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Drainage Patterns and Glaciations in Eastern Nebraska

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Most of the stream courses of eastern Nebraska came into existence during the recession of an ice margin. Their patterns include many drainage anomalies that suggest both the manner and the times of ice disappearance. Rivers coming from the west flow down the regional slope of the High Plains. Along and east of the "Kansan" glacial border most streams are subparallel, trend S30°-40°E, and probably mark pauses of an actively retreating ice margin. Logan Creek, an underfit stream, flows S45°E from Hartington to the Thurston/Burt county line, then directly southward to the Elkhorn. East of Logan Creek and above the bend, South Blackbird, Omaha, and Cow creeks flow parallel to Logal Creek then bend abruptly back northward to the Missouri. The Bow creeks in Cedar and Knox counties describe a series of arcs that surely mark successive retreatal positions of an ice lobe that crossed the Missouri trench around Yankton, South Dakota. Bazile Creek in the Santee Sioux Reservation flows northward to the Missouri, but the gravel and sand along it indicate a southeastward flow for the currents that deposited them. These sediments can be traced into the North Fork of the Elkhorn, thence to the Platte Valley near Fremont.

These drainage lines define the lobate margins of the ice through the James and Red River lowlands. The degree of dissection and alteration of the associated tills suggests the relative lengths of time since the ice melted from them. The compact and weathered tills in east-central Nebraska are oldest (classical Kansan); the softer, less weathered tills near the Missouri are younger (Illinoian?); Wisconsinan ice may have blocked the Missouri River near Yankton and shunted it to the Elkhorn, but left little till on the south side of the Missouri.

† † †

INTRODUCTION

Throughout the Tertiary, streams that rose on the eastern slopes of the rising Rocky Mountains drained eastward, eventually building a broad alluvial slope, the moderately dissected remains of which are now known as the High Plains. The courses of the rivers that deposited Oligocene and Miocene fluviatile sediments across Nebraska and the adjacent states changed many times during that period, but the alluvial surface continued to slope eastward, and the drainage lines followed that slope.

At the time the first of the Early Pleistocene continental glaciers expanded southward toward what is now Nebraska, the North Platte River probably was the master stream of the state. It headed in the Front and Laramie ranges, flowed eastward across Wyoming and western Nebraska, passing northeastward through the present Sand Hill region (Stanley and Wayne, 1972), and probably exited across Iowa, perhaps via the Grand River valley (Sendlein and Henkel, 1970; Dreeszen and Burchett, 1971). Tributaries joined it along its route, and, although the thick cover of Quaternary sediments in central and eastern Nebraska has obscured most of them, a few, such as the Niobrara River and Salt Creek, still can be recognized in the present topography. The Missouri River, which now forms the eastern border of Nebraska, flowed northeastward across central Canada during Late Tertiary time (Alden, 1932).

The first continental glacier, which may have deposited a till that is overlain by the Huckleberry Ridge Ash, dated at about 2.02 m.y.B.P. (Izett and Wilcox, 1982; Boellstorff, 1978), blocked the northeastward-flowing Missouri drainage and forced it to overflow low divides toward the south. By the time the remainder of the Early Pleistocene glaciations had taken place, the Missouri and all other eastward-flowing rivers of the Dakotas and Nebraska had been diverted repeatedly, and a thick blanket of gravelly sand had accumulated across east-central Nebraska. The course of the Platte changed several times during that period. Finally, about 800,000 yr.B.P. and after the disappearance of the ice of the third identifiable major glaciation (Boellstorff, 1978), it had become fixed in its present valley (Stanley and Wayne, 1972).

This is a report of progress on a reexamination of the Pleistocene history of eastern Nebraska. The following discussion is based largely on an analysis of drainage patterns and a reconnaissance study of exposed tills and associated fluviatile sediments in the northeastern and east-central part of the state.

