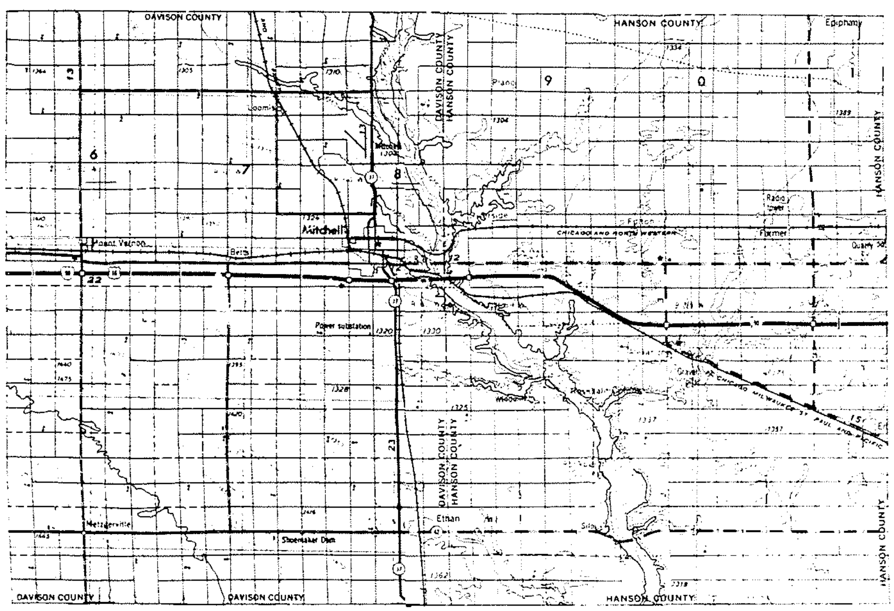
BULLETIN 33

GEOLOGY OF DAVISON AND HANSON COUNTIES, SOUTH DAKOTA

by

C. M. CHRISTENSEN
SOUTH DAKOTA GEOLOGICAL SURVEY



Prepared in cooperation with the United States Geological Survey, Lower James Conservancy Sub-District, and Davison and Hanson Counties

DEPARTMENT OF WATER AND NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY
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Vermillion, South Dakota

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ABSTRACT

Davison and Hanson Counties are located in east-central South Dakota near the center of the James Basin in the Central Lowland Physiographic Province and have a total area of 864 square miles. Although exposures of Cretaceous Pierre Shale, Niobrara Marl, Carlile Shale, Codell Sandstone and Precambrian Sioux Quartzite are present in the area, Pleistocene deposits comprise the bulk of surficial sediments. These Pleistocene deposits consist primarily of till with lesser amounts of stratified drift. All Pleistocene deposits are of late Wisconsin age. Recent sediments consist mostly of alluvium. Ground water, sand, gravel and quartzite are the most important mineral commodities.

INTRODUCTION

Purpose

The investigation of Davison and Hanson Counties is one of a series of cooperative studies conducted through the combined efforts of the South Dakota Geological Survey and the U.S. Geological Survey (fig. 1). Each study is conducted with several goals in mind. Of primary concern is the location and evaluation of the mineral and water resources available in each of the areas being studied. In addition, the knowledge gained from each study will be a most important contribution to understanding the overall geology of South Dakota.

Results of the investigation of Davison and Hanson Counties are published in several parts. This report contains the geology with special emphasis on deposits of Pleistocene age. Hansen (1983a) contains the technical results of the water-resources investigation. An additional report compiled by Hansen (1983b) describes the locations and characteristics of all major aquifers in the two counties. Two other reports which resulted from the study deal with sand, gravel and quartzite resources (Hammond, 1982a, b). In addition, a compilation of all basic data collected during the investigation will be available as an open-file report at the office of the South Dakota Geological Survey in Vermillion. All test-hole information is available and accessible via computer printout.

Location

Davison and Hanson Counties are located near the center of the James Basin in the Central Lowland Physiographic Province and each has an area of 432 square miles (fig. 2). They are bordered on the west by Aurora County, on the north by Sanborn and Miner Counties, on the east by McCook County and on the south by Douglas and Hutchinson Counties.

Previous Investigations

The two-county area has been included in a number of reconnaissance investigations dealing with the general geology and bedrock of the area (Todd, 1894, 1903a, b; Darton, 1909; Rothrock, 1943; Wong, 1960; and Hoff and Steece, 1961). Flint (1955) made a reconnaissance survey of the Pleistocene geology of eastern South Dakota which included Davison and Hanson Counties.

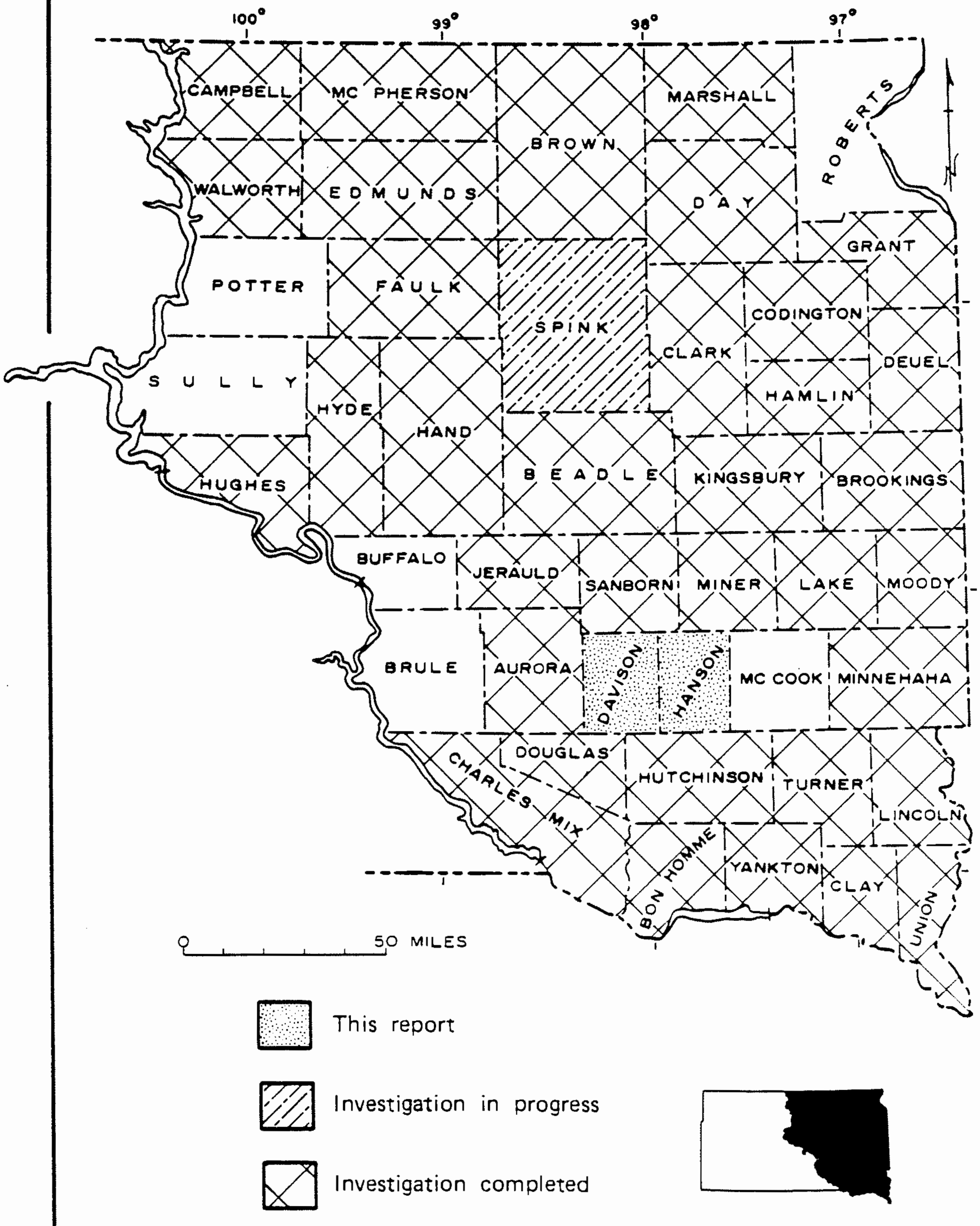

Figure 1. Status of county-wide investigations in eastern South Dakota.

