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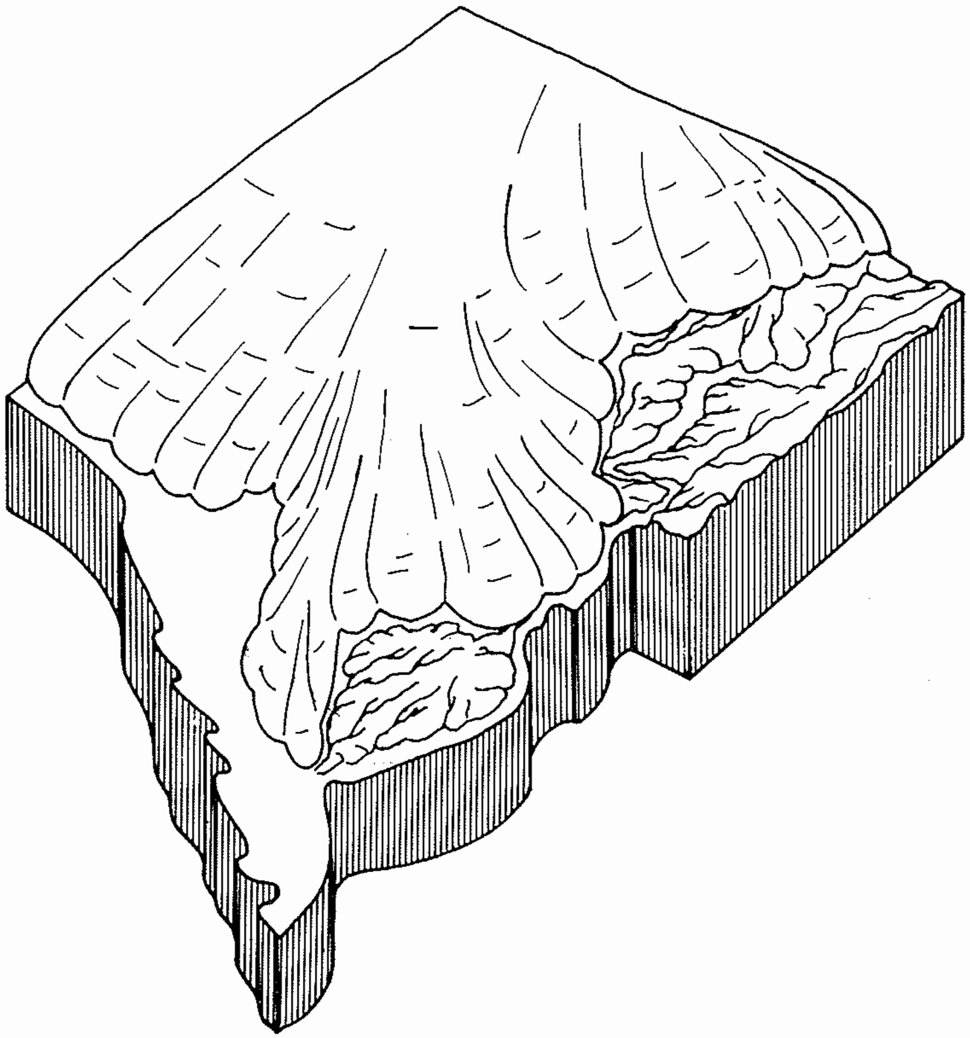
SOUTH DAKOTA GEOLOGICAL SURVEY