DRAINAGE ALIGNMENT IN GLACIATED NEBRASKA

The present drainage basin of the Platte River in Nebraska is highly asymmetrical (Fig. 1). East of its junction with the South Platte River, nearly all the tributaries of the Platte join it from the north, and the divide between the Platte and the Republican lies almost along the rim of the Platte's south valley wall. Examined broadly, the Platte and its Nebraska tributaries are consequent streams flowing down the initial slope of the land surface, but they are also in part subsequent, in that they have become adjusted to the broad structures of the state.

Many of the streams of eastern Nebraska came into existence while the last ice sheet to expand across that part of the state was disappearing. Even though one or more earlier glaciers had covered the area, the only clear record of drainage lines dates from the last giaciation. The southwestern margin of the last ice sheet is marked by a series of subparallel streams that trend roughly S30°E (Fig. 2). One of the most prominent of these is the Big Blue River, which follows closely the edge of the Cedar Bluffs till of Reed and Dreeszen (1965) from Seward County southward to the state line and surely came into existence as an ice-marginal drainage line. Loseke Creek and Meridian Creek evidently mark this ice margin northward between the Platte and the Elkhorn, and north of the Elkhorn River the North Fork of the Elkhorn and Bazille Creek lie along it. The abrupt elbow of the Niobrara just above its junction with the Missouri surely also is a result of ice-marginal diversion, although the glacier that caused it may not have been the one that left the Cedar Bluffs till.

South of the Elkhorn River, both forks of Maple Creek follow straight troughs that align with Skull and Oak creeks south of the Platte. The middle reach of the Elkhorn River aligns with Todd Valley, and the Platte River below Ashland must have been glacially superposed across a bedrock upland. Logan Creek and the Elkhorn–Platte below Fremont likewise formed as an ice-marginal drainage line. Finally, Bell and Papillion creeks surely mark one of the last positions occupied by the glacier margin before ice disappeared from eastern Nebraska.

