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PAPER 61-15

SURFICIAL GEOLOGY OF ELBOW MAP-AREA, SASKATCHEWAN

72 O

(Report, map, and 1 figure)

J. S. Scott

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By

J.S. Scott

D E P A R T M E N T O F

M I N E S A N D T E C H N I C A L S U R V E Y S

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INTRODUCTION

Field work in Elbow map-area, carried out during 1958 and 1959, consisted of large scale mapping of surficial deposits of map-areas 72 O/2, O/6 and O/7 of the National Topographic Series. The purpose was to provide information on the surficial geology of the area surrounding the South Saskatchewan River dam. During 1960 the surficial geology of the remaining area of 72-O was mapped at a scale of 1 inch to 4 miles. Data obtained during both phases of the investigation are contained in this report.

Acknowledgments

Able assistance was given in the field by Paul W. Seder in 1958, by Gordon E. L. Sorli in 1959, and by Thomas H. Gorkoff in 1960. Valuable information was obtained through consultation with Earl A. Christiansen of the Saskatchewan Research Council and with employees of Prairie Farm Rehabilitation service engaged in the South Saskatchewan River project.

A doctoral dissertation presented at the University of Illinois (Scott, 1960)[1] was based on the work done during 1958 and 1959. Professor George W. White, head of the Department of Geology at the university, is gratefully acknowledged.

References

Acton, D.R., et al.
1960: Physiographic Divisions of Saskatchewan (map-scale 1 inch to 24 miles); Sask. Soil Survey, Geol. Div., Sask. Research Council, Dept. Geol., Univ. Sask.

Christiansen, E.A.
1959: Glacial Geology of the Swift Current Area, Saskatchewan; Sask. Dept. Mineral Resources, Rept. 32.

Edmunds, F.H.
1940: Some Stages in the Recession of the Pleistocene Ice from Saskatchewan; (Abs.) Proc. Roy. Soc. Can., 3rd ser., vol. 34, app. D, sec. 4, p. 161.

Scott, J.S.
1960: Surficial Geology of the Elbow-Outlook Area, Saskatchewan, Canada; Univ. Illinois, unpub. Ph.D. thesis.

[1] Names and dates in parentheses refer to publications listed in the References.

PHYSIOGRAPHY

The area contains elements of the Saskatchewan Plains and Alberta High Plains regions of the Great Plains physiographic province (Acton et al., 1960). Uplands within the Alberta High Plains region are The Coteau in the southwestern part of the area and Bear Hills in the northwestern part; both are part of the extensive, southeast-trending Missouri Coteau. These uplands range in elevation from 2,000 to 2,500 feet and are characterized by gently to strongly rolling topography produced by hummocky moraine.

Uplands of the Saskatchewan Plains region—Hawarden Hills and Allan Hills—occur in the east-central and eastern parts of the area respectively. Hawarden Hills Upland is an undulating to gently rolling till plain ranging in elevation from 1,950 to 2,025 feet. Allan Hills Upland ranges from 2,000 to 2,150 feet although isolated hills exceed elevations of 2,200 feet. The gently to strongly rolling surface of this upland is produced by both undulating and hummocky ground moraine. All of the upland areas reflect bedrock highs, but bedrock exposures were observed only on the west flank of The Coteau southeast of Hughton.

The gently undulating to rolling surface of the South Saskatchewan River Plain intervenes the upland areas. Elevations on this plain range from 1,950 feet in the south to 1,650 feet in the north. Local relief is low, apart from that produced by the valley of South Saskatchewan River, but aeolian accumulations of sand in the form of parabolic and transverse dunes produce as much as 50 feet of local relief.

South Saskatchewan River—the dominant drainage feature—flows north through the central part of the area with a gradient of about 1.3 feet per mile. Its valley varies in size from 1 mile wide and 250 feet deep in the south to about 4 miles wide and 70 feet deep in the north. The river channel itself, along the reach within the map-area, is generally 1/2 mile wide, but is filled with water only at times of greatest run-off in late March and late June. At other times of the year the river assumes a braided character.

Upland surfaces lack integrated drainage, consequently undrained depressions or sloughs are numerous and tributary drainage to South Saskatchewan River is intermittent.

Beaver Creek drains the lowland between Hawarden Hills and Allan Hills. It meanders north from its headwaters east of Hawarden and empties into Brightwater Lake near Dundurn. It also drains Brightwater Lake by flowing north through an extensive area of sand dunes, and becomes tributary to South Saskatchewan River at the north end of the map-area.