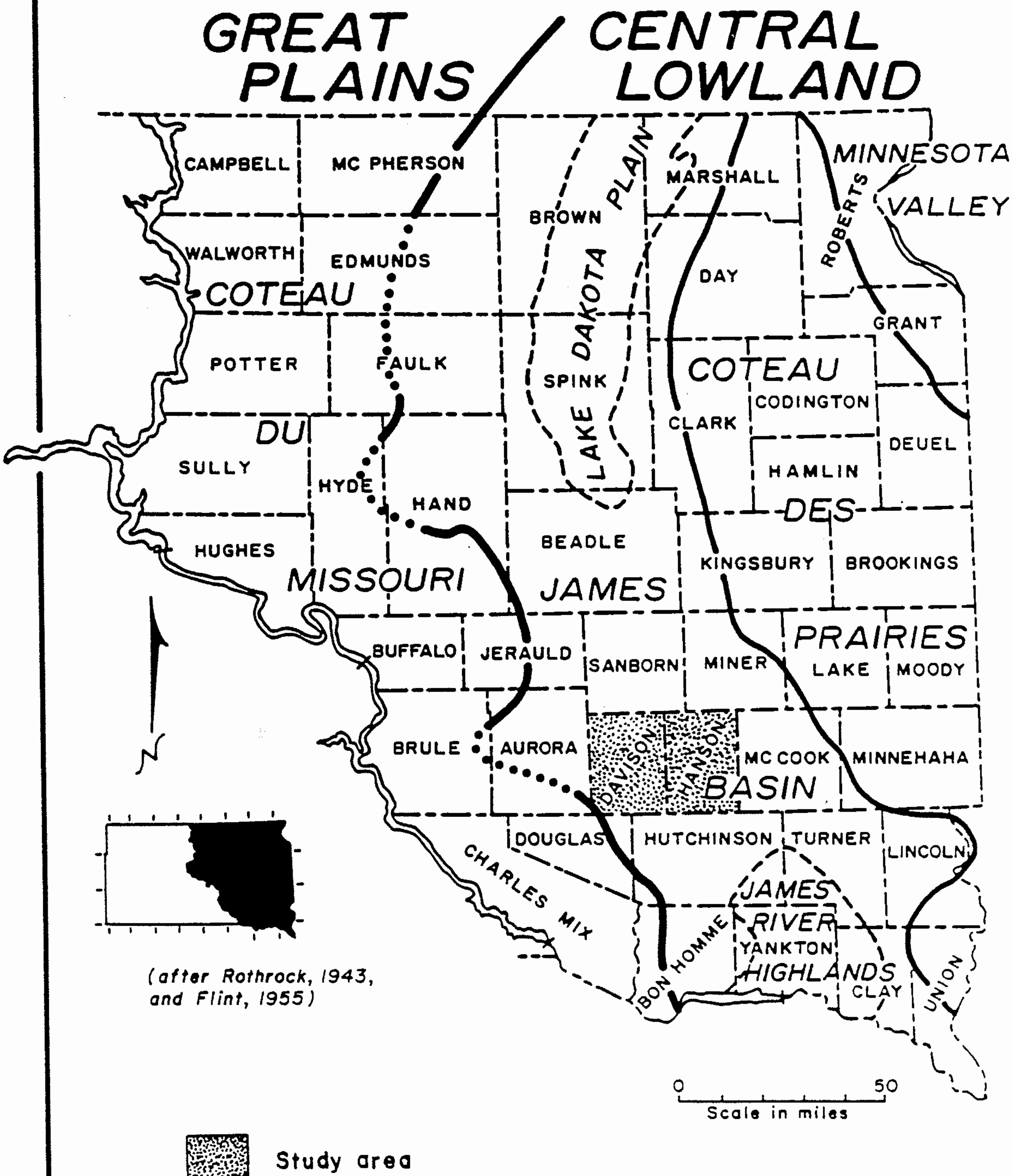

Figure 2. Physiographic divisions of eastern South Dakota and location of the study area.

In addition, parts of the two-county area have been studied during a number of ground-water investigations in recent years (Jorgensen, 1960; Barari, 1966, 1972 and 1979; Barari and Stonestrom, 1976; Barari and Cripe, 1977; and Barari and others, 1981).

Several studies dealing with the Precambrian Sioux Quartzite (Baldwin, 1949) and gravity measurements (Lum, 1961; and Hansen, 1984) have also included parts of the area.

With the exception of McCook County, all of the surrounding counties have been the subject of investigations similar to those which resulted in this report. Reports from the surrounding counties include Aurora County (Hedges, in preparation), Sanborn County (Steece and Howells, 1965), Miner County (Schroeder, 1988), Hutchinson County (Duchossois, in preparation) and Douglas County (Hedges, 1975; Kume, 1977).

Method of Procedure

Information contained in this report results primarily from geologic mapping conducted during four field seasons in 1976, 1977, 1978 and 1979. The geology of the two-county area was mapped on aerial photographs having a scale of approximately 1:70,000 (about 1 inch = 0.9 miles) and later transferred to a base map of the same scale. The resulting map was then reduced to a scale of more manageable size for reproduction (pl. 1).

Information obtained from natural outcrops and man-made exposures of rock material was supplemented by numerous test holes drilled by the South Dakota Geological Survey. Most subsurface information was obtained by examination of well cuttings and electric logs from these test holes. Supplemental information was obtained from the files of local well drillers and from a well inventory conducted by the U.S. Geological Survey during the water-resources investigation of Davison and Hanson Counties (Hansen, 1983a).

Acknowledgements

The investigation and preparation of this report were performed under the supervision of Merlin J. Tipton, State Geologist. The writer wishes to thank the entire staff of the South Dakota Geological Survey for their advice and assistance throughout the project. Special thanks go to Layne D. Schulz who assisted the writer with the preparation of maps and cross sections used in this report.

Financial assistance for the project was contributed by the South Dakota Geological Survey, U.S. Geological Survey, Lower James Conservancy Sub-District, Davison County and Hanson County. The study was initiated at the request of the County Commission from each of the above named counties and their cooperation as well as that of the residents of both counties is gratefully acknowledged.

Physiography

With the exception of a few sections in southwestern Davison County, which is part of the Coteau du

Missouri in the Great Plains Physiographic Province, the entire two-county area is within the James Basin in the Central Lowland. The Central Lowland Physiographic Province extends from north to south through eastern South Dakota and is bisected by the James River. The James River flows through Davison and Hanson Counties (pl. 2) and is the primary drainage for the entire two-county area.

GEOLOGY

Stratigraphic Relations

Stratigraphic nomenclature used herein conforms to that accepted by the South Dakota Geological Survey (Agnew and Tychsen, 1965) and to the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1983).

Table 1 lists the pre-Pleistocene stratigraphy that is present in Davison and Hanson Counties. The youngest rocks are at the top of the list.