ILLINOIAN AGE DRIFT IN SOUTHEASTERN SOUTH DAKOTA

by

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INTRODUCTION

Prior to 1955 the glacial drift in eastern South Dakota and parts of adjacent states had been mapped as Wisconsin and Kansan in age (Chamberlin, 1883; Todd, 1899; Carman, 1913, 1931; Rothrock, 1926; Kay and Apfel, 1929; Leverett, 1932; Smith and Riecken, 1947; and Ruhe, 1950). Flint (1955) was first in correlating the Wisconsin drift in South Dakota with the classification of Leighton (1933), namely the Iowan, Tazewell, Cary and Mankato subages of the Wisconsin stage. Flint mapped Iowan drift in the interlobate area of eastern South Dakota, from near Watertown in Codington County to Richland in Union County. Steece (1958) and Tipton (1958a) found no evidence to corroborate the boundary Flint had drawn between Iowan and Tazewell drifts, and consequently they extended the Iowan drift up the Sioux River valley as far north as east-central Day County. While mapping farther south in the Big Sioux River valley Steece (1959) and Tipton (1959) discovered what they believed to be early Wisconsin end moraine remnants just north of Sioux Falls indicating that there are two ages of surface drift composing the interlobate area, not one as believed by previous investigators. The remnants further indicate that in the area between Sioux Falls and Dell Rapids there is a major drift border (Fig. 1).[2]

Steece and Tipton also observed a topographic discontinuity adjacent to these end moraine remnants. The drift surface north of the border is less maturely developed than that to the south. This difference is readily visible on air photos and can also be discerned on topographic maps. Tipton (1960) suggested that the southern drift was Illinoian in age.

Further evidence to support the existence of a drift boundary in this area is supplied by long linear (drumlinoid?) features which persist mainly on the drift surface north of the boundary; several of these ridges overlap the boundary onto the older southern drift. These may represent constructional elements of the younger drift or they may be ice-margin phenomena.

In the summer of 1964 the writer obtained additional field evi-

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[2] The drift (early Wisconsin) north of this border was termed Trent drift after the town of Trent where the drift is typically displayed; and the drift (Illinoian) to the south was called Crooks drift, after the town of Crooks. (Steece, Tipton, and Agnew, 1960.)