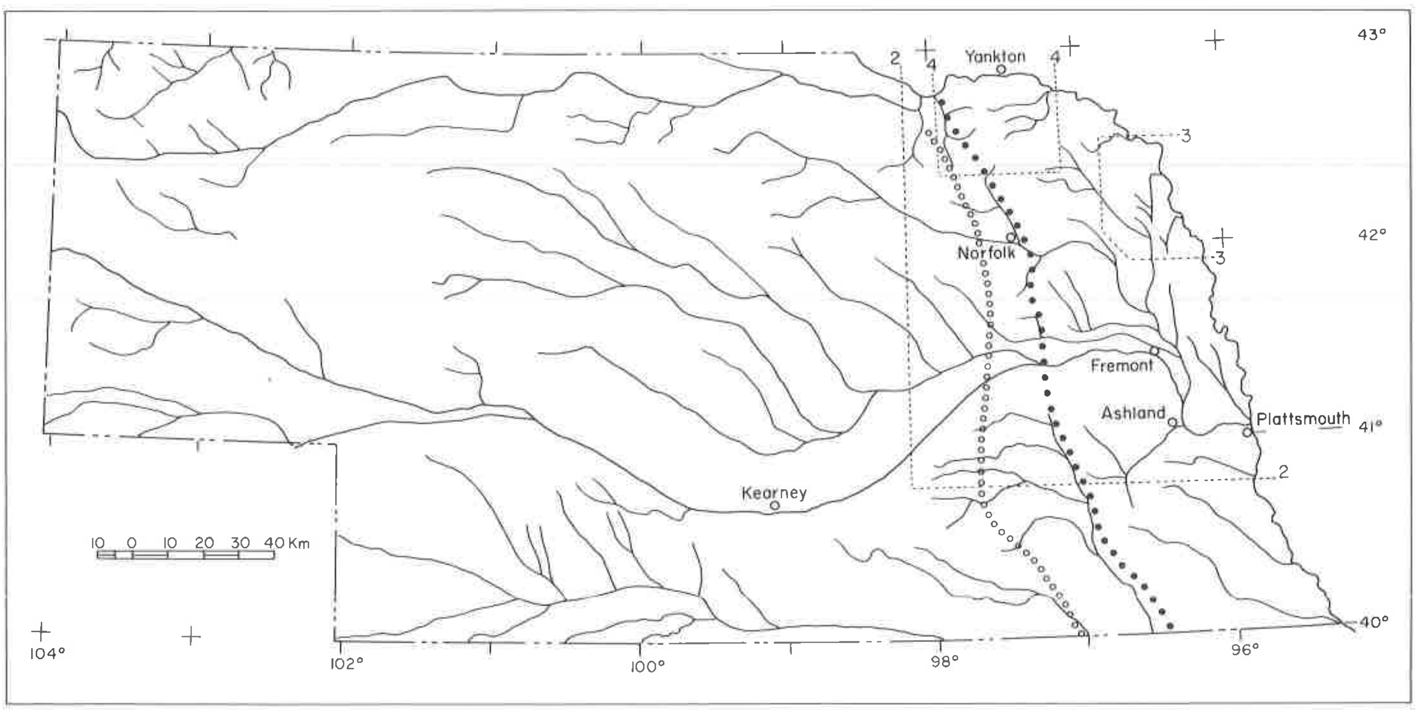

FIGURE 1. Map of Nebraska showing major drainage lines, glacial limit (open circles), Cedar Bluffs till limit (dots), and locations of areas shown on larger scale maps.

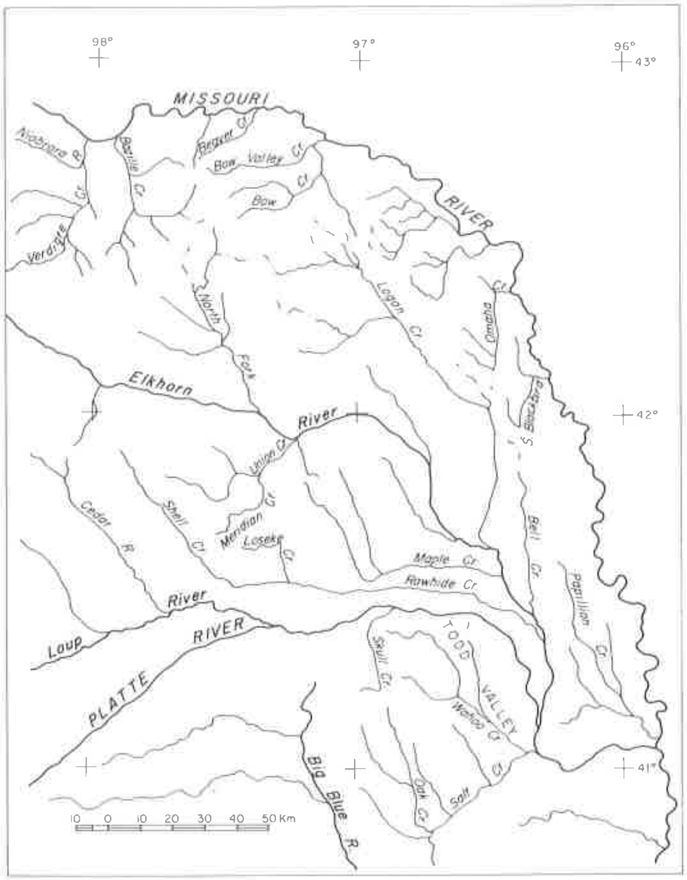

FIGURE 2. Map of eastern Nebraska showing subparallelism of streams that probably formed as ice-marginal drainage lines.

This succession of aligned drainages suggests that the last glacier to spread into eastern Nebraska retreated actively rather than by stagnation. Each of the ice-marginal streams surely represents either a stillstand or a retreat and readvance of relatively small magnitude, as do many of the Wisconsinan moraines of central Illinois and their ice-marginal streams, such as the Mackinaw, Vermillion, and Kankakee rivers (Lineback, 1979).

Logan Creek, a decidedly underfit stream, flows through a wide trough that has the characteristics of a former glacial sluiceway. Like the ice-marginal drainageways to the west of it, it trends about S40°E from its headwater area near Hartington in Cedar County to the Thurston–Burt county line, then turns directly southward to the Elkhorn Valley. Bell Creek, just to the east of Logan Creek, is smaller, but it, too, flows southward and has the characteristics of a meltwater channel.