TABLE 1
Pre-Pleistocene stratigraphy

SYSTEMS	ROCK UNITS
Cretaceous Systems	
Upper Cretaceous Series	Montana Group
	Pierre Shale
	Colorado Group
	Niobrara Marl
	Carlile Shale
	Codell Sandstone
	Greenhorn Limestone
	Graneros Shale
Upper and Lower Cretaceous Series	Split Rock Creek Fm.
	Dakota Formation
	Sioux Quartzite "wash"
Precambrian	Sioux Quartzite

Because a complete discussion of the pre-Pleistocene stratigraphy is beyond the scope of this report, only those pre-Pleistocene rocks that are exposed at the surface, immediately underlie Pleistocene sediments or have directly influenced Pleistocene events will be discussed. From oldest to youngest, these are the Sioux Quartzite, Carlile Shale, Codell Sandstone, Niobrara Marl and the Pierre Shale. Of these, all are Cretaceous age except the Sioux Quartzite which is Precambrian. For information regarding other stratigraphic units, the reader is referred to Schoon (1967).

Sioux Quartzite

Precambrian age Sioux Quartzite is exposed at the surface in many areas of Hanson County within the valleys of the James River and Enemy, Johnson, Pierre, Plum and Wolf Creeks (pl. 1). It is also the first bedrock encountered below the Pleistocene deposits in a major part of the county (pl. 2).

Exposures in Hanson County show the Sioux Quartzite to consist primarily of pink, well-cemented, fine-grained sand. Vertical jointing is common and, although not always apparent in the exposures just described, horizontal jointing most definitely exists. Joint patterns of both a horizontal and vertical nature can be seen in the Sioux Quartzite at a quarry immediately east of Hanson County near Spencer, South Dakota, and at exposures near Sioux Falls and Dell Rapids, South Dakota. Near the surface, the rock commonly fractures in blocks 1 to 4 feet on a side but the joints become more widely spaced with depth. Thickness of the Sioux Quartzite in the study area is unknown, but it is estimated to be well in excess of 1,000 feet.

No exposures of Sioux Quartzite exist in Davison County and all subsurface information indicates that Cretaceous age rocks are always present between the Pleistocene sediments and the Sioux Quartzite.

Carlile Shale

The Carlile Shale was first named and described by Gilbert (1896) from exposures near Carlile Station, Colorado. The Carlile consists of medium to dark gray, noncalcareous, greasy shale. It is fossiliferous and bentonitic and weathers light gray to orange. In the central part of the mapped area, it is the first bedrock encountered beneath the Pleistocene deposits (pl. 2). Carlile Shale (primarily the Codell Sandstone Member) is also exposed at several locations in the two counties. Most notable of these exposures are northwest of Mitchell along Firesteel Creek (pl. 1).

Codell Sandstone Member

In Davison and Hanson Counties the Codell Sandstone Member of the Carlile Shale consists of fine-grained sandstone interbedded with gray shale. The sandstone is multicolored and may vary from white to green or gray. It may be well cemented to uncemented and contains thin limestone layers. The Codell Sandstone is often fossiliferous, usually glauconitic and weathers to a light yellow or orange color. Thickness of this deposit ranges from 5 to 90 feet and averages about 40 feet. Although the Codell crops out in several areas of the two-county area (pl. 1), it is at a depth of 350 feet below land surface in the southwest part of Davison County and is the most widespread and widely used bedrock aquifer in Davison and Hanson Counties (Hansen, 1983a).

Niobrara Marl

In the study area the Niobrara Formation consists of light to medium blue-gray marl and white to cream-colored chalk and limestone. It is highly fossiliferous and calcareous and weathers to a white or light yellowish-orange color. The Niobrara is exposed at the surface in the two-county area (pl. 1) and is the first bedrock beneath the glacial deposits in most of Davison County (pl. 2). Average thickness of this formation is approximately 100 feet. Like the Codell Sandstone, the Niobrara Marl is a major bedrock aquifer in the area (Hansen, 1983a).

Pierre Shale

Pierre Shale is the first bedrock encountered below the glacial deposits in several townships in southwestern Davison County (pl. 2). Although rare, exposures of Pierre Shale also exist in the same area. One such exposure is located in sec. 15, T. 102 N., R. 62 W. (pl. 1).

In the mapped area the Pierre Shale can best be described as a light gray to black marine claystone and shale. Marl and chalky zones occur throughout the formation, it is bentonitic and generally calcareous. The Pierre Shale has a maximum thickness of slightly over 200 feet in the southwestern part of Davison County (pl. 2) and this represents the maximum thickness of the formation in the two-county area. Stratigraphic cross sections D-D' and E-E' (pl. 3) show the relationship of the Pierre Shale to the underlying formations and the Pleistocene sediments.

Pleistocene Deposits

Late Wisconsin age sediments resulting from the action of glacial ice and meltwaters comprise the vast majority of surficial deposits in Davison and Hanson Counties. These consist primarily of till and outwash (pl. 1). A series of five east-west cross sections (pl. 3) show the subsurface relationships of these Pleistocene deposits in the two-county area. Pleistocene sediments are thickest over a buried valley in northwestern Hansen County (pl. 3, cross sections A-A' and B-B'). In this area the sediments attain a maximum total thickness in excess of 300 feet. In general, the Pleistocene sediments average less than 100 feet in thickness throughout the mapped area (pl. 3).

Till

Till derived directly from the late Wisconsin ice sheet is the most abundant sediment in Davison and Hanson County (pl. 1). This till is a heterogeneous mixture of clay, silt, sand and gravel, usually in a clayey matrix, and averages approximately 75 feet thick throughout the area (pl. 2). Although a wide variety of rock fragments are represented in the till, there is an abundance of fragments derived from local rocks. Exposures of the Niobrara Formation, Codell Sandstone Member of the Carlile Formation and Sioux Quartzite are common in the area and isolated exposures of the Pierre Formation occur in the western part of Davison County. It is, therefore, common to find fragments of these rocks in the till. Most easily recognized are specimens derived from the Codell Sandstone and the Sioux Quartzite.

The till is medium to dark gray when unoxidized, however, where exposed at the surface it weathers to a yellow-brown color. Test holes drilled for this study indicate that oxidation extends to depths of approximately 25 feet (pl. 3).

Outwash

Late Wisconsin age outwash deposits are present at the surface (pl. 1) and in the subsurface (pl. 3) in the two counties.

Two extensive bodies of surficial outwash exist in Davison County. The first occupies an area of approximately 20 square miles in the southeastern part of the county in T. 101 N., and T. 102 N., R. 60 W. (pl. 1). This deposit consists of fine sand to medium gravel composed of a wide variety of rock fragments. Local rock types (Niobrara Marl and Codell Sandstone) are abundant but are mixed with various other igneous, metamorphic and sedimentary types. Thickness of this outwash deposit seldom exceeds 30 feet and generally averages less than 20 feet.

A second outwash exists at the surface along an extent of Firesteel Creek in northern Davison County (pl. 1). This outwash reaches a maximum thickness of 30 feet in isolated instances, however, the average thickness is about 15 feet based on test holes drilled for this study. Outwash exists both within the valley of Firesteel Creek (shown as Qwlo on pl. 1) and as thin terrace deposits along the valley walls (shown as Qwlot on pl. 1). The outwash is covered by a thin layer of alluvium.

A detailed investigation of all outwash deposits in Davison and Hanson Counties was conducted during this study. For further information on these deposits, the reader is referred to Hammond (1982a, b).

Holocene Deposits

Alluvium

The only Holocene age deposits in the two-county area are alluvial deposits that exist along the valley floors of most streams (pl. 1). Most significant of these is the alluvial fill in the valley of the James River. Alluvium in the James valley attains a maximum thickness of about 20 feet, however, average thickness is usually less than 10 feet. Although the alluvial deposits generally consist of clay to fine sand, some of the deposits contain medium to coarse sand and fine gravel (Hammond, 1982a, b).

DEVELOPMENT OF LANDFORMS

Preglacial Topography

Prior to ice invasion the surface of what is now Davison and Hanson Counties looked very similar to the surface that is depicted on plate 2. The highest area was in the extreme southwestern part of Davison County and these highlands reached an elevation of more than 1,600 feet above sea level. From here the landscape sloped to the northeast. A major drainageway began in the central part of the area, flowed toward the northeast and exited the mapped area in the southeast part of T. 104 N., R. 57 W. at an elevation of less than 1,050 feet above sea level.