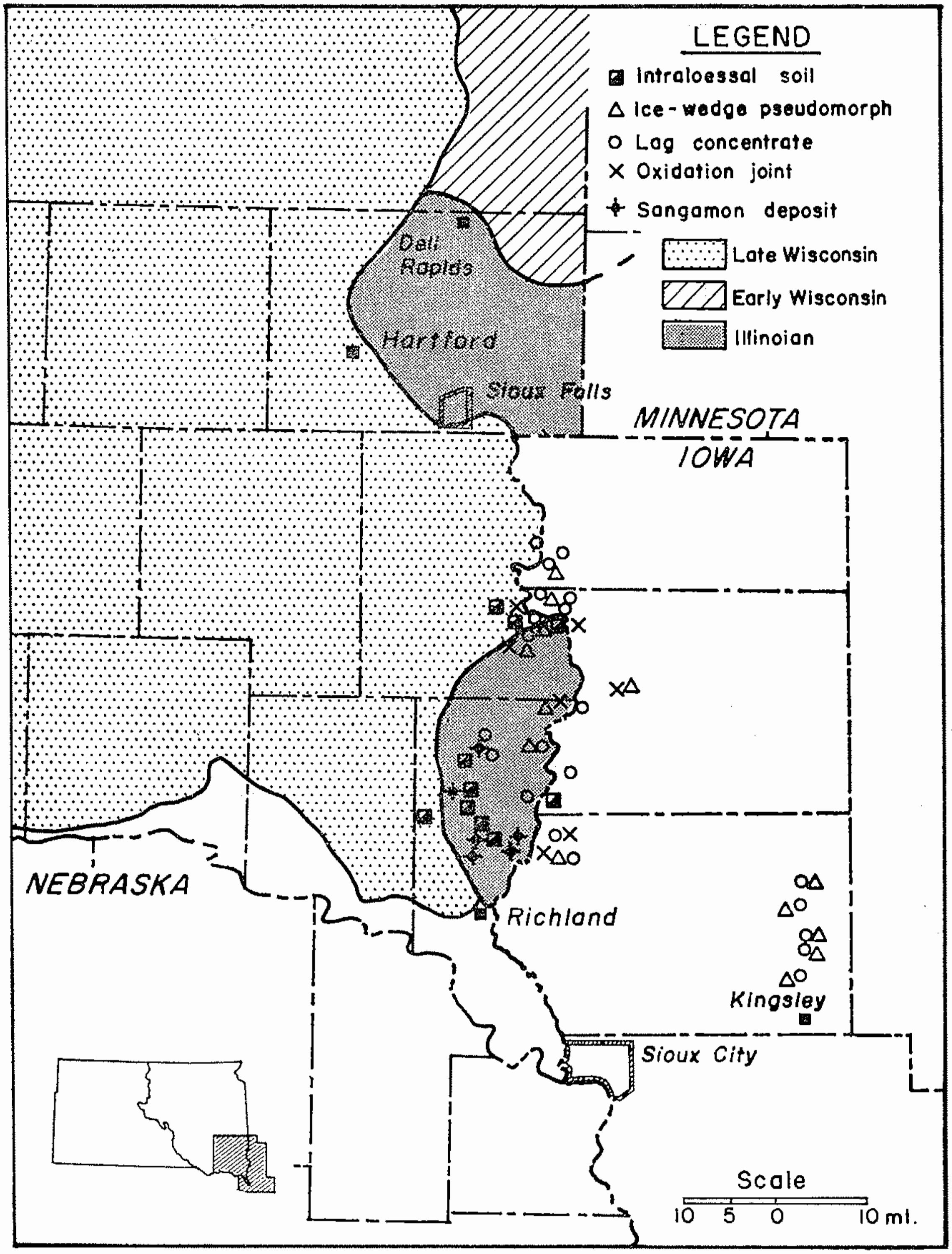

FIG. 1. Map of southeastern South Dakota and parts of adjacent States, showing distribution of glacial drift sheets and location of significant outcrops.

dence, presented below, to support the assignment of this drift to the Illinoian Glaciation.

Sangamon Soil

A buried paleosol 4 feet thick is exposed in northern Union County in a road cut one-half mile west of Nora townsite, SW¼ SE¼ sec. 23, T. 94 N., R. 50 W., Union County. The soil is composed of dark reddish-brown clay that is essentially leached. The upper part of this clay is weakly stratified and slightly darker than the lower part, probably indicating the presence of an "A" soil zone. This unit grades into till below and is overlain by Wisconsin loess 6 feet thick.

A second road cut revealing a buried paleosol about 6 miles southeast of the above locality was reported by Tipton (1958b). This cut location reveals a somewhat similar lithologic sequence, namely 17 feet of Wisconsin loess overlying 7 feet of medium to dark reddish-brown clay that is essentially leached. The upper few feet is slightly darker in hue than lower down, which probably represents the "A" zone of the profile. The paleosol at this locality is more distinctly red than at the first locality, and more closely resembles true Sangamon soils of Illinois, southeastern Iowa and northeastern Missouri.

While not exposing true paleosols as such, two other road cuts reveal deposits that may be the equivalent of the Sangamon period of weathering. The first of these cuts in NE¼ NE¼ sec. 26, T. 93 N., R. 49 W., Union County, exhibits 27 feet of Wisconsin loess overlying 4 feet of orange-brown leached clay containing pebbles. Because of the reddish coloration and leaching, the clay is probably the equivalent of the Illinoian gumbotil that is so well developed in the region to the southeast. Below this buried weathered zone lies more than 40 feet of oxidized Illinoian till.

The second cut in NE¼ NE¼ sec. 24, T. 93 N., R. 49 W., Union County, exposes a minimum of 15 feet of Wisconsin loess which rests on 9½ feet of moderate-brown leached clay containing occasional pebbles. The top of this zone is slightly darker than the main body, possibly indicating the presence of a weak "A" or "B" soil zone. This weathered zone like the similar zone in the above locality might properly be called an Illinoian gumbotil. Lying below the weathered unit is more than 17 feet of oxidized Illinoian till.

The degree of development of the buried soils and the depth of weathering in the tills of the lower Big Sioux River area are not as great as the equivalent occurrences of known Sangamon deposits elsewhere in the midwest, namely Illinois, southeastern Iowa and northwestern Missouri. This can be explained by assuming a drier, less humid climate for South Dakota than for the region mentioned above. Such a climatic difference exists today and is reflected in the relative modern soil development between the two regions.