North of Bell Creek and east of the Logan Creek trough above the elbow, several streams, particularly Cow Creek, North Omaha Creek, and South Blackbird Creek, flow parallel to the upper part of Logan Creek, then turn abruptly northward and enter the Missouri River through valleys that are parallel with the lower part of Logan Creek and with Bell Creek (Fig. 3).

In northeastern Nebraska, Bow, Antelope, and Beaver creeks follow courses completely discordant to the other streams of the state (Fig. 4). Bow Creek and its tributaries, Norwegian Bow Creek, and Bow Valley Creek describe arcs that seem to outline the margin of a small ice lobe that extended across the Missouri into Nebraska from the James Valley lowland in South Dakota. Antelope and Beaver creeks outline successively smaller arcs nearer the Missouri trench.

Several streams head just south of the valley of Bow Creek and radiate outward (Fig. 4). Howe and Little Bazille creeks flow southwestward to Bazille Creek, which drains northward into the Missouri River. The North Fork of the Elkhorn flows slightly west of south into a wide gravel-filled channel that runs southeastward from the dissected terrain along Bazille Creek to the main stem of the Elkhorn River at Norfolk. Logan Creek heads in a broad triangular patch that contains considerable sand and gravel and points southeastward from Bow Creek at Hartington.

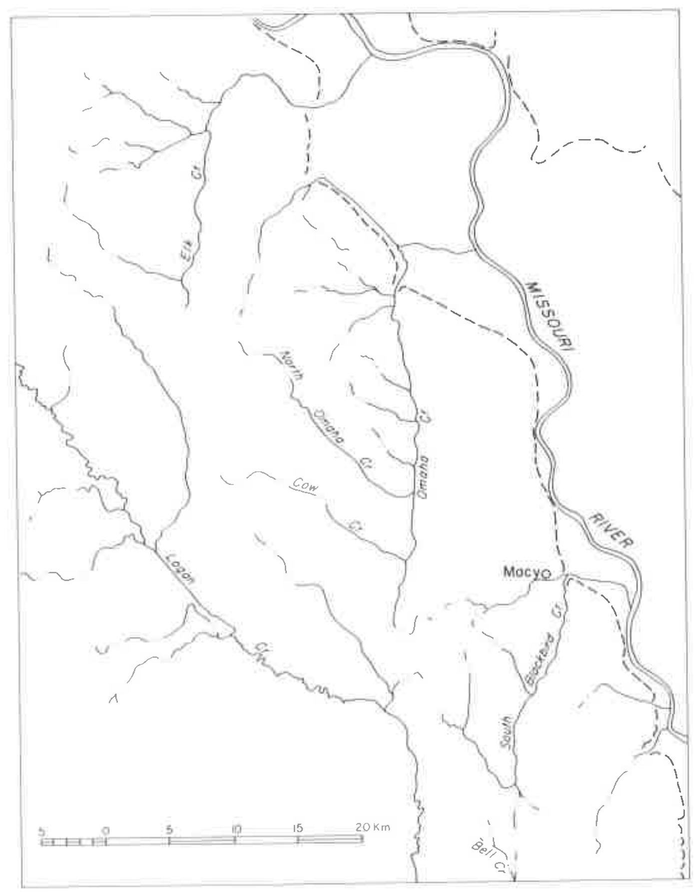

FIGURE 3. Drainage patterns of streams between the Logan Creek trough and the Missouri River bluffs.