A second, minor channel is present in the very southeastern part of the two-county area (pl. 2) and it is in this area that the lowest surface elevation (approximately 1,017 feet) was located in preglacial time. It is possible that this channel in Hanson County is the very northward extension of a tributary to the much larger ancient White River drainage farther to the south (Christensen, 1967). Investigations presently under way in Hutchinson and Turner Counties (Duchossois, in preparation) should provide sufficient data to map the extent of this drainageway.

Glacial Modification of Bedrock Topography

It is doubtful that the bedrock topography of the present two-county area was much affected by direct action of glacial ice. To be sure, some scouring must have occurred because sediment derived from local bedrock is found in the till throughout the entire area.

Speculation on the amount of erosion of sediments immediately beneath the till in the mapped area can be made by viewing the relative thickness of the Niobrara Formation in several areas shown on plate 3. Where the Niobrara is not in direct contact with glacial sediments (pl. 3, cross section D-D'), it averages about 100 feet in thickness. However, where the overlying Cretaceous rocks are missing and the Niobrara is in direct contact with the till (pl. 3, cross section A-A'), it averages less than 30 feet in thickness. It is logical to assume, therefore, that approximately 70 feet of the Niobrara has been removed by erosion. This does not necessarily mean that the entire 70 feet of sediment was removed by glacial erosion. If those areas where the Niobrara is less than maximum thickness were subjected to erosion for some time prior to glaciation a large amount of the sediment could have been removed before the ice entered the area. Although it is possible that 70 feet of sediment may have been removed by the erosive powers of glacial ice, it is more realistic to assume that part of these sediments were removed before the ice ever entered the area.

Bedrock in the mapped area was also modified by the action of running water during the Pleistocene Epoch, thus glacial ice was not the only method of glacial erosion that must be considered. An inspection of plate 3 will indicate the presence of several stream valleys that have been cut into the underlying bedrock. An example of such a valley can be seen on plate 3, cross section C-C' at test hole 54. At this particular location a substantial thickness of glacial outwash now occupies the valley. Although this does not prove that the valley was cut into the bedrock by glacial streams, it does show that meltwaters occupied the valley. A logical conclusion would be that these streams were also responsible for at least part of the valley erosion prior to the deposition of outwash.

Additional streams such as the James River have also cut their valleys to a depth sufficient to intercept bedrock beneath the till. In general these are streams that are at land surface and still active today and they will, therefore, be discussed in a later section of this report.

SURFICIAL-GLACIAL DEPOSITS AND LANDFORMS

Many of the landforms seen in Davison and Hanson Counties today are the result (either directly or indirectly) of glaciation during late Wisconsin time. They result from the influence of both active and stagnant glacial ice and from meltwaters flowing from the ice. Positions of the ice and associated meltwater streams with respect to high and low areas on the land surface have influenced the type and location of many of the deposits.

Stagnation Moraine

Moraine resulting from the stagnation of once-active ice is the only stagnant-ice deposit in the two-county area. It is shown as Qwlts on plate 1. Primarily it occurs along the western boundary of Hanson County and extends northward forming a narrow band, 1 to 3 miles wide, in Miner County (Schroeder, 1988) and southward as a similar band into Hutchinson County. The surface of this moraine is more rugged and shows greater local relief and internal drainage than the surrounding areas (fig. 3). Inspection of the

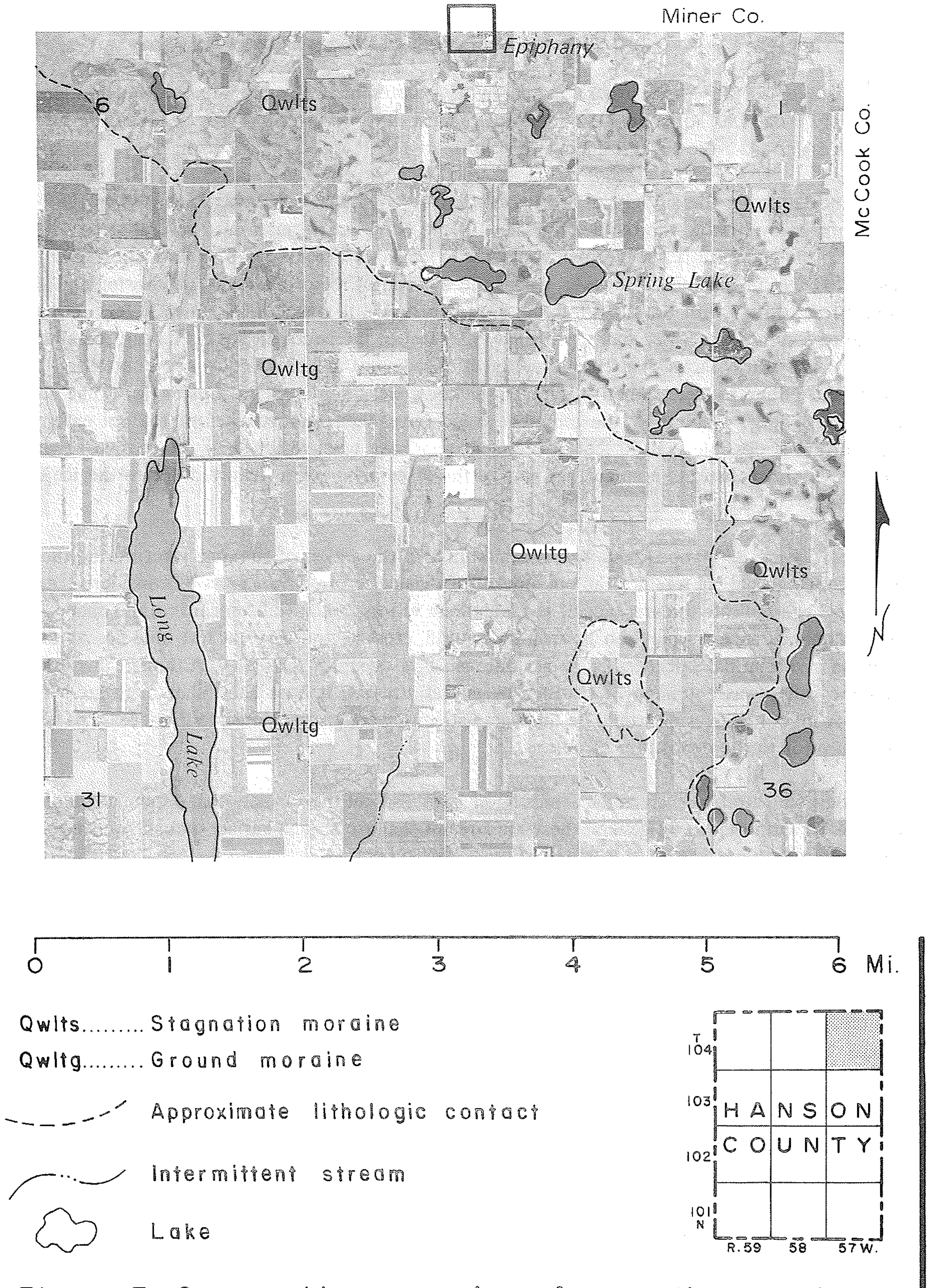

Figure 3. Geomorphic expression of stagnation moraine and ground moraine in northeastern Hanson County.

land surface as shown on cross section A-A' (pl. 3) reveals the differing surficial characteristics of this particular deposit versus those farther to the west along the cross section.