Oxidation Joints

The oxidation of a till sheet exposed at the earth's surface is accomplished mainly by chemical weathering. Ground water slowly percolates downward and gradually causes chemical and physical changes through solution, ion exchange, precipitation, clay enrichment, compaction, and other processes. The depth to which this weathering penetrates depends on many factors of which topography, permeability, precipitation, and temperature are especially important. Where conditions are favorable, ground water is able to penetrate many feet below the general level of this relatively thin weatherized zone by way of joints which seem to be indigenous to compact tills. Ground water penetrating the joints causes oxidation to creep outward from the joint; thus the original grayish color of the till is altered to shades of yellow and brown. Precipitated salts are common as central joint fillings. In some joints developed in the Illinoian till the oxidation has progressed outward as much as 6 inches into the enclosing till, making the total width of the zone of oxidation as much as 1 foot. The most common width of the oxidized joints, however, is about 6 inches.

The significance of these joints is that this process of oxidation is exceedingly slow and requires long periods of exposure to atmospheric conditions. Rarely if ever do well developed oxidation joints of the magnitude found in the Illinoian drift in South Dakota occur in younger tills. Wisconsin tills, for example, are often extremely compact and jointed, but they almost never exhibit wide oxidation joints.

Many exposures in the region of the Illinoian till reveal anastomosing patterns of oxidized joints enclosed by grayish tills and truncated sharply upward by Wisconsin loess. At these localities there is no evidence of the surface zone of oxidation above the jointed till. This fact suggests that the surface zone of oxidation has been removed by erosion further widening the time lapse between the time of joint formation and the deposition of the Wisconsin loess.

Lag Concentrate

The subaerial erosion that removed most of the Sangamon soil and the upper oxidized zone from the Illinoian till also produced a maturely dissected topography on its surface. The erosion proceeded mainly by deflation and by slopewash of the fine-grained till matrix into consequent streams reaching headward. Where conditions were favorable dense aggregates of the coarser rock fragments, mainly boulders, cobbles and large pebbles, thus released from the till remained on the surface to form a widespread lag concentrate. Where now present on the Illinoian till surface, the lag concentrate is overlain by Wisconsin loess. It is evident that a long period of time was required to produce this concentration of rock debris, other factors not considered.

Ice Wedge Pseudomorphs

In periglacial regions marginal to continental ice sheets frozen ground phenomena occur. The proximity of glacial ice results in perennially frozen ground beyond the ice front. Such features as frost wedging, solifluction, and patterned ground are common to periglacial regions. In southeastern South Dakota and northwestern Iowa patterned-ground phenomena in the form of ice wedge pseudomorphs are common in the upper part of the Illinoian till. These typically wedge-shaped features are widest at the top and occur as clastic dikes filled with well-sorted medium to coarse sand. They range in width from 1 inch to more than 1 foot at the top, and average about 3 to 4 inches. The maximum known depth of wedge penetration is 3½ feet. In plan view the wedges ideally form a fairly regular polygonal pattern, but commonly the pattern appears to be anastomosing, probably because of few good low angle road cuts. The wedges, formed by increasingly greater accumulation of ice in a crack in perennially frozen ground, are always filled with yellow to orange well-sorted medium sand that is presumably eolian in origin; the features are therefore pseudomorphs of the ice wedges that formed them.

The requirement of perennially frozen ground to produce the ice wedges implies a regional climate similar to that of Nome, Alaska, whose mean annual temperature is about 25°F (Blair, 1948), and where permafrost exists during much of the year. At the above latitude valley glaciers are presently active at sea level and above.

It is suggested that the ice wedge pseudomorphs were produced during the early Wisconsin glacial advance. While it is believed by some workers (Steece, 1959; Tipton, 1959) that the early Wisconsin ice margin halted between Sioux Falls and Dell Rapids, at the longitude of the Sioux Falls area, it is also believed that the region to the south and east of this margin for many tens of miles suffered severe climatic effects.

The pseudomorphs are always terminated at their tops by Wisconsin loess. In addition they often bisect the oxidation joints in the Illinoian till. These facts clearly date the pseudomorphs as being older than the Wisconsin loess and younger than the oxidation joints.