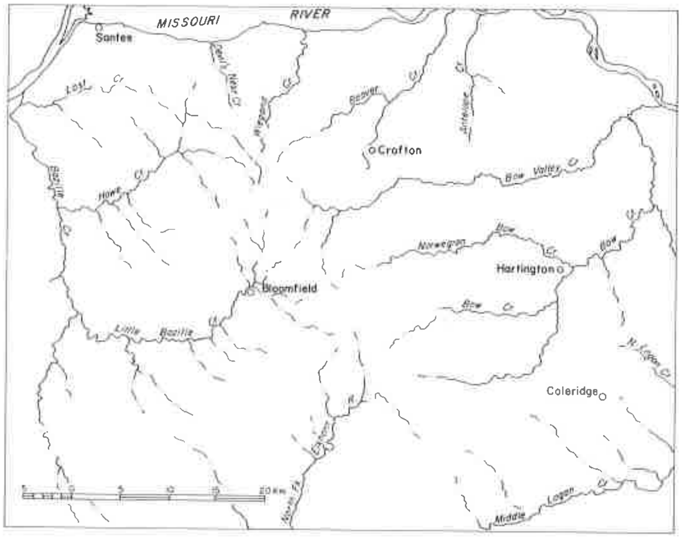

FIGURE 4. Drainage patterns of streams in the Bow Creek basin, northeastern Nebraska.

THE SURFACE TILLS IN EASTERN NEBRASKA

Lithology and Provenance

The till that lies nearest the surface throughout east-central Nebraska has relatively uniform characteristics. Even though two or more tills may be present (Reed and Dreeszen, 1965), their lithic characteristics are so similar that they cannot be distinguished petrographically (Boellstorff, 1978). They are silty clay tills that contain clasts of Sioux Quartzite. In contrast, within the arc of Bow creeks, the till is more clayey than that farther south, and it lacks Sioux Quartzite clasts.

Horberg and Anderson (1956) pointed out that during the Wisconsinan glaciation the ice margin became lobate, following major lowlands. The part of the glacier that flowed southward through the Dakotas and Minnesota was split by the Coteau des Prairies into the James River and Des Moines lobes. Aber (1982) suggested that a similar lobation took place during the Early Pleistocene glaciations and called the two ice streams the Dakota Lobe and the Minnesota Lobe (Fig. 5).

In eastern Nebraska, Sioux Quartzite clasts are ubiquitous in the older surface till. This, along with the parallelism of ice marginal drainage, suggests that the two lobes coalesced and that the Minnesota Lobe may have dominated the movement (Fig. 6). After the ice had disappeared from the state, though, the tip of a lobe from the James River tongue extended across the river as far as Bow Creek and left a concentric series of small ice-marginal streams as it melted. Topography to the east of Bow Creek suggests that the edge of the more easterly ice lobe may also have reentered the state, reaching perhaps as far as Logan Creek. The north-south orientation of lower Logan Creek, Bell Creek, and Papillion Creek would make it seem likely that this ice advance did not alter their courses.

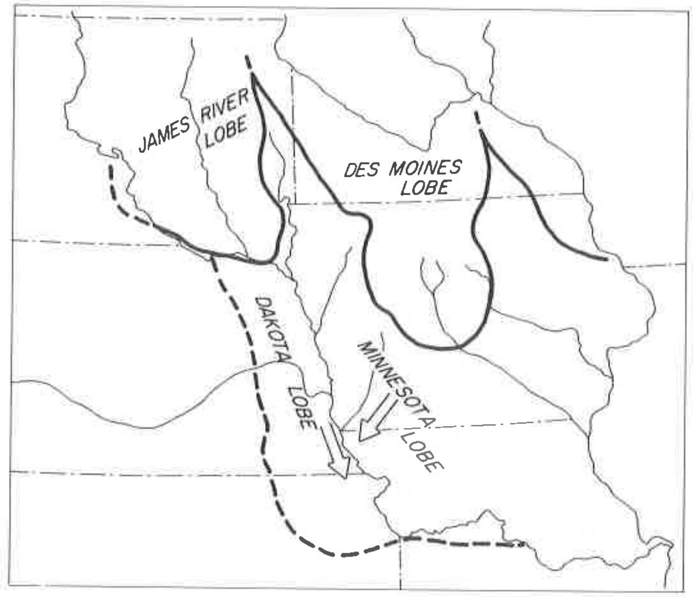

FIGURE 5. Wisconsinan ice lobes (*after* Horberg and Anderson, 1956) and Early Pleistocene ice lobes (*after* Aber, 1982).

