SASKATCHEWAN RESEARCH COUNCIL
GEOLOGY DIVISION

Report No. 7

GEOLOGY AND GROUNDWATER RESOURCES

of the

KINDERSLEY AREA (72-N)

SASKATCHEWAN

by
E. A. Christiansen
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ABSTRACT

The Kindersley area (72-N) lies between 108° and 110° West Longitude and between 51° and 52° North Latitude in west-central Saskatchewan. The mean annual precipitation is 13.4 inches, and the soils belong to the Dark Brown and Black Zones.

The surficial sediment comprises mainly till and lacustrine silt and clay but locally includes fluvial sand and gravel. The drift thickness ranges from a few feet to 900 feet, the maximum of which occurs where a well developed end moraine is superposed on a preglacial valley. Oxidized zones in the subsurface sequence indicate that more than one glaciation has taken place. Discordance of end moraines and three radiocarbon dates suggest that the surficial sediments were deposited during two glaciations. The readvance of the glacier which deposited the surficial till in the southwestern part of the area took place 20,000 to 21,000 years ago, and the surficial till in the northeastern part of the area was deposited by a glacier which readvanced over the area about 13,000 years ago. The bedrock surface topography is dominated by one major preglacial valley and its tributaries and one glacial bedrock valley which was cut 600 feet into bedrock. The bedrock consists of Upper Cretaceous Grizzly Bear Member of the Belly River Formation, Oldman and Bearpaw Formations, and "Preglacial gravel" of Tertiary or Quaternary age. The textures of tills range from loam to clay loam. The total carbonate content of tills ranges from 3 to 18 per cent. X-ray diffraction patterns of silt and clay show montmorillonite and illite and lesser amounts of kaolinite and chlorite to be the main clay minerals in tills of the Kindersley area.

Groundwater occurs in fine- to medium-grained sand in the Oldman Formation; in fine- to very fine-grained sand in the Bearpaw Formation; in sand and gravel in "Preglacial gravel"; and in intertill, surficial, and lenses of sand and gravel in drift.

Gravel occurs in outwash plains associated with ice frontal positions; in interlobate moraines, kame moraines, kames and eskers; and in terrace deposits along the South Saskatchewan River and Eagle Creek Spillways.

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INTRODUCTION

Location

The Kindersley area (72-N), which comprises about 6000 square miles, lies between 108° and 110° West Longitude and between 51° and 52° North Latitude (Fig. 1). The western border coincides with the Alberta-Saskatchewan boundary and the southern border of the area is about 140 miles north of the Montana-Saskatchewan boundary. The Kindersley area includes Townships 23 to 35 and Ranges 15 to 29 inclusive. All ranges are west of the Third Meridian. The location-numbering system used herein is shown in Figure 2.

Previous Work

Fraser *et al.* (1935), in their study of southern Saskatchewan, mapped the bedrock geology of the east half of the Kindersley area between 108° and 109° West Longitude on a scale of 1 inch to 8 miles. MacKay (1949) included the bedrock geology of the Kindersley area in his geological map of southern Saskatchewan. Johnston and Wickenden (1931) mapped the moraines, glacial lakes, and drainage outlets in southern Saskatchewan.

Johnston *et al.* (1948) published a preliminary map of the surficial deposits in southern Saskatchewan on a scale of 1 inch to 6 miles. Bretz (1943) included the Kindersley area in his reconnaissance study of glacial history of southwestern Saskatchewan and southeastern Alberta. His conclusions were based entirely on end moraines and the altitude of glacial lakes and channels. Russell (1934) included a description of specimens collected from glacial deposits near Gunnworth.

Mitchell *et al.* (1947) published soil maps of southern Saskatchewan on a scale of 1 inch to 6 miles. Because the surficial geology can be interpreted to a large degree directly from these soil maps, such maps have greatly facilitated the study of surficial deposits in the Kindersley area. Acton *et al.* (1960) published a map showing Physiographic Divisions of Saskatchewan on a scale of 1 inch to 24 miles.

Present Studies

The present report is based on field work conducted during the summers of 1961 to 1963 and on a test-drilling program conducted in 1963 and 1964. Before field work was attempted contacts of surficial sediments as interpreted from soil maps and aerial photographs were plotted on topographic sheets. With the aid of these preliminary maps and with further study of aerial photographs and soil maps, the land forms were classified. The office interpretation was then checked and amplified in the field, at which time stratigraphic studies and test-drilling programs were conducted.

Field mapping was done on 1:50,000 and 1:40,000 topographic sheets which have a 25 foot contour interval. These data were transferred to 1:250,000 maps which have a 100 foot contour interval. These base maps are available from Canada Department of Mines and Technical Surveys, Ottawa. Aerial photographs were purchased from the Royal