Intraloessal Soil

There is little doubt that the loess which forms a nearly continuous mantle on the Illinoian till is Wisconsin in age. In at least

12 localities in southeastern South Dakota and adjacent Iowa, the loess is divided into upper and lower units by a thin, weakly developed regolithic paleosol. The paleosol characteristically has a thin leached zone and is a bright shade of orange or yellow as contrasted to the usual buff color of the enclosing loess. Associated with this oxidized zone is dark-brown carbonaceous material occurring as widely scattered flecks and spots that represent plant remains. This paleosol divides the loess into a lower increment which comprises about two-thirds of the total loess thickness at most localities, and an upper increment, comprising the remaining one-third. The lower two-thirds of the loess was deposited in the periglacial region peripheral to the early Wisconsin ice sheet from which it was derived. The ice-wedge pseudomorphs were presumably formed during early Wisconsin ice advance, and the basal loess was deposited during its retreat; the loess lies unconformably on the sand-filled pseudomorphs. A period of weathering and soil formation followed the deposition of the basal increment of the loess. During this interstadial period, however, small amounts of loess were slowly accumulating as shown by the scattered carbonaceous remains incorporated in a loess matrix. Evidently plants grew, were short lived, and were covered with loess, resulting in the gradual build-up of loess and plant fragments. Weathering was in approximate equilibrium with loess build-up as shown by the thin oxidized and leached band.

Finally late Wisconsin ice expanded eastward from the James River lowland, overlapped the early Wisconsin drift, and climbed onto the margin of the Illinoian drift highland. Deflation of the late Wisconsin meltwater streams and bare drift surface produced the loess that was carried southeastward and spread on the older surficial deposits. The dust thus derived forms the upper one-third of the loess mentioned above.

Stratigraphic Position

Deposits older than Illinoian in age occur at numerous localities in southeastern South Dakota and northwestern Iowa, particularly in the east bluffs of the Big Sioux River near Canton and in the Newton Hills south of Canton. These deposits are older than the Illinoian till, as shown by their lithology and paleontology. Thin volcanic ash beds occur in the interglacial sequence beneath the Illinoian till near Hartford (SW¼ NE¼ sec. 11, T. 102 N., R. 51 W., Minnehaha County), and near Richland (SE¼ SW¼ sec. 18, T. 92 N., R. 49 W., Union County). The ash has been correlated with the Pearlette ash bed of late Kansan age (Swineford and Frye, 1946; Tipton, 1958b; and Steece, 1960).

In many places in the lower Big Sioux area, till containing oxidation joints and/or ice wedge pseudomorphs lies below deposits of Wisconsin age, chiefly loess, and above older interglacial deposits and still older till. The interglacial sequence as much as 140 feet thick commonly exhibits bedded to massive well-sorted sands interbedded with brown to gray massive clays and silty clays. The finer beds in this sequence often contain fresh unaltered ash shards that may correlate with the Kansan Pearlette ash bed; the coarser sometimes contain materials foreign to local glacial deposits and presumably of western origin. These interglacial sediments may be equivalent to the late Kansan and Yarmouth, Sappa-Grand Island sediments of Kansas and Nebraska.

At a few localities these interglacial deposits enclose dense populations of fossil mollusks, some of which have restricted stratigraphic range, and of ostracodes and charophytes. Among the several dozen snail species usually present in these assemblages, the gastropods *Gyraulus labiatus,* Leonard, *Menetus pearlettei,* Leonard, and *Planorbula nebraskensis,* Leonard, are stratigraphically restricted to the Yarmouth Interglacial stage (Leonard, 1950). These deposits often are underlain by oxidized till of probable Kansan age.

Therefore, the till that overlies the interglacial deposits is post-Yarmouth and pre-early Wisconsin in age. Since the Illinoian glacial stage by definition coincides with this time period, there is little doubt that the till in question is Illinoian in age.

Summary of Pleistocene Events

The foregoing discussion leads to a reasonable sequence of events in southeastern South Dakota and adjacent Iowa. The sequence is interpreted as follows: (1) deposition of Kansan (and older?) till, and weathering and erosion of this till; (2) deposition of late Kansan and Yarmouth fluvial sediments and volcanic ash during interglacial conditions; (3) deposition of Illinoian till; (4) development of Sangamon soil and weathering of Illinoian till, including development of oxidation joints; (5) erosion of Illinoian drift surface and formation of lag concentrate; (6) formation of ice wedge pseudomorphs; (7) deposition of early Wisconsin loess; (8) weak soil developed on early Wisconsin loess; (9) deposition of late Wisconsin till near Illinoian margin and loess over the older deposits. The numbers correspond to the numbers on Figure 2.