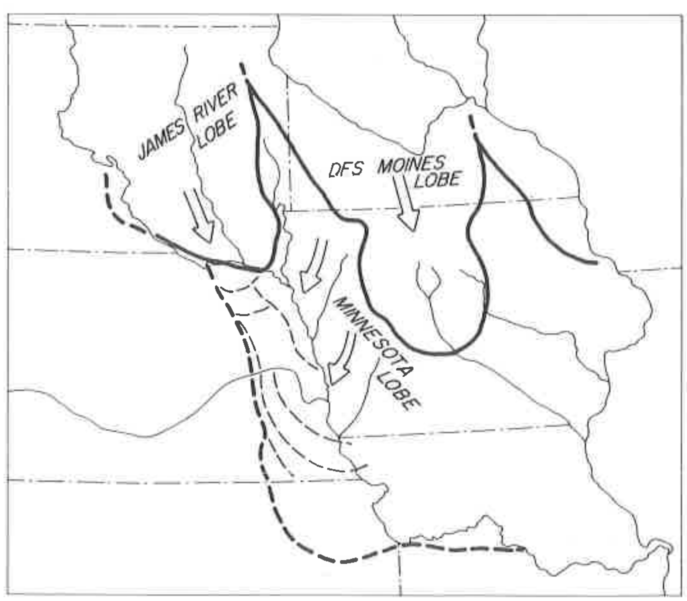

FIGURE 6. Pleistocene ice lobes of Nebraska based on indicator-clast lithology and drainage patterns.

Weathering Characteristics

The tills of eastern Nebraska are generally blanketed with loess. In many places, where the loess cover happens to be thin or absent, the pre-Holocene soil profile evidently was removed by erosion, but enough places with the full weathering profile remain that the extent of alteration of the tills in different areas can be compared. Throughout most of eastern Nebraska south of the Bow Creek basin, where a full soil profile has been preserved on well drained sites, the B horizon is strong brown and clay-rich, with blocky structure and peds that display well developed clay skins. Fractures that extend beneath the solum form polygonal patterns and typically are bordered by bands of oxidation about 5 cm wide. Generally, chalky veins as thick as 1 cm or nodules are present along the fractures below the B horizon to a depth of 2 or 3 m.

North of the arc formed by Antelope, Bow Valley, and Devil's Nest creeks (Fig. 4), soil profiles on the till are nowhere as thick and strongly developed as are those south of the Bow Creek basin. The till is less compact, fractures are bordered by oxidation bands less than 1.5 cm wide, and chalky carbonate nodules or veins are rarely present below the solum. These differences in weathering suggest considerable differences in length of time and nature of conditions of weathering of the tills of the two areas.

CORRELATIONS

Both drainage patterns and till characteristics make it seem likely that the surface tills of Nebraska fall into two main groups, widely separated in age. The till beneath the surface of most of the region has distinctive weathering characteristics that indicate a relatively long period of exposure. As the glacier lobe that deposited that till shrank, it left a series of parallel ice-marginal drainage lines. To the north, Bow Creek represents the limit reached by ice that advanced later from the James River Lowland. An ice lobe from the lowland on the eastern side of the Coteau des Prairies probably reached as far as Logan Creek but did not extend any farther south in Nebraska than the elbow at the Thurston-Burt county line. The tills in both areas show considerably less weathering than those farther southwest in Nebraska. In addition, a reddish-brown loess, the Loveland, which overlies the older tills in many exposures, has not been observed on top of the younger tills.

Classically, the older, more weathered tills at the surface in eastern Nebraska have been considered Kansan in age, and I refer them to that glaciation in this report. The character of weathering at the surface of the tills, where a full soil profile has remained, suggests that considerably greater time has been involved in its development than for the Sangamon paleosols observed in Nebraska, Iowa (Ruhe, 1969), and areas to the east (Follmer, 1978). Further, the existence of chalky carbonate-filled fractures beneath the solum suggests that the climate may have been measurably more arid for a considerable amount of time. Within our present understanding of the Pleistocene, such a climatic event took place during the Yarmouth interglaciation.