The overall topography of the stagnation moraine in Davison and Hanson Counties is much more subdued than stagnation moraine found in many other parts of South Dakota such as McPherson County (Christensen, 1977) and Clark County (Christensen, 1987). This change in character is directly attributable to the area in which the respective morainic deposits were formed. Those areas of northern South Dakota where massive stagnation moraines exist are, without exception, highlands of the Coteau du Missouri and the Coteau des Prairies (fig. 2). On these particular highlands massive amounts of thick ice were stagnated as the main body of late Wisconsin ice continued down what is now the James lowland. For the most part the entire area between these two highlands contained only active ice. It is expected, therefore, that only minor amounts of less than massive stagnation moraine exists within the James River basin.

End Moraine

Two areas of end moraine (Qwlte) exist in the area mapped for this report (pl. 1). The first of these is located in the extreme southwestern corner of Davison County and represents a section of end moraine that extends from Aurora County (Hedges, in preparation) southeastward through Davison County into Douglas County (Hedges, 1975). The area of this moraine in Davison County is characterized by a highland that reaches an altitude of nearly 1,700 feet above sea. The till which comprises this end moraine is over 160 feet thick near test hole 76 (pl. 3, cross section E-E').

A smaller area of end moraine is shown on plate 1 approximately 3 miles south of the city of Mitchell in Davison County. This moraine, known locally as the Mitchell Hills, reaches an elevation of approximately 1,400 feet above sea level.

Ground Moraine

The majority of Davison and Hanson Counties is presently covered by ground moraine which is depicted as Qwltg on plate 1. This moraine has low relief, is nearly devoid of sloughs or potholes and lacks any sign of constructional linearity (fig. 3). Maximum thickness of this deposit is 325 feet between test holes 44 and 45 (pl. 3) in N½ sec. 4, T. 103 N., R. 57 W., in western Hanson County. This large thickness of drift occurs over a very deep channel cut into the basement rock (pl. 3, cross section B-B', test hole 45) and is abnormal for the two-county area. In general, the drift is quite thin throughout the James Basin in South Dakota and this area is no exception. Average thickness of the drift is approximately 75 feet in the mapped area and on several occasions no till is present between the bedrock and other surficial deposits (pl. 3, cross section B-B', test hole 30).

Minor Moraine

Vast areas of minor moraine (Qwltm) are present in the southern two-thirds of Davison County (pl. 1). These moraines represent minor (perhaps annual) still stands along the ice front during the waning phase of the late Wisconsin glaciation. Although the height of individual minor moraines seldom exceeds 10 feet and is generally less, they are easily recognized on aerial photographs (fig. 4). Minor moraines are common throughout the James Basin and have been mapped in other areas of South Dakota (Gwynne, 1951; Christensen, 1977) and surrounding states (Kemmis and others, 1981). Composition, texture and

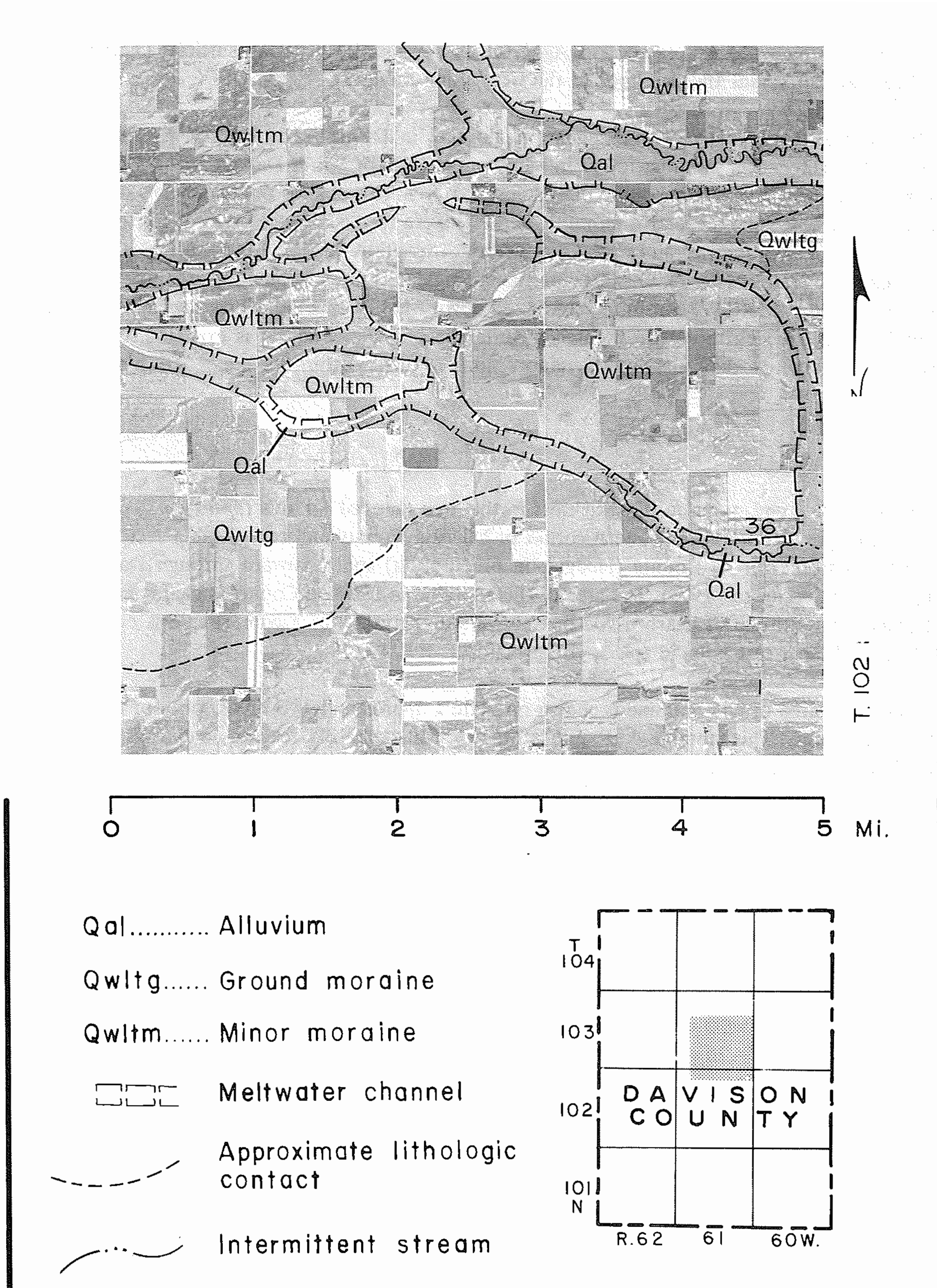

Figure 4. Minor moraines and meltwater channels in Davison County.

weathering profiles within the till that comprises the minor moraine are identical to that found in the ground moraine.

Meltwater Channels

Although it is normal to find meltwater channels throughout the James Basin, Davison County contains an overabundance of such features (pl. 1). It is obvious by noting the number and configuration of the meltwater channels (fig. 4) that they occupied ice-marginal positions for short periods of time during the melting stages of the late Wisconsin ice. The vast number of these deposits in the James Basin has been attributed in part to isostatic rebound of the soft bedrock after unloading of the glacial ice (Helgerson and Christensen, 1975). The channels are generally very shallow and contain very thin alluvial deposits or outwash.

Outwash

Outwash present in the mapped area is confined almost exclusively to Davison County and is shown on plate 1 as Qwlo. The only outwash deposit mapped in Hanson County is located in sec. 32, T. 103 N., R. 59 W.

Usually these deposits are less than 15 feet thick, however, thicknesses in excess of 30 feet were documented by test holes in the area south of Firesteel Creek in T. 104 N., R. 61 W. The thickest outwash drilled during the study measured 40 feet and occurs approximately 6 miles southeast of the city of Mitchell in SW¼SW¼SW¼SW¼ sec. 19, T. 102 N., R. 60 W.