It should be pointed out that all the features described above are never found at a single locality. The illustration (Fig. 2) is a composite of many exposures, and is highly generalized.

CONCLUSIONS

With the evidence at hand it can be concluded that the till under discussion is known to be post-Yarmouth and pre-early Wisconsin loess in age, and therefore deserves the identity of the Illinoian till.

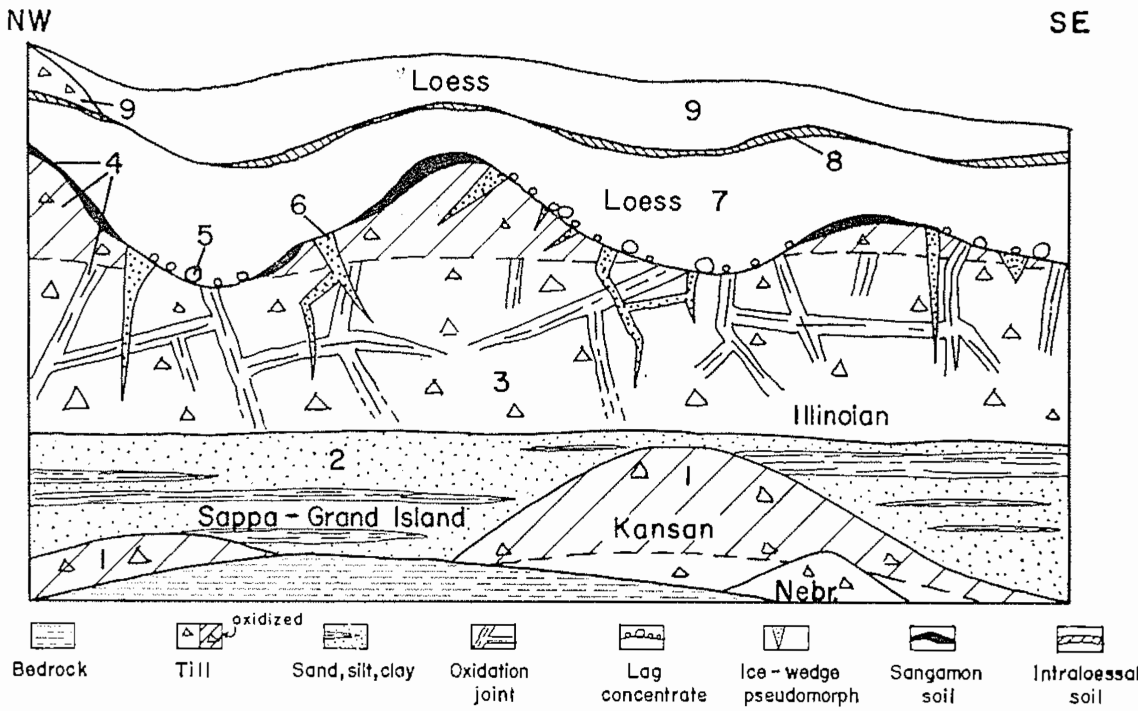

FIG. 2. Idealized diagram of southeastern South Dakota and northwestern Iowa, showing the sequence of Pleistocene events as related to the age of the Illinoian drift.

This till at the surface in large areas of southeastern South Dakota and northwestern Iowa (and southwestern Minnesota?) was formerly mapped as Kansan and Iowan (both as stage and substage) but these classifications are no longer tenable in light of the new evidence presented.

No glacial drift younger than Sangamon in age is present in this region except where Wisconsin drift has overlapped the Illinoian.

The southern and eastern limits of the Illinoian till are not known, but the till occurs at the surface as far southeast at least as Kingsley, Iowa (Fig. 1), 80 miles southeast of Sioux Falls, and 25 miles east-northeast of Sioux City, Iowa.

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