Macdonald and Stonyridge Creeks drain the lowland northwest of The Coteau. They are underfit streams flowing in broad, shallow channels eroded during the Pleistocene. These streams empty into the swampy area surrounding Goose Lake. Drainage from Goose Lake is effected by an unnamed stream that flows northeast beyond Delisle.

Eaglehill Creek, also an underfit stream in a Pleistocene drainage channel, enters the west side of the map-area north of Rosetown. This creek drains the eastern part of Bear Hills and the northwestern part of the map-area. It flows north, parallel with South Saskatchewan River, to become tributary to North Saskatchewan River beyond the map-area.

DESCRIPTION OF DEPOSITS

Bedrock (R)[1] consists of pale to dark grey, massive, soft clay shale of the Upper Cretaceous Bearpaw formation. The surface of the exposures in tp. 24, rge. 14, and tp. 26, rge. 12, and outcrops along South Saskatchewan River, are covered by an abundance of individual crystals and crystalline aggregates of selenite (hydrous calcium sulphate).

Buff-weathering, fine-grained, friable sandstone beds of the Upper Cretaceous Belly River formation are exposed along the west bank of South Saskatchewan River at Outlook, and on the east bank of the river 5 miles south of Outlook. At these localities the rocks contain ferruginous, calcareous concretions, some of which are 8 feet in their largest dimension. Fragments of marine macrofauna are commonly found at the nucleus of some of the concretions.

Ground moraine (1) is composed of oxidized, khaki-brown to dark olive-brown till and unoxidized blue-grey till. The average grain-size distribution of till particles less than 4 mm in diameter is sand 35 per cent, silt 40 per cent, and clay 25 per cent. In most places the till is overlain by a layer, 1 foot to 15 feet thick, of stratified ablation deposits comprising fine sand and silt with lenses and pockets of coarse sand and gravel.

Hummocky moraine (2) is confined to altitudes above 2,050 feet. It is composed of till similar to that of unit 1, and contains pockets of sand and gravel. It occurs as a heterogeneous assemblage of knobs and mounds separated by circular or 'doughnut'-shaped, rimmed kettles producing a local relief ranging from 10 to 50 feet.

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[1] Letters and numbers in parentheses refer to map-units on the enclosed geological map.

Hummocky moraine (2a) in tps. 33 and 34, rges. 13 and 14, is covered by 15 feet or less of stratified silty clay and fine sand with, in some places, interstratified till. These deposits resemble lake deposits, but are at altitudes above the general level (2,050 feet) of lake deposits to the southeast. Dead-ice plateaux (2b) occur as flat elevated areas within hummocky moraine. Areas of oriented ice-disintegration mounds and ridges (2c) contain materials and landforms similar to those of unit 2. The subrectilinear orientation of ice-disintegration features, however, may indicate an origin in proximity to an ice-front.

End moraine (3) also consists of till with local deposits of sand and gravel. Boulders are abundant on the surface of areas containing subparallel, arcuate ridges (3a). The ridges, which have a local relief of 20 to 50 feet, are probably the result of thrusting of till and bedrock along shear planes at the front of the glacier. Subsequent ablation of the ice superposed hummocky moraine features on the ridges.

Outwash (4) consists of deposits of sand and gravel with local inclusions of till. The surface expression of these deposits closely resembles that of ground moraine or hummocky moraine. Numerous small gravel pits have been developed within these deposits.

Ice-contact deposits (5) are stratified sand and gravel. They occur both as isolated hills or mounds (kames) about 50 to 100 feet high and as terrace-like features adjacent to areas of end moraine. The most prominent kame deposit occurs 2 miles south of Bradwell (tp. 34, rge. 2) where an isolated mound, extensively exploited for sand and gravel, rises 100 feet above the surrounding terrain.

Lake deposits consist of silty clay with local varved deposits (6a), fine- to medium-grained sand (6b), minor deposits of sand and gravel (6c), or a mixture of these materials (6). They occur mainly in South Saskatchewan River lowland north of The Coteau and west of the elbow of South Saskatchewan River.

Deposits of alluvium and colluvium (7) are confined to channels that carried meltwater from glaciers or drained proglacial lakes. They consist of silt, clay, boulder lag, sand, and gravel. Extensive deposits of sand and gravel (7a) occur within the channel containing Barber Lake (tp. 28, rge. 12).

Delta deposits (8) comprise stratified sand, gravel, and finely laminated silt and clay and occur at the outlets of meltwater channels. Thus these deposits are transitional with those of map-units 6 and 7. The deposits that occur in the west abutment area of South Saskatchewan River dam (sec. 35, tp. 26, rge. 7, and sec. 1, tp. 27, rge. 7) consist of discontinuous lenses of fine sand, silt, and clay overlain by coarse-grained sand and gravel. Vertical sections through these deposits characteristically display abrupt variations in texture.