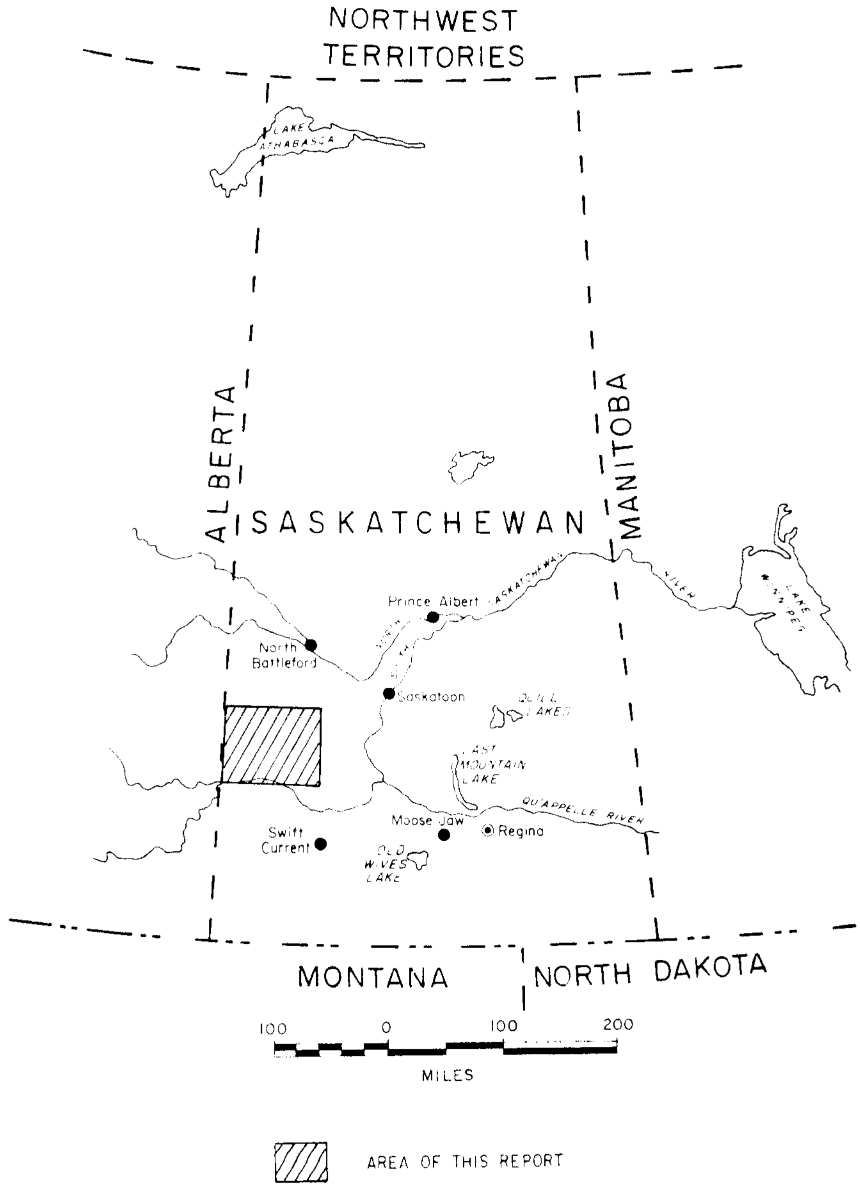

Figure 1.—Location of Kindersley area

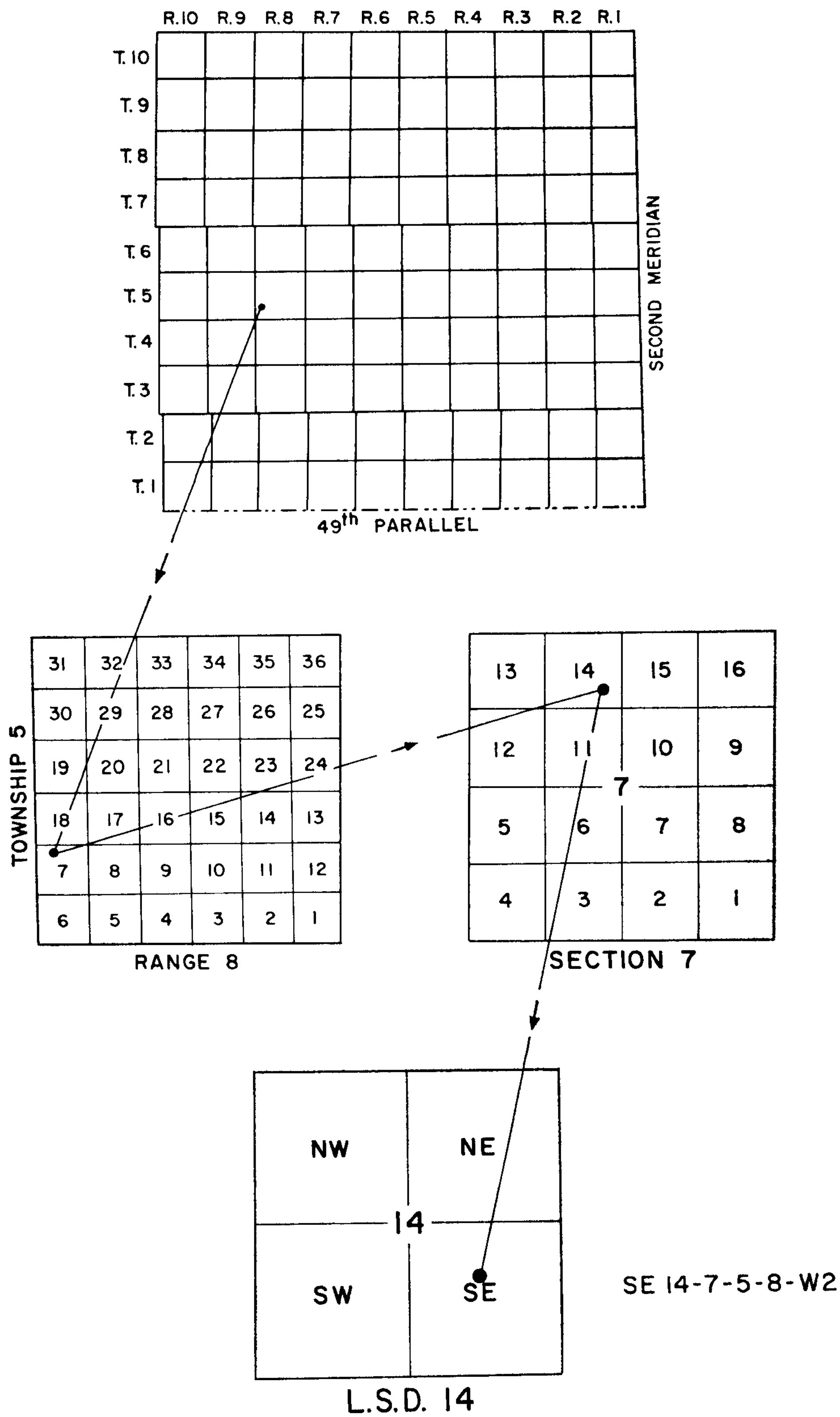

Figure 2.—Location-numbering system

Canadian Air Force and aerial photo-mosaics on a scale of 1 inch to 1 mile were borrowed from the Department of Geological Sciences, University of Saskatchewan.

Acknowledgments

The author was assisted in the field by Messrs. R. A. Bedet, D. A. Bohun, J. D. Chapman, and D. W. Watson. Mr. W. C. Ross conducted the textural, carbonate, and clay mineral analyses presented in this report; assisted in the supervision of the test-drilling program; and logged samples and cores obtained during the drilling program. Drafting was done by Messrs. W. E. Taylor and M. A. Kanwischer, Saskatchewan Research Council. One half of the cost of stratigraphic drilling was defrayed by the Agricultural Development and Rehabilitation Act (ARDA). Without these funds, this report would not be possible.

PHYSIOGRAPHY

Climate

The climatological data recorded herein were obtained from the Experimental Farm at Scott, Saskatchewan which is about 25 miles north of the Kindersley area. The precipitation, evaporation, and temperature data are shown graphically in Figure 3.

The annual precipitation ranges from 6.59 to 20.79 inches; the maximum range of 14.20 inches is greater than the mean of 13.71 inches (Fig. 3c). The cumulative departure curve (Fig. 3b) shows the precipitation cycles. The monthly precipitation ranges from zero to 6.16 inches, the highest being in June and July (Fig. 3a).

The mean monthly evaporation from open tanks for May to September inclusive ranges from 2.8 inches in September to 5.0 inches in July (Fig. 3a). The mean monthly evaporation is greater than the mean precipitation for all months but is less than the maximum monthly precipitation except for May when the mean monthly evaporation is greater than the maximum monthly precipitation. It is recognized that the relationship between the mean monthly evaporation of May and June is anomalous (Fig. 3a), but no explanation is given here.

