at roughly 14,000 years before present. At that time, glaciers covered all of South Dakota east of the Missouri River, with the exception of portions of the lower Big Sioux River valley (see Figure 3). Evidence of older glaciations consists of glacial sediments found beneath and beyond the limit of the late Wisconsin deposits, as well as glacial *striations* and *erratics* in areas without these sediments.

During the peak of the most recent period of glaciation in South Dakota, the ice in the Aberdeen area was at least 1,000 feet (303.3 m) thick, and may have been as much as 1,500 feet (455 m) thick over Rosholt in the extreme northeast corner of the state.

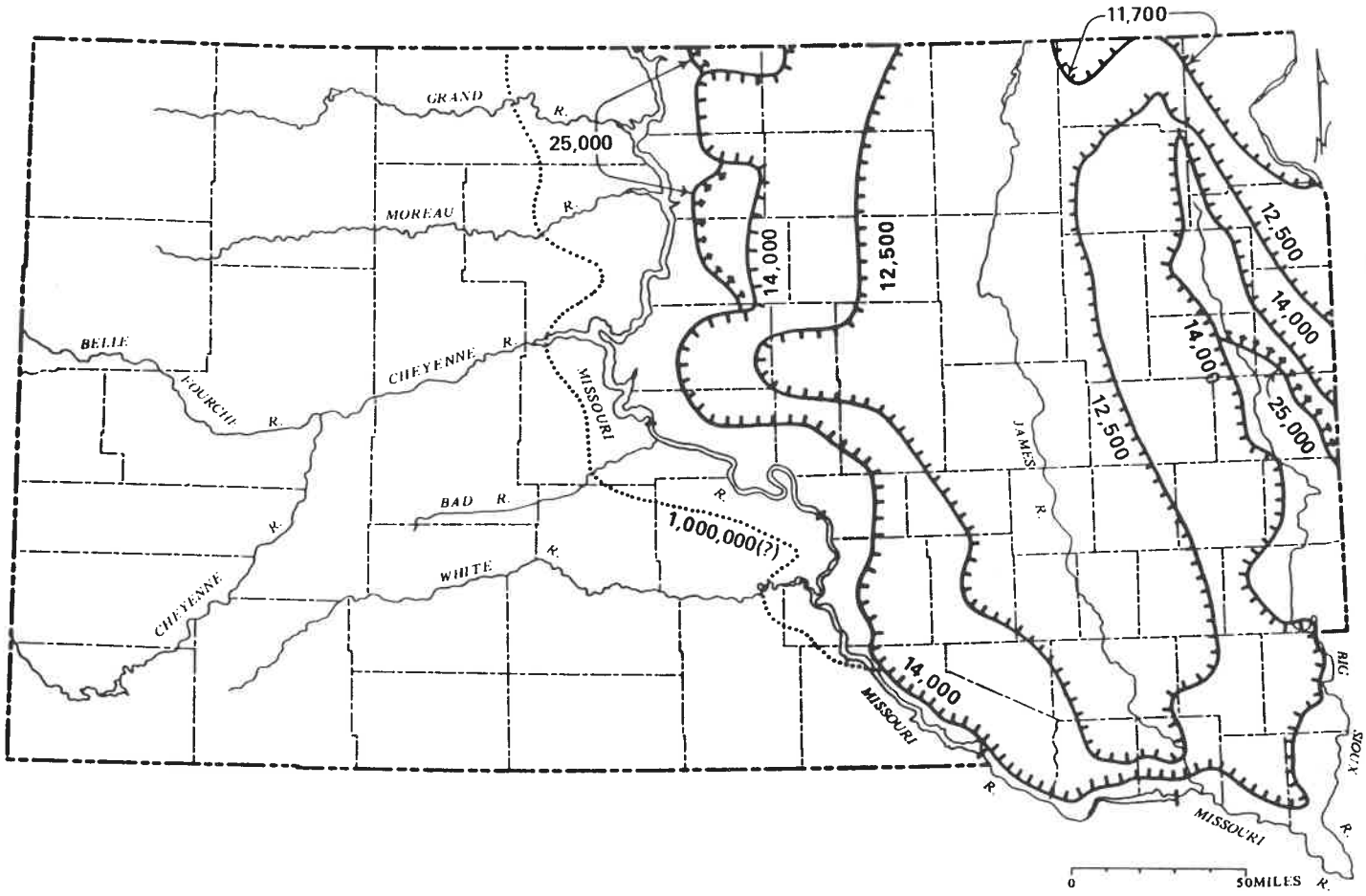

Figure 3. Approximate Ice Margins in South Dakota With Approximate Number of Years Before Present Indicated

Are Glacial Deposits Important?