Wind deposits (9)—generally uniform, medium-grained sand—represent aeolian modification of map-units 4, 6, and 10. Parabolic dunes, with local relief up to 25 feet, and separated by deflation pits or 'blowouts', constitute the dominant form of sand accumulation. The deflation pits are elongated toward the northwest in the direction of the prevailing wind.

Alluvium (10a) consists of sand, silt, clay and minor amounts of sand and gravel derived from older deposits by modern streams. Alluvial deposits within South Saskatchewan River channel (10b) are mainly fine- to medium-grained sand derived mostly from sources west of the map-area. Large boulders, derived from erosion of the valley walls, are also contained within the river channel. High-level deposits of South Saskatchewan River (10c) consist mainly of medium- to coarse-grained sand and gravel. Well-rounded fragments of coal are, in places, incorporated with these deposits.

Pond deposits (11) are silt and clay. They occur in shallow, poorly drained depressions. The surface of these deposits is commonly covered by a white efflorescence of sodium and magnesium sulphate commonly known as 'white alkali'.

Colluvium (12) consists mainly of slumped blocks of till along the valley walls of South Saskatchewan River. Successive failures have produced a series of elongated, arcuate ridges that are parallel with the river. Slumped areas generally occur where down-cutting by the river has progressed into the underlying Bearpaw formation. Lateral expansion of shale toward the river produces tension in the overlying till, and the resulting increased shear stresses cause failure of the slopes.

MINOR GLACIAL FEATURES

The only ice-flow features in the area are shallow linear grooves in till; they are locally covered by thin lake deposits. The direction of the grooves (southwest in tp. 29, rge. 10, southeast in tp. 30, rge. 4) reflects the influence of topography on local glacier movement.

Minor till ridges, generally less than 6 feet high and 1/2 mile long, are interpreted as crevasse fillings. The trend of the ridges in tp. 28, rge. 9—at right angles to the trend of ice-flow features—suggests that ice-movement controlled the orientation of the ridges.

Chains of kettles within narrow, well-defined valleys or in broad depressions indicate former meltwater spillways.

GLACIAL HISTORY

The Laurentide glacier, which covered the area during the late Wisconsin, advanced generally towards the south and southeast, although local glacier movements within the area were towards the southwest. Evidence for major glaciation prior to late Wisconsin time is scarce, but the end moraine in tp. 34, rges. 12 and 13, and multiple tills encountered in exploratory borings near Elbow, are probably the result of an earlier glaciation. Coarse-grained sand and gravel, separating layers of till, are exposed in places along the north wall of the valley containing Anerley Lakes. These multiple-till sections indicate a local readvance of the ice.

The glacier receded, in general, to the north, in the direction of the consequent slope. Upland areas were first deglaciated, largely by stagnation and wasting of the ice, followed by the recession of local ice-lobes within the lowlands. Proglacial lakes, bounded by uplands and the ice-front, developed in lowland areas. Drainage from these lakes toward the north was prevented by the presence of the glacier. Lake outlets were therefore established across uplands in a direction parallel with the ice-front. Further recession of the ice uncovered successively lower outlets and previously formed channels were abandoned in their side-hill positions.

Seven phases of deglaciation of the area are interpreted from the type and distribution of sediments and from the position of meltwater spillways (see Fig. 1). No temporal significance is assigned to any of the various phases.

Phase I

Ridged end moraine, an extension of Clearwater Lake Moraine (Christiansen, 1959), was first uncovered as the glacier receded from the south into the map-area. During this phase, meltwater was carried south and east, beyond the map-area, into glacial Lake Regina by Thunder Creek channel (Christiansen, 1959).

Phase II

During this phase, two glacial lakes, separated by The Coteau, were formed in front of the glacier. An early stage of glacial Lake Rosetown (Edmunds, 1940) developed in the lowland west of The Coteau. Silt and clay were carried into the lake by the channel situated 4 miles south of Hughton.