The mean monthly temperatures are shown in Figure 3a. The coldest month is January when the mean monthly temperature is about 0°F, and the warmest is July when the mean monthly temperature is about 64°F. The mean monthly temperature is below freezing from November to March inclusive.

The fact that about 60 per cent of the mean annual precipitation occurs during May, June, July, and August when transpiration and evaporation are highest for the year is not conducive to groundwater recharge during this period. Because the ground is frozen from November to March inclusive, April, September, and October remain as the best months for groundwater recharge.

Soils

The dominant soils in the Kindersley area belong to the Dark Brown and Black Zonal types (Mitchell *et al.*, 1947). The Soil Association or Catena as defined by Clayton, Sask. Soil Survey (personal communication) is "a group of closely associated Soil Series found in a recurring pattern within a natural soil land form and developed on a specific parent material" (geological deposit). Because Soil Catenas are based on parent material, it is possible for geologists to interpret the nature of surficial sediments directly from soil maps.

Except for a few bedrock outcrops, all soils in the Kindersley area are developed on drift, dominantly till, lake silt and clay, and fluvial sand and gravel. The Echo, Haverhill, Robsart, and Weyburn Associations are developed on till; the Elstow, Fox Valley, Regina, and Sceptre Associations are developed on lake silt and clay; and the Asquith, Biggar, Chaplin, and Hatton Associations are developed on fluvial sand and gravel.

Topographic Features

Acton *et al.* (1960), in their map of the Physiographic Divisions of Saskatchewan, divided the Kindersley area into four Physiographic Divisions: Saskatchewan Rivers Plain; Missouri Coteau Upland; Snipe Lake Plain; and Neutral Hills Upland.

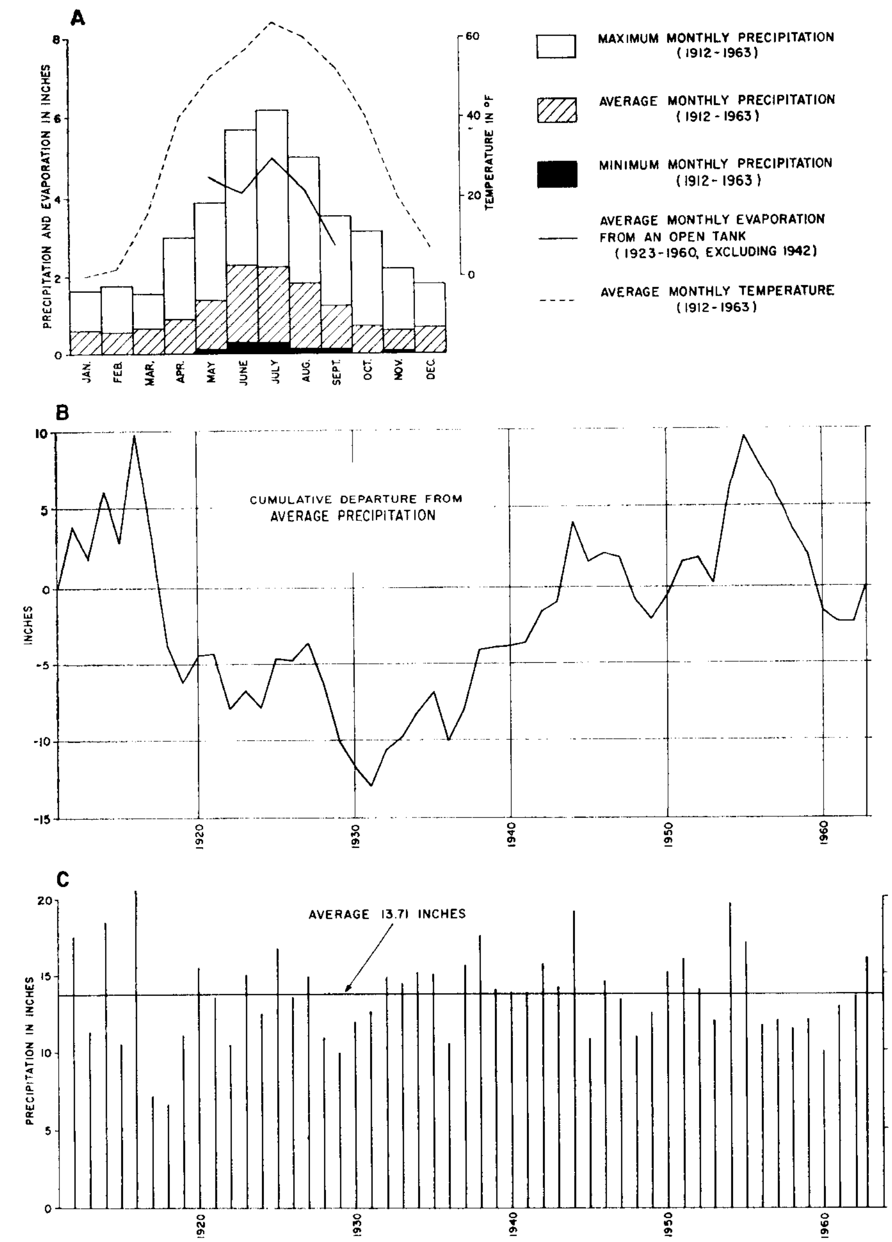

Figure 3.—Precipitation, temperature, and evaporation data from the Scott Experimental Farm

The Saskatchewan Rivers Plain forms a major topographic lowland in the eastern part of the Kindersley area. The lowland lies east of the morainic belts which include the hills south of Greenan (T.26, R.17; Pl. 1), The Bad Hills, and The Bear Hills. The lowland extends to the center of the Kinderlsey area along Eagle Creek between The Bad and The Bear Hills. The Eagle Creek lowland is bordered by bedrock escarpments and is a surface expression of a topographically low area on the bedrock surface. The landscape is gently undulating, and the surficial sediment is essentially lake silt and clay.

The morainic belt which includes the hills south of Greenan, The Bad Hills, and The Bear Hills (Pl. 1) are mapped as part of the Missouri Coteau Upland by Acton *et al.* (1960). This morainic belt rises up to 400 feet above the Saskatchewan Rivers Plain to the east. The landscape is rolling to strongly rolling and the surface sediment is composed mainly of till.

The Snipe Lake Plain lies between the Missouri Coteau Upland to the east and the Neutral Hills Upland to the west. Cabri Lake (T.25, R.27; Pl. 1), Verendrye Valley, Glidden Moraine, and the upland north of Eatonia (T.26, R.25) are the most striking features in the otherwise monotonously flat plain. Cabri Lake lies in a partly filled preglacial valley whereas the Verendrye Valley represents a partly filled glacial bedrock valley. The Glidden Moraine is entirely a glacial feature whereas the highland north of Eatonia is underlain by topographically high bedrock. The surface is flat to undulating and the till is covered for the most part with lake clay.