Within Nebraska, fission track dates of ash beds beneath the surficial tills are few; the Mesa Falls ash, dated 1.2×10^6 yr, however, underlies the uppermost till near Coleridge (Boellstorff, 1978; Izett and Wilcox, 1982). Petrographic identification of eastern Nebraska tills is difficult, and for some units that were recognized by Reed and Dreeszen (1965) evidently cannot be done (Boellstorff, 1978).

Based on these records, the Cedar Bluffs till of central Nebraska has weathering characteristics that would readily permit it to be considered a Kansan correlative. It seems to be bracketed by ash beds that place its age between 1.2 and 0.7×10^6 yr. Reed and Dreeszen (1965) reported that another till, the Clarkson, overlies the Cedar Bluffs in eastern Nebraska, but that no exposure of it was known. Boellstorff (1978: Fig. 2) considered Clarkson till to be equivalent to the till at Hartford, South Dakota, that overlies the Lava Creek Ash, dated at 0.62×10^6 yr (Izett and Wilcox, 1982), although it is petrographically similar to the Cedar Bluffs till, and no ash underlies it in the type section. It, too, probably is Kansan in age. Little can be said at this time about the Hartington till, which is the surface till at Hartington but is not well exposed, except that it evidently was deposited by an ice lobe that entered Nebraska from the James River Lowland and stopped just north of Bow Creek. Boellstorff found it, too, to be indistinguishable petrographically from the Cedar Bluffs and Clarkson tills.

The till exposed just east of Crofton has been weathered much less than have the older tills, and oxidation along joints is minor. According to Boellstorff, it overlies ash at Hartford, South Dakota. Its relationship to the Loveland Loess has not been determined, although only the Peoria Loess overlies it in road-cut exposures examined. From these data it must be considered one of the Late Pleistocene tills and could equally well be either an Illinoian or a Wisconsinan equivalent.

A few observations are available to aid in an effort to decide the most likely correlation of the Crofton till. First, it is moderately "soft"—the older tills in Nebraska are much more compact. Both the Illinoian and older Wisconsinan tills in the type areas of southern Illinois and Indiana are relatively compact; the youngest Wisconsinan tills there, though, are noticeably less well consolidated. Second, oxidation bands along joints are narrow—1.5 cm or less, comparable to those observed on tills of Illinoian age in southern Indiana (Wayne, 1963:53). Third, its surface has been altered rather extensively by post-depositional erosion. The oldest Wisconsinan moraines of central Indiana and Illinois, which have been dated at 20,000–21,000 yr.B.P., show relatively little erosion. Moraines are present but discontinuous on the Illinoian till plain, and their depositional forms, though readily recognizable in some places, have been extensively modified. Fourth, a distinctive pattern of closely spaced parallel NW–SE lines that is visible on aerial photographs and detailed topographic maps crosses the older tills of northeastern Nebraska. On the ground these are seen to be aligned ridges separated by undulating troughs. This fluting seems to be absent on the Wisconsinan drift of southern South Dakota but is clearly present outside that drift border. This fluted pattern, which probably resulted from erosion by strong unidirectional winds along the Wisconsinan ice edge, is present on the Crofton till surface as well as on the tills beyond it to the south. Although no one of these observations is more than an indication, together they suggest that the Crofton till is likely pre-Wisconsinan in age, although clearly younger than the Kansan tills. The most probable glacier to have deposited it is the Illinoian.

East of Logan Creek, outcrops are few, and many of those that do exist expose only thick Peoria Loess. Nevertheless, in a few places till can be found beneath the loess blanket. Road cuts and stream banks in the Omaha Creek basin contain exposures of Peoria Loess over brown Loveland Loess, which lies on top of till that has widely oxidized and $CaCO_3$-filled joints, features strongly suggestive of Kansan tills west of Logan Creek. In one road cut near Macy (Fig. 3), a different till, more sandy and pebbly, with a mature, strong brown (7.5YR 5/6) B horizon in the buried solum and no chalk-filled joints, is suggestive of a younger but pre-Sangamon till.

No direct evidence—i.e., no till—has been found to confirm that glacial ice entered Nebraska during the Wisconsinan glaciation. Indirect evidence, though, is considerable that it must have crossed and blocked the Missouri River at least briefly.