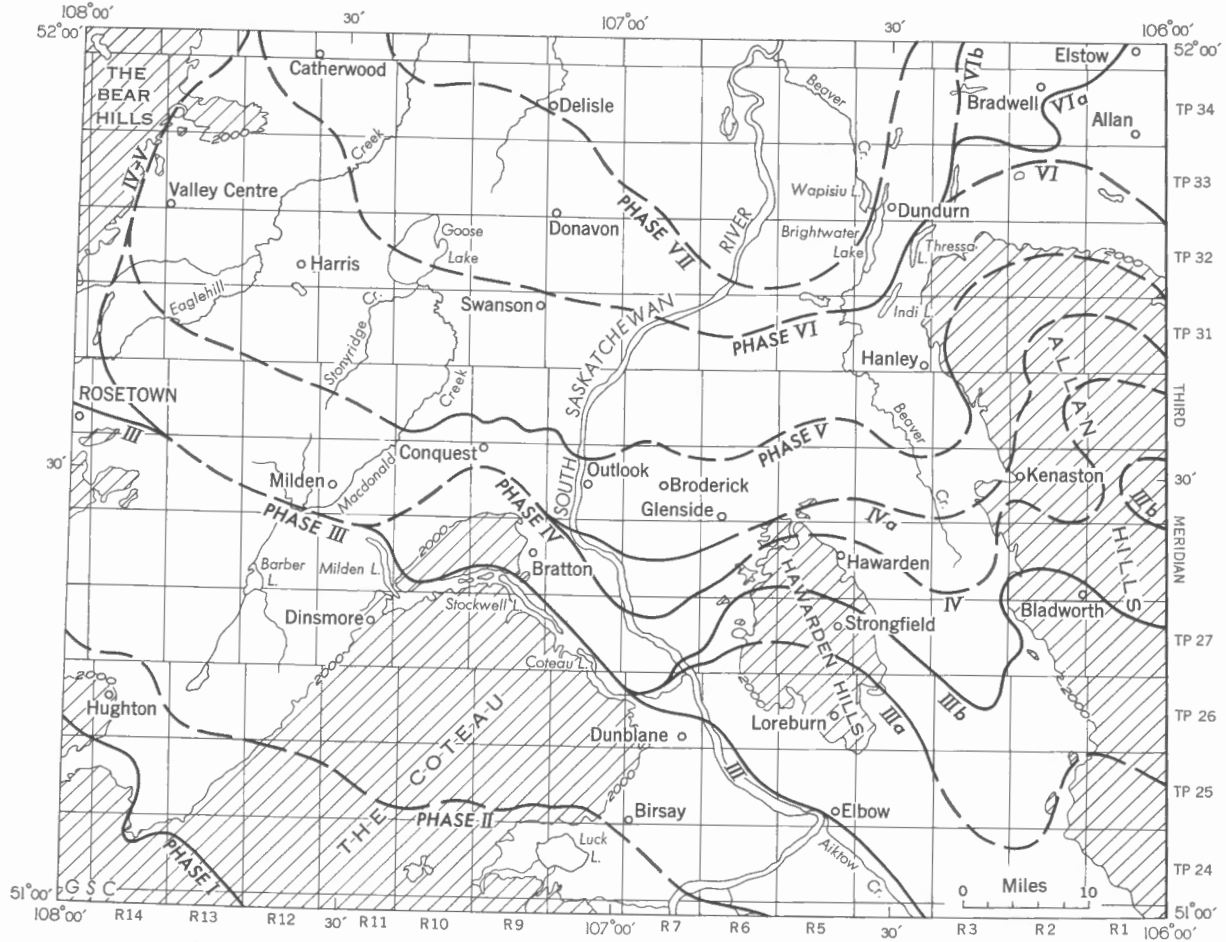

Figure 1. Various positions of the Late Wisconsin ice-fronts during deglaciation

The ice-front position along The Coteau is marked only by outwash sand and gravel (tp. 25, rge 10).

Glacial Luck Lake, which developed in a re-entrant into the east side of The Coteau, was a northward extension of glacial Lake Beechy described by Christiansen (1959). Deposits of sand and gravel at the west end of the basin indicate a shoreline altitude of about 2,100 feet. Most of the deposits in the central part of the basin are silty clay carried in from the south by an early stage of South Saskatchewan River. Drainage from Luck Lake was eastward, along the ice-front beyond the map-area, by way of Sage Creek channel, thence into Qu'Appelle channel.

Phase III

During phase III the ice-front position was on the north-east side of The Coteau, and is well marked by the channel containing Anerley Lakes. Eaglehill channel, to the west beyond Rosetown, and Qu'Appelle channel southeast of Elbow, indicate the extension of the ice-front during this phase. Aiktow Creek is in the part of Qu'Appelle channel that is situated in the map-area.

A drainage divide on The Coteau, at altitude 2,050 feet, separated the flow of meltwater that was derived both from the ice-front and from stagnant ice on The Coteau, into western and eastern drainage. Expanded Lake Rosetown thus received meltwater from The Coteau and from the west by Eaglehill channel. Meltwater flowed east of the divide into Luck Lake, thence eastward along Qu'Appelle channel.