The Neutral Hills Upland is formed by a discontinuous morainic belt which trends north-south along the Alberta-Saskatchewan border. These hills rise up to 600 feet above Cabri Lake. The landscape is rolling, and the sediment is mainly till which is covered with lake clay below an elevation of 2400 feet.

Drainage

The South Saskatchewan River and Eagle Creek constitute the only drainage of runoff from the Kindersley area, and for the most part drainage is not well developed inland from these streams. Over about 80 per cent of the area, the runoff enters undrained depressions, from which the water is evaporated and transpired. The major depressions lie in swales on the drift surface and in partly filled bedrock and drift valleys. These major depressions include Bad, Cabri, and Kiyiu Lakes; and Snipe and Verendrye Valleys.

GEOMORPHOLOGY

Landforms are defined and described and their distribution is shown in Plate 1.

STRATIGRAPHY

Upper Cretaceous Series

General Statement

The bedrock geology of the Kindersley area is shown in Plate 2 and in the cross sections in Plate 1. The stratigraphic subdivisions of the Upper Cretaceous in the Kindersley area (Fig. 4) are based on electric log interpretation and have been correlated with the McColl Frontenac (4-5-32-4-W4) log in the A-B cross section of Shaw and Harding (1954, p. 301). In ascending order these subdivisions are: (1) Grizzly Bear Member; (2) Oldman Formation; and (3) Bearpaw Formation (Fig. 4). In scattered localities chert and quartzite gravels overlie these Upper Cretaceous bedrock sediments and are referred to herein as "Preglacial gravel".

Grizzly Bear Member

The Grizzly Bear Member is underlain by the Ribstone Creek Member and is overlain by the Oldman Formation (Fig. 4) except in the Tyner and Eyre Valleys where the Grizzly Bear Member is overlain by either "Preglacial gravel" or drift and in the Verendrye Valley where it is overlain entirely by drift (Pl. 2). The Grizzly bear Member is composed of 50 to 200 feet of grey, non-calcareous, silty shale as indicated by field tests on sidehole cores. Laboratory analyses of Sample 18 (Table 1) indicate that the sample is predominantly clay (Fig. 5) with 0.9 per cent calcite and 1.7 per cent dolomite. An X-ray diffraction pattern (Pl. 3, 4a and b) indicates montmorillonite, illite, and chlorite are the most abundant clay minerals.

The structural contour map of the Grizzly Bear Member (Fig. 6) shows that the unit dips eastward at about 4.5 feet per mile. The Tyner, Eyre, and Verendrye Valleys were cut about 100 feet into this member. Broad poorly defined, eastward trending valleys suggest that erosion of the upper part of the Grizzly Bear Member may have taken place prior to the deposition of the overlying Oldman Formation.

Oldman Formation

The Oldman Formation overlies the Grizzly Bear Member and underlies the Bearpaw Formation (Fig. 4) except in the Tyner, Eyre, and Verendrye Valleys where the entire formation was removed by glacial and preglacial erosion (Pl. 4). The Oldman Formation is composed of up to 300 feet of noncalcareous, silty, very fine to medium-grained sand which is interbedded with silt and clay as indicated by field tests on sidehole cores. Laboratory analyses of Sample 21 (Table 1) show that the sediment is loamy sand (Fig. 5) with 0.4 per cent calcite and zero percent dolomite. Plate 3 (5 a and b) indicates that the predominant clay mineral is montmorillonite. Minor amounts of illite, kaolinite, and chlorite are also present.

The structural contour map and point thicknesses of the Oldman Formation are shown in Plate 4. The top of the formation dips eastward at about 4.5 feet per mile. Broad poorly defined, eastward trending valleys (Pl. 4) suggest that erosion of the upper part of the Oldman Formation may have taken place prior to the deposition of the Bearpaw Formation.

Bearpaw Formation

The lower and upper contacts of the Bearpaw Formation are defined by Plates 4 and 2 respectively and by the cross section shown in Figure 4.

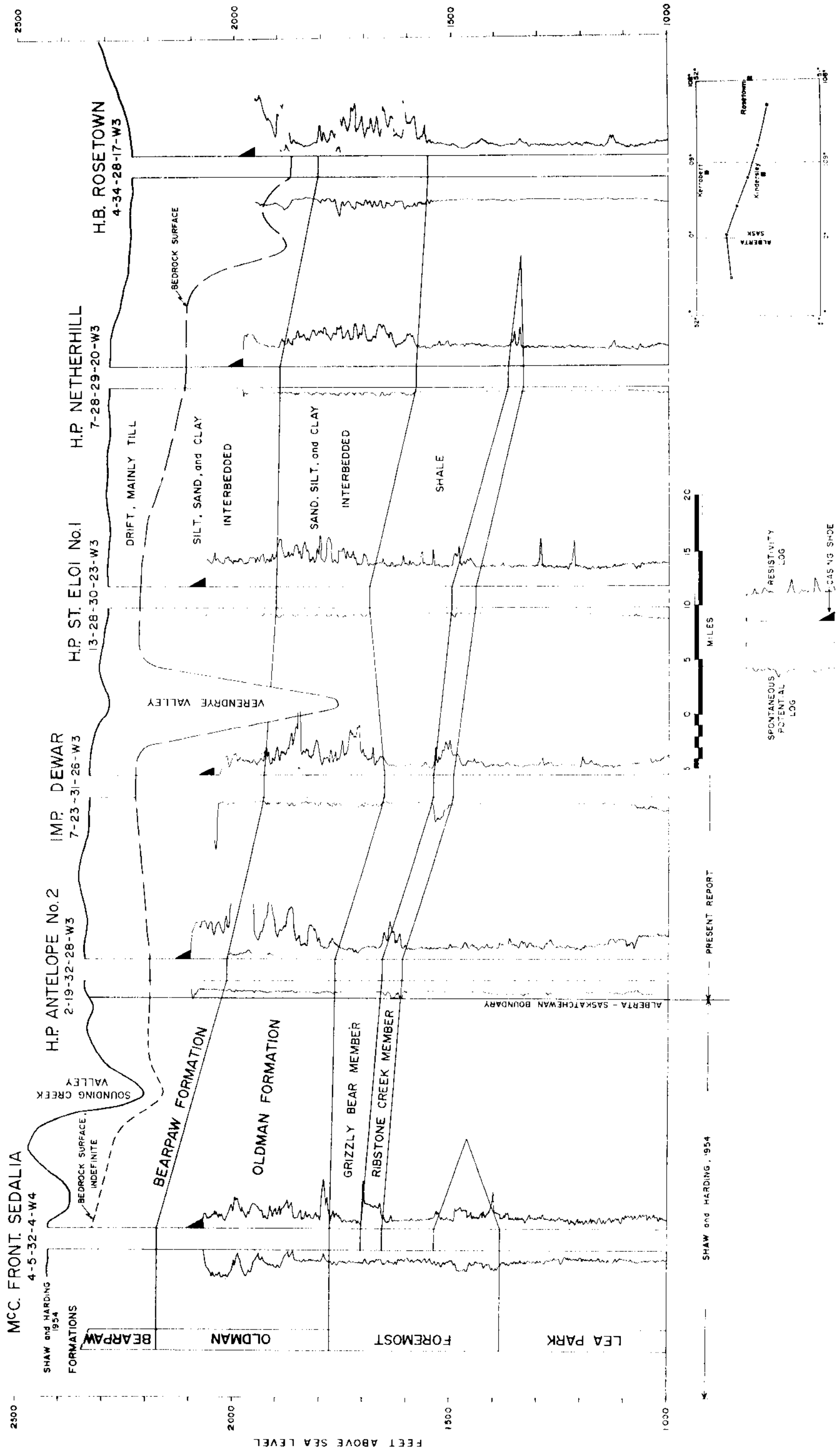

Figure 4.—Stratigraphic cross section showing electric-log correlation

Table 1.—Texture and carbonate content of tills, stratified drift, and bedrock of the Kindersley area