Composition of the outwash varies markedly but on average the outwash contains rock fragments similar to those found in the surface till. Common throughout the outwash deposits are fragments of local rocks such as the Codell Sandstone and Niobrara Marl.

In most instances where test holes were drilled through the complete thickness of outwash deposits oxidation was complete and the deposits were yellow-brown, brown or dark brown in color. Several test holes did, however, show an absence of oxidation below approximately 20 feet (Hammond, 1982a, b).

As with all water-lain deposits grain size is dependent upon the velocity of the water from which the material was deposited. The outwash deposits within the mapped area may normally be classified as fine sand to fine gravel with only minor amounts of finer and coarser material.

Outwash Terraces

Similar to the areal distribution of the outwash just described, most outwash terraces in the two-county area are confined to Davison County and are shown on plate 1 as Qwlot. Isolated terrace deposits do occur in Hanson County in proximity to the James River such as those located in the east half of T. 102 N., R. 59 W., however, they are very rare.

Thickness of the outwash terraces varies from only a few feet to a maximum thickness of approximately 20 feet. Maximum thickness, based on test-hole information gathered during the sand and gravel exploration phase of this project occurs in the terraces associated with Firesteel Creek.

In general, the outwash terrace deposits are more coarse grained than other outwash deposits in the area. They consist primarily of fine- to medium-grained gravel with only minor amounts of sand or finer-grained particles. Areas of coarse gravel, up to boulder-size, occur in several areas along Firesteel Creek.

GEOMORPHIC DEVELOPMENT

Pre-Pleistocene Topography and Drainage

Prior to invasion by the late Wisconsin ice the topography of what is now Davison and Hanson Counties would have looked very similar to that shown on plate 2. The land surface sloped from west to east with the highest land area being in the southwestern corner of Davison County at an elevation exceeding 1,600 feet above sea level. A major stream valley drained the entire area and exited near the southeast corner of T. 104 N., R. 57 W. at an elevation of approximately 1,050 feet above sea level (pl. 2). Total relief on the land surface was about 550 feet.

Late Wisconsin Glaciation

Although earlier glaciers had entered South Dakota from the north and northeast several times prior to the late Wisconsin glaciation, their resulting deposits have never been found in Davison or Hanson Counties. Massive (up to 900 feet) thicknesses of deposits from earlier glaciers do, however, exist to the east of the mapped area on the Coteau des Prairies. These deposits were of sufficient altitude to control, to some extent, the path of the late Wisconsin glacier when it entered South Dakota. Existing as a giant north-south linear mass along the Minnesota-South Dakota border, it effectively split the late Wisconsin ice into two major lobes. The eastern lobe followed a southeasterly course through Minnesota and Iowa and is termed the Des Moines lobe; whereas, the western lobe followed a path between the Coteau du Missouri and the Coteau des Prairies in eastern South Dakota and is termed the James lobe. It is the ice of the James lobe that entered the area that is now Davison and Hanson Counties from the north more than 12,000 years ago. An exact date of this occurrence was recorded in wood discovered 11.5 feet above the base of the late Wisconsin till during construction of Interstate Highway 90 in 1965. This wood was recovered from a road cut 2 miles southeast of Mitchell at SW¼SW¼SW¼NE¼ sec. 25, T. 103 N., R. 60 W. and radiocarbon dated at 12,340 $\pm$ 300 years before present (B.P.) by the U.S. Geological Survey (sample W-1756). This date corresponds well with other dates for late Wisconsin till in the area and establishes an absolute date for the base of the late Wisconsin till in the area mapped for this report.

As the ice continued southward, it had an erosive effect on the underlying bedrock. The total amount of material removed is difficult to estimate, however, as speculated earlier in this report it probably amounted to much less than 70 feet.

While the ice mass moved steadily southward, it also spread laterally and encroached upon the highlands of the Coteau du Missouri to the west and the Coteau des Prairies to the east (fig. 5). Stagnation of the ice occurred on both Coteaus, east and west of the main ice lobe, and active ice continued moving southward between the stagnant ice masses. Stagnation on the Coteau du Missouri effectively blocked the path of the active late Wisconsin ice to the west. Along this boundary between active and stagnant ice a large end moraine was constructed throughout much of South Dakota (Christensen, 1977). A small portion of this moraine exists in southwestern Davison County (pl. 1).

Drainages that existed within the area between the two Coteaus were blocked and continually diverted to the south to seek new outlets. The advancing ice eventually reached an area near the present-day

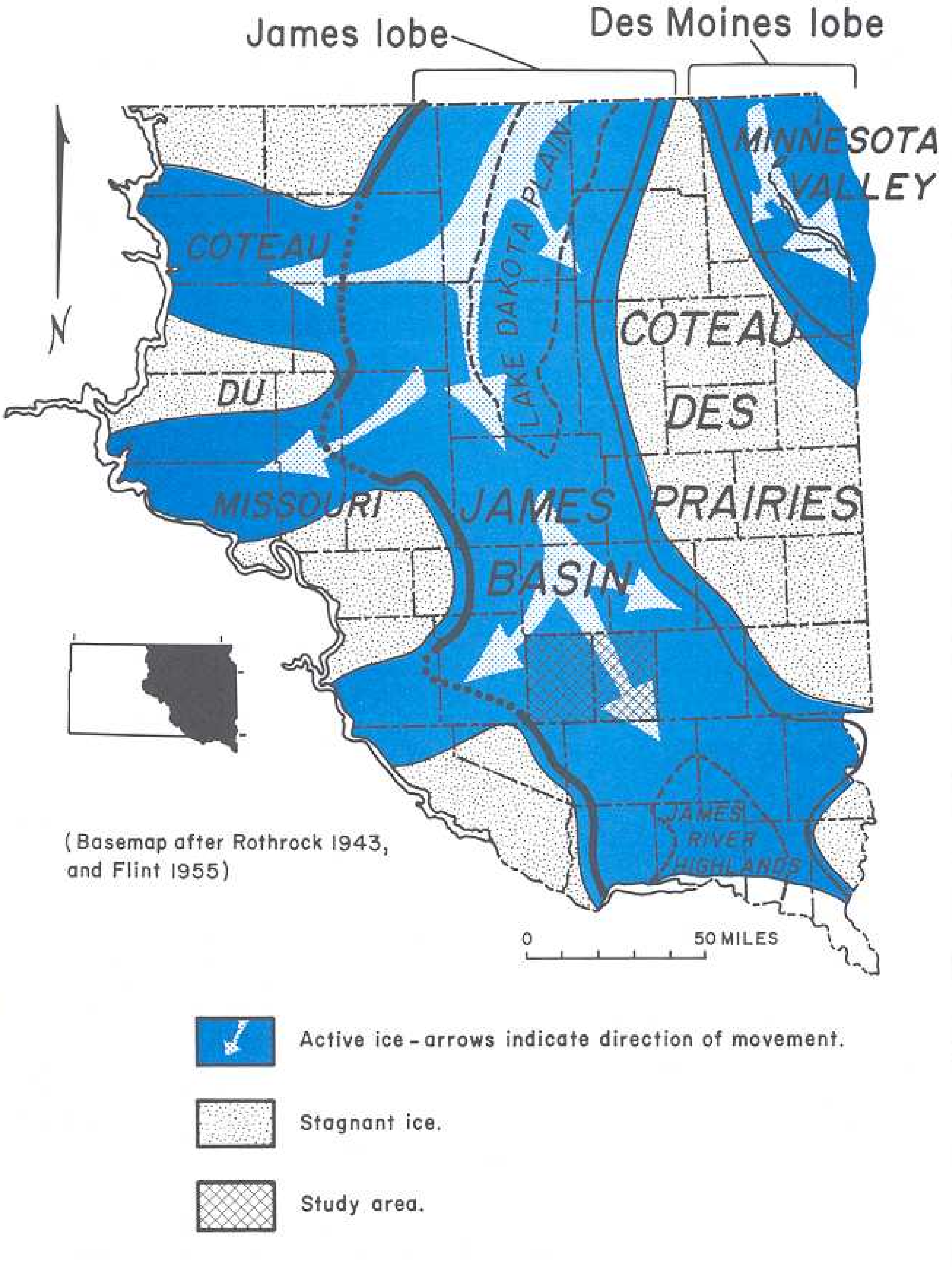

Figure 5. Generalized relationship of James lobe ice to the Coteau du Missouri and the Coteau des Prairies.