Glacial deposits are important in South Dakota for a variety of reasons. Much of the drinking water used in the glaciated part of the state is ground water. The source *aquifers* for drinking water wells are most commonly saturated bodies of sand and gravel (*outwash*) deposited by the glaciers. Sand and gravel used in road building and other construction projects are also provided by *outwash* bodies. As these are non-renewable resources, we are always looking for additional deposits. The rich soils in eastern South Dakota are derived from till, which consists of ground up, nutrient-rich rock fragments carried here by glaciers. In addition, a good deal of the recreational activities and tourism in the glaciated part of the state is centered around the many rivers and lakes, which originated in glacial times. Finally, landfills and other waste repositories in the glaciated part of the state are located in these materials. An understanding of how well they contain these wastes is critical if we are to maintain the quality of our natural environment.

Glossary

Ablation – all processes by which snow and/or ice are lost from a glacier. These processes include melting, evaporation, or wind erosion.

Ablation zone – the part of a glacier in which, over a year's time, ablation exceeds accumulation.

Accumulation zone – the part of a glacier in which, over a year's time, accumulation exceeds ablation.

Aquifer – any rock or sediment with spaces that hold water in sufficient quantities to yield economically valuable amounts of water to wells and springs.

Carbon-14 age dating – a method of age determination that involves measuring the amount of the isotope carbon-14 in old organic matter. The isotope occurs in all living things in a fairly constant amount, but the amount decreases as a function of time once the organism dies. Because carbon-14 decays at a known rate, the amount remaining in old organic matter can be used to calculate its age.

Erratic – a rock carried by glacial ice and deposited at some distance from its point of origin. Erratics typically have very different compositions than "local" rocks.

Kettles – a depression or basin found in glaciated areas that form as a result of the melting of blocks of glacial ice that were either wholly or partially buried in glacial drift. Commonly contain lakes or swamps.

Loess – deposits of windblown, predominantly silt-sized, particles which originated as windblown sediments derived from outwash deposits.

Moraine – accumulation of glacial sediment deposited by the ice.

Outwash – stratified (layered and/or sorted) sediment, chiefly sand and gravel, that has been "washed out" of a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of an active glacier. Coarser material is usually deposited nearer to the ice.

Striations – scratches, or minute lines, inscribed on rock surfaces by rock fragments contained within glacial ice.

Till – predominantly unsorted and unstratified glacial drift, generally unconsolidated, deposited by glacial ice without subsequent reworking by meltwater. Typically consists of a heterogeneous mixture of clay, silt, sand, gravel, and boulders.

Glossary terms are adapted from Bates and Jackson, 1987, *Glossary of Geology*, American Geological Institute, Alexandria, Virginia.

Selected Resources For Teachers

Textbooks for college or university level introductory geology courses provide a basic introduction to the field of glacial geology.

The Division of Geological Survey has completed series of county-wide investigations in eastern South Dakota which contain specific descriptions and maps of glacial features found within the counties. Contact the Survey for individual reports and locations of particular glacial features. (See Natural Source directory phone number)

Gilbertson, J.P., 1989, editor, *Quaternary geology of northeastern South Dakota*: South Dakota Geological Survey Guidebook 3, 57 p. Contains brief descriptions of important glacial landforms and drift exposures in northeastern South Dakota, as well as a summary of the glacial history of the region.

A geologic map of South Dakota is currently in production, and should be available through the Division of Geological Survey in late 1995. This will provide an up-to-date presentation of the glacial geology of the state.

Outreach (Resource Agency Personnel)

(See Natural Source directory for phone numbers.)

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