Sample Number	Testhole	Unit	Depth (feet)	% Sand 2.0-0.5 mm	% Silt 0.5-0.002 mm	% Clay < 0.002 mm	% Calcite	% Dolomite	% Carbonate	Field test on dry sample
1	Glidden	Till (o) *	10	42	31	27	3.2	7.3	10.5	calc.
2	NW 15-21-24-24-W3	Till (u) **	100	51	23	26	2.5	6.0	8.5	calc.
3		Till (o)	165	48	26	26	6.0	7.2	13.2	calc.
4		Till (u)	200	47	28	25	5.0	8.3	13.3	calc.
5		Till (o)	300	39	31	30	3.5	4.4	7.9	calc.
6	Kerrobert	Till (o)	20	51	22	27	2.3	5.8	8.1	calc.
7	NW 13-20-34-21-W3	Till (u)	60	35	30	35	3.1	3.3	6.4	calc.
8		Till (u)	120	44	42	14	2.7	3.7	6.4	calc.
9		Till (u)	240	35	32	33	3.2	3.4	6.6	calc.
10	Court	Till (o)	30	43	30	27	8.1	9.5	17.6	calc.
11	NE 8-15-34-28-W3	Till (u)	70	29	38	33	4.7	3.2	7.9	calc.
12		Clay loam	150	44	29	27	6.5	4.0	10.5	calc.
13		Bearpaw Formation	230	46	30	24	1.0	0.6	1.6	noncalc.
14	Isham	Till (u)	90	46	27	27	2.8	5.5	8.3	calc.
15	SE 1-15-24-19-W3	Till (o)	98	46	26	28	—	—	—	calc.
16		Till (u)	190	36	35	29	4.4	7.9	12.3	calc.
17		Till (u)	430	63	21	16	1.2	2.3	3.5	sl. calc.
18		Grizzly Bear Member	520	7	38	55	0.9	1.7	2.6	noncalc.
19	Isham	Till (u)	60	46	28	26	3.6	7.4	11.0	calc.
20	NW 13-34-24-19-W3	Till (u)	210	40	33	27	6.0	4.2	10.2	calc.
21	Anglia SW 4-31-30-15-W3	Oldman Formation	410	75	16	9	0.4	0	0.4	noncalc.
22	Gunnworth	Till (o)	19	65	21	14	5.8	5.5	11.3	calc.
23	NE 8-1-29-16-W3	Till (u)	50	59	19	22	5.5	8.2	13.7	calc.
24		Till (o)	90	63	21	16	5.2	6.5	11.7	calc.
25		Till (u)	250	40	37	23	4.3	5.1	9.4	calc.
26	Gunnworth	Till (o)	60	60	23	17	5.0	10.0	15.0	calc.
27	NW 16-24-28-16-W3	Till (u)	107	52	27	21	3.0	3.3	6.6	calc.
28		Slit (o)	111	9	66	25	1.1	5.2	6.3	sl. calc.
29		Silt (o)	112	12	61	27	0.8	5.2	6.0	noncalc.
30		Silt (u)	113	25	52	23	1.2	5.2	6.4	sl. calc.
31		Till (u)	160	46	29	25	4.0	5.0	9.0	calc.