Missouri River in what is now Clay and Yankton Counties (Christensen, 1967) approximately 12,000 years ago.

Late Wisconsin Deglaciation

Melting of the ice began shortly after it had reached its most southerly extent and continued steadily for several thousand years. Seasonal fluctuations occurred along the ice front as the ice responded to winter and summer seasons. These seasonal changes resulted in a series of minor ridges of till being deposited along the ice front, on nearly an annual basis, throughout the entire length of the James Basin as the ice slowly melted toward the north. It is these small linear features that are shown on plate 1 and figure 4 as minor moraines.

An area of end moraine shown on plate 1 south of the city of Mitchell in Davison County also formed at the same time as the minor moraines. Although mapped as end moraine because of its size, it is in fact, a large scale minor moraine formed while a small portion of the ice front occupied a stationary position for a long period of time.

As the ice melted, massive amounts of meltwater were released. Because stagnant ice existed to both the east and west (fig. 5), there was only one direction for this meltwater to flow and that was to the south. Generally a direct path was not, however, available and water flowed close to the ice front for some distance before taking a more southerly course. This was caused primarily by the weight of several thousand feet of ice depressing the land surface. As the ice melted, rebound of the land slowly occurred to the south but low areas were continually present along the ice front. Meltwaters occupied these lows and carried sediment through them for short periods of time. As the ice continued to melt and the ice front receded to the north, the meltwater channels (pl. 1) were successively abandoned and left choked with outwash or other alluvial debris (pl. 1) while the meltwaters carved a new shallow channel closer to the ice front.

Most of the surficial deposits within Davison and Hanson Counties were emplaced during the melting of late Wisconsin ice. Ground moraine makes up the majority of these deposits (pl. 1) and although some of this material was deposited beneath the glacier during its advance the majority of it was let down onto the ground surface as the ice melted.

Stagnation moraine resulted from the same ablative process but differed from ground moraine in the fact that it originated within and upon a mass of stagnant ice. Because of this origin and the large amount of differential melting that occurred, the resulting stagnation moraine has a much more rugged surface than the ground moraine and contains a larger number of sloughs and potholes (fig. 3). It is likely that stagnation moraine was still being deposited long after the active ice had retreated from the central part of the James Basin. Christensen (1977) speculated, based on radiocarbon dates from fossil shells in stagnation deposits in McPherson County, that melting of stagnant ice occurred for a period of over 5,000 years on the Coteau du Missouri near the South Dakota-North Dakota border. Because the stagnant ice was thinner and not as well insulated with debris in Davison and Hanson Counties, the period required for melting would have been much less, however.

After ice abandoned the area, effects of the late Wisconsin glaciation were still controlling landscape development in the mapped area. Isostatic rebound continued to effect drainage development but eventually a major stream began to form and carry water from the area toward the south to intercept the newly formed Missouri River. This was undoubtedly the early stages of formation of the James River. During this period of time large amounts of outwash must have been deposited in the James River and its tributaries. This theory is substantiated by the fact that terrace deposits can be found along several areas of the James

River (pl. 1) indicating a period of sediment deposition when the river was higher above base level. However, much less outwash exists in the James River valley than would be expected in such a major drainageway.

During the later stages of late Wisconsin deglaciation, a large glacial meltwater lake was formed in the area that is now Spink and Brown Counties. This lake, which has been termed Lake Dakota, was shallow but occupied a large areal extent (fig. 2). The eventual draining of Lake Dakota released large amounts of water down the newly formed James River, causing increased downcutting in the drainage system and the removal of most of the glacial sediments that had existed in the trench. Outwash was thus removed from the area and now exists only as isolated remnants in the form of outwash terraces high above the present James River trench. Sediments that now exist within the trench in Davison and Hanson Counties are primarily clays, silts and very fine sands reminiscent of those found within the Lake Dakota plain farther to the north. These sediments were probably deposited in the trench by low-velocity waters representing the final stage of the draining of Lake Dakota.

Recent Modifications

Since the retreat of late Wisconsin glaciers from the area, the landscape of Davison and Hanson Counties has undergone little modification. Recent streams have continued to develop their drainage systems and the James River has established itself as the primary drainage for the area. Many of the meltwater channels that existed during the Pleistocene Epoch contain streams today but they are small and intermittent (pl. 1).

Soils that are present at the surface of the land have all developed since the retreat of the ice sheet and are continuing to form through the steady process of weathering. Erosion is also occurring and the landscape is slowly being leveled. Much of the sediment that results from this erosion is transported from the area by the James River and by the action of wind blowing across barren fields. However, some of the sediment is deposited locally in sloughs, potholes and area lakes which will eventually result in the filling of these depressions.

ECONOMIC GEOLOGY

Mineral Resources

Water

Water is by far the most important mineral resource in Davison and Hanson Counties. One of the major aspects of this study was to locate, map and evaluate this precious mineral commodity. For this reason, an entire report has been assembled on the subject and is available as a companion to this publication. For information on this subject the reader is referred to Hansen (1983a). In addition, a quick, easy to read pamphlet is also available which describes the location, depth, thickness and general aspects of water quality for all of the aquifers that exist within the two-county area (Hansen, 1983b).

Sand and Gravel

Nearly as important as water to the development of Davison and Hanson Counties is a continued source of sand and gravel for construction purposes. Again separate studies were conducted during this investigation to locate and map these deposits. The resulting reports for Davison County (Hammond, 1982a) and Hanson County (Hammond, 1982b) contain all information presently available on this subject. Included in these reports are additional information on the location and availability of Sioux Quartzite as a quarry stone.

Other Mineral Deposits

Although the entire area was thoroughly investigated and hundreds of test holes were drilled throughout the project, no other mineral deposits of economic importance were discovered during the geologic and hydrologic investigation of Davison and Hanson Counties.

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APPENDIX

Legal Descriptions of Test-Hole Logs

The following list contains the numbers and legal descriptions of all test-hole logs used to construct the cross sections shown on plate 3. These logs are available from the computer files of the South Dakota Geological Survey. The numbers refer only to this report. Any request for logs should contain the legal descriptions.