During each of the pre-Wisconsinan glaciations the Missouri River was shunted around the ice margin, and some of the gravel deposits south of the bend of the Niobrara contain clasts of upper Missouri River provenance as well as those of the Laramie Range and glacial ice from the northeast. Part of that ice-marginal drainage went southward through the Big Blue River basin. At other times, and surely during the Illinoian glacial maximum in Nebraska, the overflow poured into the Elkhorn Valley at Norfolk, and evidence remains as part of the broad sand and gravel plain downstream along the Elkhorn and between the Elkhorn and Logan Creek.

Prior to the Wisconsinan glaciation, the Platte and Elkhorn may have shared the same valley downstream from Fremont as they do today, or the Platte may have passed through Todd Valley, as others (Condra, 1903; Lueninghoener, 1947) have suggested. In either event, something forced the Platte River to aggrade to the level preserved in Todd Valley, which in the terrace north of Fremont is underlain by loess-covered sand and stands as a divide between Maple Creek and the Platte. Aggradation on the Platte extends upstream well past the junction with the Loup River and may be present as far as the junction of the North and South Platte rivers. The high Platte terrace surface that terminates at the north end of Todd Valley has a gradient of 0.0010 between Kearney and Fremont, whereas the modern Platte gradient in the same reach is 0.0012; from Fremont to Ashland, the modern Platte gradient is 0.0010, but 0.0016 is the gradient of Todd Valley. The Missouri River carried Wisconsinan meltwater and aggraded its channel at the mouth of the Platte (Gowen, 1982), but the amount of valley filling there would not account for the extensive and thick fill beneath the Todd Valley surface nor the slope change in the terrace surface above Fremont. Logan Creek must also have been blocked during the Wisconsinan glaciation; terraces in the lower 20 km of Logan Creek slope upstream rather than downstream.

These several phenomena might be readily explained if the Missouri River were dammed, even briefly, by ice that blocked it at the maximum advance of the Wisconsinan glacier. Extensive dune-covered sand plains along the Elkhorn River suggest that it must have been a route for considerable flow. It is one of the routes followed by pre-Wisconsinan overflow from the Missouri and would have been occupied again during the Wisconsinan glaciation if ice dammed the Missouri. Sediment carried and deposited along the Elkhorn would have blocked Logan Creek, causing a small delta to develop where Missouri-Elkhorn flow entered it and thus reversing Logan Creek's gradient near its mouth. The sediment load of the Missouri-Elkhorn would have created a large dam of alluvium where it entered the Platte-Elkhorn junction north of Fremont, filling it and forcing the Platte to aggrade its valley floor with sand, ultimately to the level of Todd Valley. The constriction of the Platte below Ashland also would have contributed to the backup of sediment and water because it would have forced the effluent from a broad channel into a very narrow one; the steeper slope of Todd Valley represents the surface produced by the Platte flow as it passed the alluvial barrier dumped into it from the Elkhorn. The aggrading Platte channel would have held all incoming tributaries against the valley wall for long distances before their channels finally joined the main one. Maple Creek, Shell Creek, and Loup River, in particular, enter from the north, and their channels hug the north valley wall for several tens of kilometers before joining the Platte.

If the ice front entered the Missouri Valley at Yankton and blocked the river causing it to overflow the south bank, the glacier could have spread a short distance out on the south side and yet have failed to deposit any significant amount of till. The debris-laden base of the glacier would have been in the valley and little except clean ice would have expanded over the south rim of the valley. Both drainage lines and patterns on aerial photographs outline a small lobate area that is about 20 km long and extends 7 km south of the bluffs over the Missouri Valley; it is bordered by Beaver Creek and the lower part of

Devils Nest Creek. A moderate search has turned up a few polished and striated boulders but no till, although little would be expected under such circumstances. This small ice lobe would have been sufficient, though, to block the Missouri briefly and to divert its flow, swollen by glacial meltwater, up Bazille Creek (and perhaps Verdigre Creek) to the sand and gravel plains that lead into the North Fork of the Elkhorn. From Norfolk southward, the main stem of the Elkhorn served as the route to the Platte.

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