*Oxidized **Unoxidized

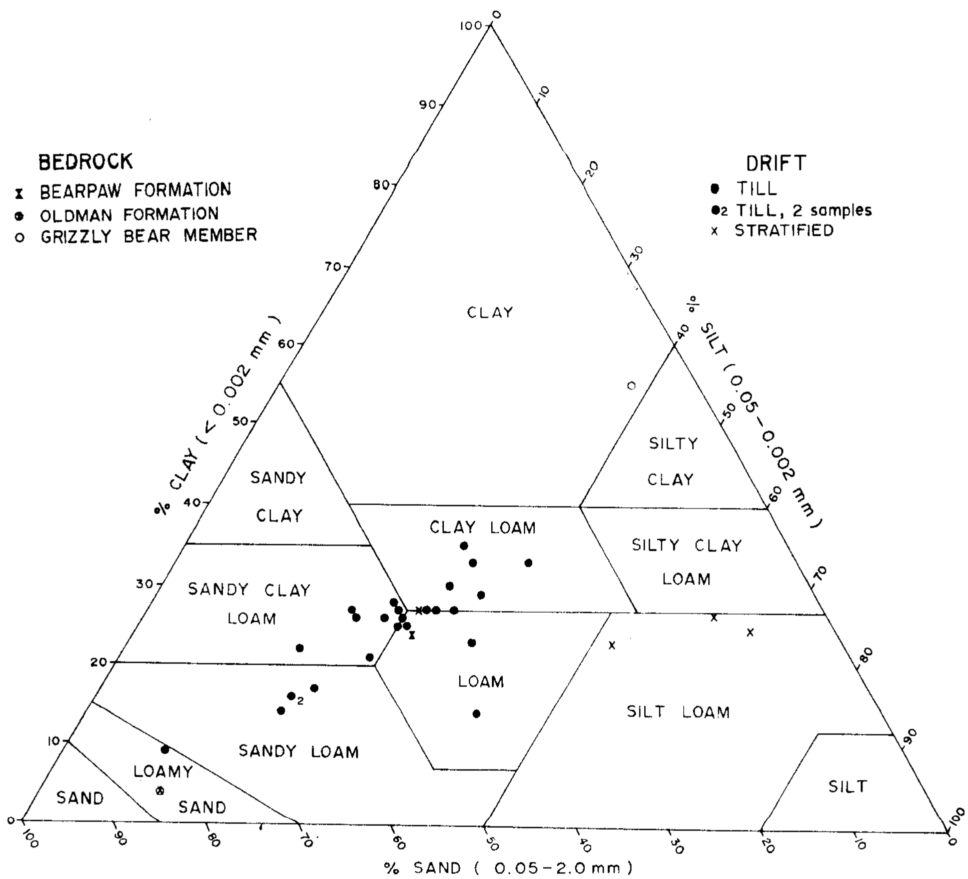

Figure 5.—Texture of tills, stratified drift, and bedrock of the Kindersley area

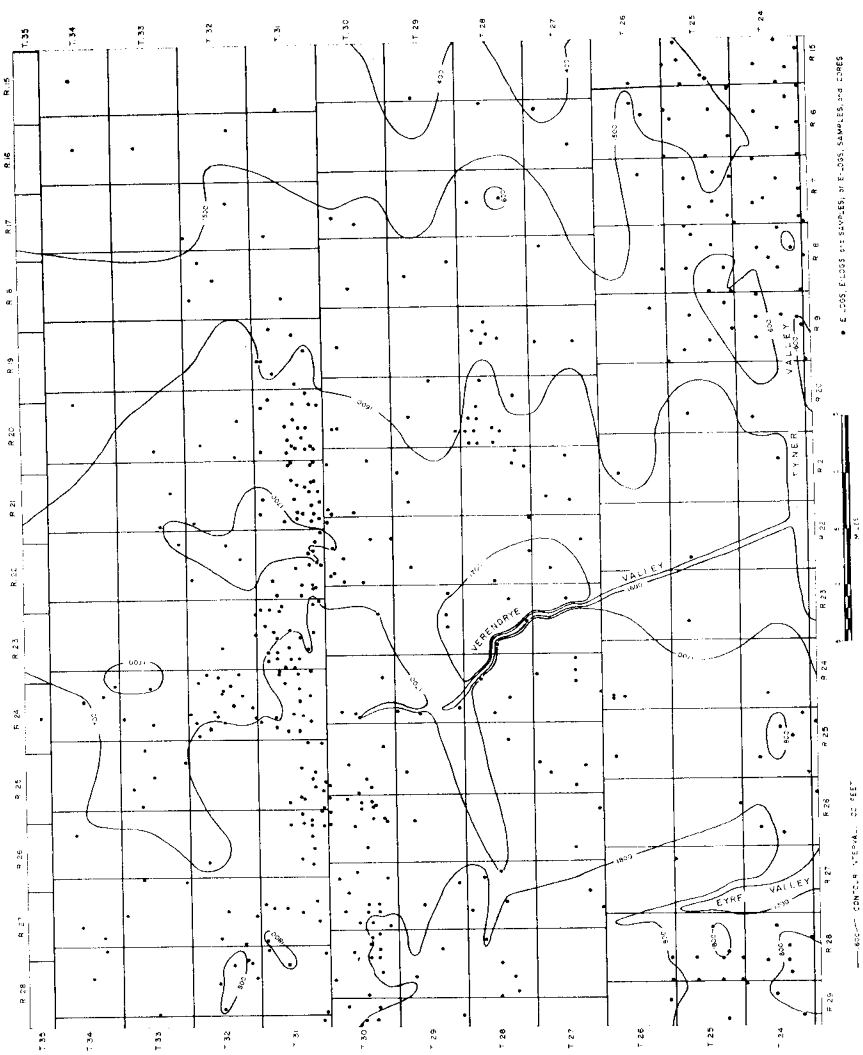

Figure 6.—Structural contour map of Grizzly Bear Member of the Kindersley area

The Bearpaw Formation has been removed by preglacial erosion in the Tyner and Eyre Valleys and by glacial erosion in the Verendrye Valley (Pl. 2). The contact between the Oldman and Bearpaw Formations has a local relief equal to the thickness of the formation which is up to 450 feet.

The Bearpaw Formation is composed of 0 to 450 feet of grey, non-calcareous, interbedded silt, very fine to fine-grained sand, and clay as indicated by field tests on sidehole cores. Laboratory analyses on Sample 13 (Table 1) indicate that the Bearpaw Formation near Court (T.33, R.28) is composed of 46 per cent very fine-grained sand, 30 per cent silt, and 24 per cent clay; and 1.0 per cent calcite and 0.6 per cent dolomite. An X-ray diffraction pattern (Pl. 3, 3 a and b) indicates that the dominant clay mineral in the Bearpaw Formation near Court is montmorillonite. Illite and chlorite are also present in minor amounts and a trace of kaolinite is indicated.

"Preglacial gravel"

The sand and chert and quartzite gravels which lie between drift and Upper Cretaceous sediments are referred to herein as "Preglacial gravels". "Preglacial gravel" occurs on the Grizzly Bear Member and on the Oldman and Bearpaw Formations beneath drift at elevations ranging from 1500 to 2600 feet (Pls. 1, 2, and 5). The unit is composed of 1 to 30 feet of light brown, well rounded quartzite pebbles and brown, grey, green, black, and red, rounded chert pebbles. In the Tyner Valley (T.25, R.15, Pl. 2) 1 to more than 50 feet of sand comprise the "Preglacial gravel" unit.

Bedrock Surface Topography

The topography of the bedrock surface is shown in Plate 2. The total relief is about 1100 feet, the highest point being 2600 feet (T.25, R.29) and the lowest point being less than 1500 feet in the Tyner Valley (T.25, R.15). The maximum local relief is about 500 feet where the Verendrye Valley is cut sharply into bedrock. Except for the lower end of the Tyner Valley and local irregularities caused by end moraines, the bedrock surface topography is similar to the topography of the present day surface. The lowland in the bedrock surface in the Plenty (T.32, R.19) area for example is reflected in the present day surface where it is outlined by escarpments (Pls. 1 and 2). The Verendrye, Eyre, and Tyner Valleys are the most striking topographic features in the bedrock surface. The Verendrye Valley is about 500 feet deep, about one half mile wide, has steeply sloping walls, and, according to samples from the Verendrye and Smiley testholes (Pl. 5), the valley has no preglacial gravel in its bottom. The Eyre and Tyner Valleys on the other hand are about 300 feet deep, 2 to 6 miles wide, and have gently sloping walls. According to Isham (NE 8), Tyner (NE 16), and Lille (SW 4 and SE 8) testholes (Pl. 5), the Tyner Valley has 1 to 50 feet of preglacial sand and gravel in its valley bottom. The fact that preglacial gravel occurs in the Tyner Valley indicates that this valley and presumably its tributary, the Eyre Valley, is preglacial. The trench-like shape of the Verendrye Valley, absence of tributaries, and its similarity to the upper reaches of the Eagle Creek and Snipe Lake Valleys which are meltwater valleys suggest that the Verendrye Valley is glacial rather than preglacial.

Pleistocene Series

General Statement

Graphic, lithologic logs of 59 testholes are shown in Plate 5. Only lithologic units thicker than 10 feet are shown. Cross sections based on a number of these testholes are shown in Plate 1. Drift sections in the South Saskatchewan River Valley of the Kindersley area were described by David (personal communication).