NUMBER	LEGAL DESCRIPTION
CROSS SECTION A-A′	
1	SE¼NE¼NE¼NE¼ sec. 01, T. 104 N., R. 63 W.
2	NE¼NE¼NE¼NE¼ sec. 04, T. 104 N., R. 62 W.
3	NW¼NW¼NW¼NE¼ sec. 01, T. 104 N., R. 62 W.
4	NW¼NW¼NW¼NW¼ sec. 06, T. 104 N., R. 61 W.
5	SW¼SW¼NW¼NW¼ sec. 05, T. 104 N., R. 61 W.
6	SE¼NE¼NE¼NE¼ sec. 05, T. 104 N., R. 61 W.
7	NW¼NW¼NW¼NE¼ sec. 04, T. 104 N., R. 61 W.
8	NW¼NE¼NE¼NE¼ sec. 04, T. 104 N., R. 61 W.
9	NW¼NW¼NW¼NW¼ sec. 03, T. 104 N., R. 61 W.
10	SW¼NW¼NW¼NW¼ sec. 02, T. 104 N., R. 61 W.
11	NE¼NW¼NW¼NW¼ sec. 06, T. 104 N., R. 60 W.
12	NE¼NE¼NE¼NW¼ sec. 05, T. 104 N., R. 60 W.
13	SW¼SW¼SE¼SE¼ sec. 33, T. 105 N., R. 60 W.
14	SW¼SW¼SW¼SW¼ sec. 35, T. 105 N., R. 60 W.
15	NE¼NW¼NE¼NW¼ sec. 01, T. 104 N., R. 60 W.
16	NW¼NW¼NW¼NW¼ sec. 06, T. 104 N., R. 59 W.
17	NW¼NW¼NW¼NW¼ sec. 03, T. 104 N., R. 59 W.
18	NW¼NW¼NW¼NW¼ sec. 06, T. 104 N., R. 58 W.
19	NW¼NW¼NW¼NW¼ sec. 05, T. 104 N., R. 58 W.
20	NW¼NW¼NW¼NW¼ sec. 03, T. 104 N., R. 58 W.
21	NE¼NE¼NE¼NE¼ sec. 02, T. 104 N., R. 58 W.
22	NE¼NE¼NE¼NE¼ sec. 01, T. 104 N., R. 58 W.
23	NE¼NE¼NE¼NW¼ sec. 05, T. 104 N., R. 57 W.
24	SE¼SE¼SE¼SE¼ sec. 33, T. 105 N., R. 57 W.
25	NE¼NW¼NW¼NW¼ sec. 02, T. 104 N., R. 57 W.
26	NE¼NE¼NE¼NE¼ sec. 01, T. 104 N., R. 57 W.
27	NE¼NE¼NE¼NE¼ sec. 06, T. 104 N., R. 56 W.

NUMBER	LEGAL DESCRIPTION
CROSS SECTION B-B′	
28	SE¼SE¼SE¼SE¼ sec. 33, T. 104 N., R. 62 W.
29	SW¼SW¼SE¼SE¼ sec. 35, T. 104 N., R. 62 W.
30	NW¼NW¼NW¼NW¼ sec. 06, T. 103 N., R. 61 W.
31	SE¼SE¼SE¼SE¼ sec. 31, T. 104 N., R. 61 W.
32	NE¼NE¼NE¼NE¼ sec. 05, T. 103 N., R. 61 W.
33	SE¼SE¼SE¼SE¼ sec. 33, T. 104 N., R. 61 W.
34	NW¼NW¼NW¼NW¼ sec. 06, T. 103 N., R. 60 W.
35	NW¼NW¼NW¼NE¼ sec. 02, T. 103 N., R. 60 W.
36	NE¼NW¼NW¼NW¼ sec. 06, T. 103 N., R. 59 W.
37	SW¼SW¼SW¼SW¼ sec. 34, T. 104 N., R. 59 W.
38	SE¼SE¼SE¼SE¼ sec. 36, T. 104 N., R. 59 W.
39	SW¼SW¼SE¼SE¼ sec. 32, T. 104 N., R. 58 W.
40	SE¼SE¼SE¼SE¼ sec. 33, T. 104 N., R. 58 W.
41	SW¼SW¼SW¼SW¼ sec. 34, T. 104 N., R. 58 W.
42	NE¼NE¼NE¼NE¼ sec. 01, T. 103 N., R. 58 W.
43	NE¼NE¼NE¼NE¼ sec. 04, T. 103 N., R. 57 W.
44	SE¼SE¼SE¼SE¼ sec. 36, T. 104 N., R. 57 W.
CROSS SECTION C-C′	
45	NE¼NE¼NE¼NE¼ sec. 01, T. 102 N., R. 63 W.
46	SW¼SW¼SW¼SW¼ sec. 33, T. 103 N., R. 62 W.
47	NW¼SW¼SW¼SW¼ sec. 34, T. 103 N., R. 62 W.
48	SE¼SE¼SE¼SE¼ sec. 36, T. 103 N., R. 62 W.
49	SE¼SE¼SE¼SE¼ sec. 33, T. 103 N., R. 61 W.
50	SW¼SW¼SW¼SW¼ sec. 31, T. 103 N., R. 60 W.
51	SE¼SE¼SE¼SE¼ sec. 31, T. 103 N., R. 60 W.
52	SW¼SW¼SW¼SW¼ sec. 34, T. 103 N., R. 60 W.
53	SE¼SE¼SE¼NE¼ sec. 01, T. 102 N., R. 60 W.
54	NE¼NE¼NE¼NE¼ sec. 04, T. 102 N., R. 59 W.
55	SW¼SW¼SW¼SW¼ sec. 31, T. 103 N., R. 58 W.
56	SW¼SW¼SW¼SW¼ sec. 34, T. 103 N., R. 58 W.
57	NW¼NW¼NW¼NW¼ sec. 06, T. 102 N., R. 57 W.
58	NE¼NE¼NE¼NE¼ sec. 04, T. 102 N., R. 57 W.
59	NW¼NW¼NW¼NW¼ sec. 06, T. 102 N., R. 56 W.

NUMBER	LEGAL DESCRIPTION

CROSS SECTION D-D′

60	SE¼SE¼SE¼SE¼ sec. 33, T. 102 N., R. 62 W.
61	NW¼NW¼NW¼NW¼ sec. 01, T. 101 N., R. 62 W.
62	NE¼NE¼NE¼NE¼ sec. 01, T. 101 N., R. 62 W.
63	SE¼SE¼SE¼SE¼ sec. 33, T. 102 N., R. 61 W.
64	NW¼NW¼NW¼NE¼ sec. 02, T. 101 N., R. 61 W.
65	SW¼SW¼SW¼SW¼ sec. 31, T. 102 N., R. 60 W.
66	SE¼SE¼SE¼SE¼ sec. 33, T. 102 N., R. 60 W.
67	SW¼SW¼SW¼SW¼ sec. 36, T. 102 N., R. 60 W.
68	NW¼NW¼NW¼NW¼ sec. 31, T. 102 N., R. 59 W.
69	NW¼SW¼SW¼SW¼ sec. 34, T. 102 N., R. 59 W.
70	SE¼SE¼SE¼SE¼ sec. 36, T. 102 N., R. 59 W.
71	NE¼NE¼NE¼NE¼ sec. 04, T. 101 N., R. 58 W.
72	SW¼SW¼SW¼SW¼ sec. 31, T. 102 N., R. 57 W.
73	NW¼NW¼NW¼NW¼ sec. 03, T. 101 N., R. 57 W.
74	SW¼SW¼SW¼SW¼ sec. 31, T. 102 N., R. 56 W.

CROSS SECTION E-E′

75	SW¼SW¼SW¼SW¼ sec. 31, T. 101 N., R. 62 W.
76	SE¼SE¼SE¼SE¼ sec. 33, T. 101 N., R. 62 W.
77	SW¼SW¼SW¼SW¼ sec. 31, T. 101 N., R. 61 W.
78	SE¼SE¼SE¼SE¼ sec. 33, T. 101 N., R. 61 W.
79	SE¼SE¼SE¼SE¼ sec. 36, T. 101 N., R. 61 W.
80	SE¼SE¼SE¼SE¼ sec. 33, T. 101 N., R. 60 W.
81	SE¼SE¼SE¼SE¼ sec. 36, T. 101 N., R. 60 W.
82	SW¼SW¼SW¼SW¼ sec. 34, T. 101 N., R. 59 W.
83	SW¼SW¼SW¼SW¼ sec. 31, T. 101 N., R. 58 W.
84	NW¼SW¼SW¼SW¼ sec. 34, T. 101 N., R. 58 W.
85	SW¼SW¼SW¼SW¼ sec. 36, T. 101 N., R. 58 W.
86	SE¼SE¼SE¼SE¼ sec. 36, T. 101 N., R. 58 W.
87	NW¼SW¼SW¼SW¼ sec. 34, T. 101 N., R. 57 W.
88	SE¼SE¼SE¼SE¼ sec. 36, T. 101 N., R. 57 W.