A slight readvance of the glacier overrode outwash sand and gravel deposited on The Coteau and partly plugged drainage channels (tp. 27, rge. 9) that carried meltwater, derived from stagnant ice on The Coteau, north towards the ice-front.

Continued influx of meltwater to Lake Rosetown increased the lake level above 2,050 feet, thus overtopping the divide on The Coteau. Delta sand and gravel, derived from erosion of Anerley channel by waters from Lake Rosetown, were deposited in Luck Lake (tp. 26, rge. 7) which, during phase III, was at an altitude of about 1,850 feet.

The ice-front continued to recede northward (phases IIIa and IIIb) east of South Saskatchewan River leaving local ice-lobes in lowlands of South Saskatchewan River and Beaver Creek. Eroded delta deposits at the mouth of Anerley channel and lake deposits at an altitude of 1,950 feet between Dunblane and Loreburn indicate fluctuations in the level of Luck Lake between elevations of about 1,800 and 1,950 feet. These variations in lake level were probably caused by fluctuations of the ice-front east of the map-area, which affected drainage in Qu'Appelle channel.

Phase IV

Retreat of the ice-front north of The Coteau uncovered an outlet at elevation about 1,825 feet. Lake Rosetown drained southeastward around The Coteau into Luck Lake, whose outlet continued to be Qu'Appelle channel. Waters carried along South Saskatchewan River from the west also continued to flow east along Qu'Appelle channel. Bear Hills in the northwestern part of the map-area were deglaciated during this phase. Ponding of water by stagnant ice resulted in the deposition of lacustrine-like sediments on Bear Hills.

Continued recession of the ice-front east of South Saskatchewan River (phase IVa) uncovered the upland around Hawarden. Lake Rosetown and Luck Lake coalesced to form Lake Milden, which was named by Edmunds (1940). Lake deposits of silty clay, which occupy the Beaver Creek lowland east of Hawarden at altitudes ranging from 1,875 to 1,925 feet, record the eastward expansion of Lake Milden.

Phase V

The ice-front position during this phase is best shown by well-developed meltwater channels 2 miles north of Conquest. Elsewhere, evidence of the ice-front position is obscured by lake deposits or is marked only by weakly developed drainage channels. Lake Milden expanded northward, but continued drainage to the south along South Saskatchewan River and Qu'Appelle channel lowered the level of the lake to an altitude of about 1,825 feet.

Phase VI

The ice-front position during phase VI is well marked only at the northwest end of Allan Hills by the channel containing Indi, Thressa, and Blackstrap Lakes; this channel was named Blackstrap channel by Edmunds (1940).

Meltwater, locally ponded between the ice-front and Allan Hills, formed an early stage of Lake Elstow (Edmunds, 1940), which drained to the east beyond the map-area. Blocking of eastern drainage by an ice-front and an increase in lake level to about 1,875 feet caused Lake Elstow to drain to the southwest, along an early stage of Blackstrap channel, into Lake Milden. At this time the level of Lake Milden was about 1,800 feet, but continued drainage along Qu'Appelle channel lowered the lake level to about 1,750 feet.

Further recession of the ice-front north of Allan Hills (phase VIa) uncovered an outlet for Lake Elstow at an altitude below 1,750 feet, east of the map-area. Lake Milden then drained northerly through Blackstrap channel, which resulted in a lowering of its level below 1,750 feet, and drainage south through Qu'Appelle channel ceased. Water carried from the west along South Saskatchewan River then flowed northwesterly, thus creating the elbow of the river.

West of South Saskatchewan River, receding waters of Lake Milden drained northward along the channels of Stonyridge and Macdonald Creeks, thereby contributing local deposits of sand and gravel and extensive deposits of sand to the area north of township 30.

Recession of the ice-front west of Bradwell (phase VIb) uncovered a northerly outlet through which Lakes Milden and Elstow drained completely.

Phase VII

The last remnant of an ice-lobe in the area is marked only by the shallow channel presently occupied by Brightwater Lake. Evidence for the remainder of the ice-front position is obscured by silty clay and fine sand, which were probably deposited as outwash.

POST-GLACIAL EVENTS

Following the complete deglaciation of the map-area (and areas to the north), South Saskatchewan River eroded its channel into bedrock. Aggradation of fill within the channel, to a thickness of about 100 feet, probably resulted from a rise in base-level owing to isostatic rebound or to increased water level to the east. The present river is degrading its channel, particularly during periods of heavy local run-off in late March and in June when meltwater from snow near its headwaters in the Rocky Mountains reaches a maximum volume.

Aeolian modification of lacustrine and alluvial deposits, which was initiated during late glacial time, continues under the influence of prevailing northwesterly winds.