Drift and Bedrock Studies

Drift and bedrock sediments from testholes of the Kindersley area were subjected to textural, carbonate, and clay mineral analyses. The sample locations are shown in Plate 5, and the results of these analyses are shown in Table 1.

The texture of the drift and bedrock sediments was determined by the pipette method. In this method of mechanical analyses, 10 grams of untreated oven-dried sediment (less than 2.0 mm diam.) is dispersed in distilled water and 5-20 cc of sodiumhexametaphosphate. Sands (2.0-0.5 mm) are removed by seiving and silt (0.5-0.002 mm) and clay (less than 0.002 mm) are determined by the pipette method. The textural subdivisions used here are those adopted by the United States Soil Survey Staff (1951). The texture of till in the Kindersley area ranges from sandy loam to clay loam (Fig. 5). The four stratified drifts show a texture which ranges from loam to silt loam. One sample of the Grizzly Bear Member and Oldman and Bearpaw Formations show textures of clay, loamy sand, and loam respectively (Fig. 5).

The calcite and dolomite were determined by the Chittick apparatus following the procedure described by Dreimanis (1962). Calcite content of tills ranges from 1.2 to 8.1 per cent (Table 1) whereas the dolomite content of tills ranges from 2.3 to 10.0 per cent. Total carbonates in tills range from 3.5 to 17.6 per cent. A plot of calcite in relation to dolomite shows no trend or grouping. Sediments classified as being noncalcareous by field tests contain one per cent or less calcite (Table 1), by which criterion all bedrock sediments in the area are noncalcareous. The dilute HC1 test is therefore a definitive criterion for distinguishing between stratified drift and bedrock because almost all samples of drift are calcareous.

X-ray diffraction patterns were determined on the less than 2 micron clay fraction and on the less than 50 micron silt and clay fraction from 31 samples (Table 1). After the textural analyses were completed, the suspension was again mixed and 2 silt and clay and 2 clay samples were taken at the appropriate times and four oriented slides were prepared for each of the 31 samples. One silt and clay and one clay sample were glycolated and the remaining 2 slides were heated to 440 °C for 10 minutes.

Qualitatively all X-ray diffraction patterns of glycolated silt and clay (< 50 microns) are similar, and the same is true of diffraction patterns of glycolated clay (< 2 microns) for the 31 samples (Table 1). The silt and clay (< 50 microns) and clay (< 2 microns) patterns, however, show major differences qualitatively and in intensity of peaks. The first 3 patterns (1a, b, and c) in Plate 3 are taken from sample 7 (Table 1). Pattern 1a shows that on heating to 440 °C for 10 minutes the 17Å peak collapses to 10Å but that the 14Å peak remains indicating that montmorillonite and chlorite are present. Except for the collapse of the 17Å peak, the heated and glycolated patterns (1a and b) are similar.

A comparison of patterns 1b and c (Pl. 3) shows the following similarities and differences: (1) both patterns have well developed 17.3Å, 10.0Å, and 7.1Å peaks which indicates that montmorillonite, illite, and kaolinite and/or chlorite are present; (2) both patterns have chlorite-kaolinite doublets at 25 °2θ, the 004 chlorite peak being more prominent in the silt and clay pattern (lb) than in the clay pattern (1c); (3) the quartz and feldspar peaks are much more prominent in the silt and clay pattern (1b) than in the clay pattern (1c); and (4) the calcite and dolomite peaks which are well developed in the silt and clay pattern (1b) are almost absent in the clay pattern (1c). A further comparison of 2c and d (Pl. 3) shows well developed 14.2Å and 3.55Å peaks on the heated silt and clay (2C) and almost a complete absence of these peaks on the heated clay (2d). From these data (Pl. 3; 1b and c and 2c and d) it can be concluded that almost all of the calcite and dolomite; most quartz and feldspar; and some chlorite particles are 2 to 50 microns in diameter and that most montmorillonite, illite, and kaolinite particles are less than 2 microns in diameter.

Because the comparison of glycolated silt and clay to glycolated clay is similar for all samples, and because a trace of the 14Å peak remains on all slides after heating to 440°C for 10 minutes, only selected glycolated and heated silt and clay patterns for each sediment are shown in the remainder of Plate 3.

Drift Thickness

The drift in the Kindersley area ranges from a few feet in the north-central area to 900 feet in the upland south of Greenan (SW 4-2-25-17-W3, Pl. 5). An isopach of drift thickness was constructed by subtracting the elevation of bedrock surface contours from the present day surface contour elevations (Pl. 6). A comparison of this map with the bedrock surface topographic map (Pl. 2), the surface topography, and the land form map (Pl. 1) indicates that the greater drift thicknesses occur in end moraines (Court Moraine) and in buried bedrock valleys (Tyner, Eyre, and Verendrye Valleys) and that the greatest drift thickness occurs where end moraines are superposed on buried bedrock valleys (T.24 and 25, R.16 and 17 and T.25, R.22).

Till sheets range in thickness from 10 to 300 feet; fluvial sands and gravels range in thickness from 10 to 510 feet; and lacustrine silts and clays range in thickness from 10 to 340 feet (Pl. 5). The thick tills (Lille NW 13-35-25-16-W3) and lake silts and clays (Tyner NE 16-24-24-18-W3) occur in the Tyner Valley (Pl. 5) whereas the thick fluvial sands occur in the Verendrye Valley (Verendrye NE 8-4-28-23-W3, Pl. 5). The fact that all great thicknesses of drift occur in pre-existing valleys points to the importance of these features as sedimentary traps.

GLACIAL HISTORY

The glacial history of the Kindersley area is illustrated and explained in Plate 7.

AGE AND CORRELATION OF DRIFT

Criteria for separating tills in testhole logs are (1) stratified drifts, (2) fossiliferous zones, and (3) oxidized zones. Although numerous zones of stratified drift were encountered, it is difficult to determine whether they lie within or between tills. Although fossiliferous zones lie between till sheets, their paucity is a definite limitation. Oxidized zones are the most important criterion for differentiating till sheets in testholes.

Even if the above mentioned criteria are useful tools to separate till sheets in indiviual testholes, the correlaton problem between testholes still remains. This correlation can be established by means of: (1) lithology, (2) weathering profiles in oxidized zones, (3) radiocarbon dates, and, (4) glacial history of surficial tills. Texture and clay mineral and carbonate content of tills suggest that all tills are lithologically similar. Because detailed studies of weathered zones have not been undertaken, only radiocarbon dates and glacial history based on geomorphology and stratigraphy remain as tools of correlation of drift in the Kindersley area.

Each phase of the glacial history of the Kindersley area is marked by a well developed end moraine which suggests that the ice frontal positions represented by these phases are readvance positions. The abrupt discordance between the ice frontal position in Phase 5 (Pl. 7), relative to older ice frontal positions suggests that this ice margin represents the terminus of a major readvance.

Four radiocarbon dates (Table 2) and the correlation of the Swift Current Creek Section of Christiansen (1959) with the "Prelate Ferry Paleosol" as suggested by David, P. P., (1964, personal communication) in addition to the geomorphologic and stratigraphic relations are the bases of the summary of Pleistocene stratigraphy shown in Figure 7, in which the stratigraphic position of the four radiocarbon dates is also shown.

Table 2.—Radiocarbon dates in and adjacent to the Kindersley area

Name of site	Location: S.T.R.M.	Location: N. Lat.	Location: W. Long.	Lab. No.	Radiocarbon age (years B.P.)	Material	Occurrence
Prelate Ferry	SE 25-23-25-W3	50°59′	109°22′	S-176	20,000±850	Soil	120 ft below surface below 2 tills
Gunnworth	SE 17-27-16-W3	51°18′	108°12′	S-198	12,140±240	Charcoal	6 feet below surface below 1 till
Greene	SW 36-30-29-W3	51°36′	109°57′	S-227	10,800±160	Charcoal	30 in. below surface in silt
Marsden	SW 20-45-27-W3	52°53′	109°54′	S-228	21,000±800	Soil	0-4 ft below surface under till

The anomolous age of the carbonaceous material in the Greene site (Table 2 and Fig. 7) requires further discussion. The charcoal is associated with highly contorted, fossilferous silt interbedded with till. The contorted structure was formed presumably either by ice-shove or collapse during melting of stagnant ice. Christiansen (1965) indicates that the glacier stood 80 miles east of Greene near Rosetown 11,000 years ago when presumably the charcoal was deposited. It is concluded therefore that the charcoal and fossiliferous silt were deposited in a pond on stagnant ice and collapsed into its present position less than 11,000 years ago. According to Christiansen (1965) the glacier retreated from the Greene site more than 13,000 years ago which suggests that stagnant ice lingered in this area more than 2000 years.

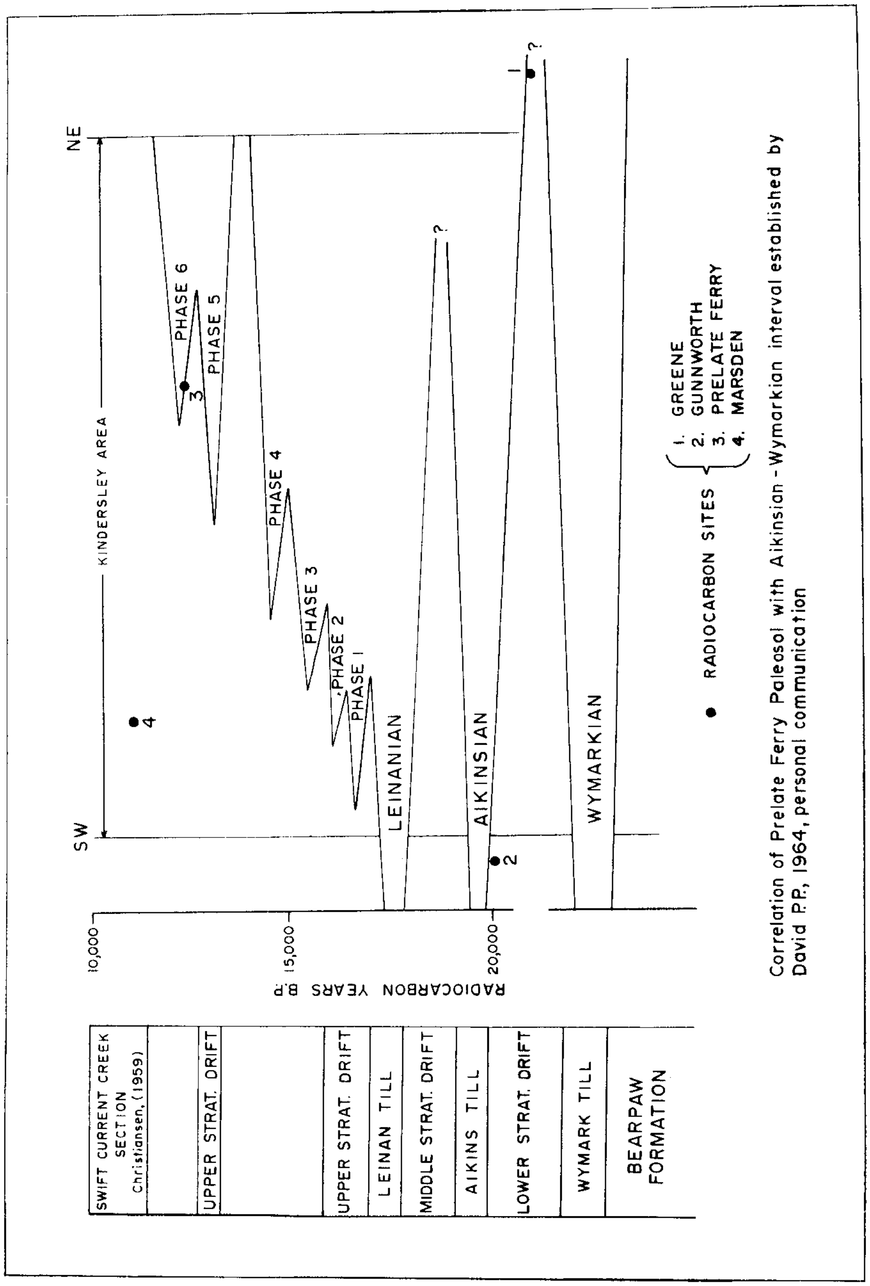

Figure 7.—Summary of Pleistocene stratigraphy of the Kindersley area

ECONOMIC GEOLOGY

Groundwater

An index map of the groundwater resources of the Kindersley area is shown in Plate 8. From this index map the reader is referred to maps upon which the index is based. The chemistry and potential of groundwater is also shown in Plate 8 along with a brief description of each aquifer.

Gravel

There are two main types of gravel in the Kindersley area: (1) those which were deposited in contact with the glacier (ice-contact gravel) and (2) those which were deposited in front of the glacier (proglacial gravel).

Ice-contact gravels in the Kindersley area take the form of kames, kame moraines, and eskers (Pl. 1). These ice-contact deposits are composed of gravel interspersed with sand, silt, clay, and till. Although these gravel deposits are not ideal for many uses, very few deposits of better quality gravel are known in the area.

Proglacial gravel occurs as outwash plains associated with ice frontal positions (D'Arcy-Fisk deposits, Pl. 1) or as terrace deposits along the South Saskatchewan River and Eagle Creek Spillways. The gravel is 5 to 20 feet thick.

Future search for gravel in the Kindersley area should include an investigation of the ice frontal position shown in Phase 5 (Pl. 7). The D'Arcy gravel deposit is associated with this ice frontal position as suggested by the fact that the gravel becomes coarser as the ice frontal position is approached from the west. Kame moraines and interlobate moraines should also be emphasized in future exploration for gravel deposits.

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