RESEARCH COUNCIL OF ALBERTA

Geological Division
Preliminary Report 57-3

GLACIAL GEOLOGY

GALAHAD - HARDISTY DISTRICT

ALBERTA

by
L. A. Bayrock

Research Council of Alberta
Edmonton, Alberta
1958

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

GLACIAL GEOLOGY
GALAHAD-HARDISTY DISTRICT, ALBERTA

CHAPTER I

INTRODUCTION

General Statement

This report presents preliminary results of mapping surficial deposits of the Galahad-Hardisty district in east-central Alberta. The distribution of the deposits in this district is shown on two maps, on a scale of one inch to one mile: (1) 57-3A, Galahad district, and (2) 57-3B, Hardisty district.

The Galahad district is made up of flat to gently rolling ground moraine. The topography of the district has been modified by debris-filled meltwater channels--stream trenches--which are numerous in the eastern portion of the area. The western portion of the Hardisty district is composed of gently rolling ground moraine which has been severely modified by a great number of anastomosing stream-trenches. The central portion of the same district is crossed from north to south by a hummocky dead-ice moraine and the Battle River. The eastern portion of the Hardisty district, including the area surrounding the town of Hardisty, is covered with glacial outwash. East of the hummocky dead-ice moraine the outwash has been modified by wind action and as a result is covered in places with extensive U-shaped dunes.

The glacial deposits of the Galahad-Hardisty district and adjacent districts to the north and south--the Sedgewick and Alliance-Brownfield districts, respectively--were developed from stagnant ice. Hence the glacial history of the Galahad-Hardisty district is interpreted in terms of large scale down-wasting and stagnation of the last glacier to cover the district.

Results of a shallow drilling program and a description of gravel deposits of the district are given at the end of the report.

Location of District

The Galahad-Hardisty district is located in east-central Alberta between 111°00' and 112°00' longitude, and between 52°30' and 52°45' latitude (fig. 1). The total area comprises about 744 square miles. The district lies west of the Fourth Meridian, and all locations in the report are given that interpretation unless otherwise specified.

Previous Work

Reconnaissance studies on the glacial geology of east-central Alberta have been made by Warren (1937, 1954), Rutherford (1941), Bretz (1943), and Bayrock (1955). The morainic belt which is found in the central part of the Hardisty district was first mapped and named the Viking moraine by Warren (1937). In the same report Warren named the area of flat ground moraine which lies to the west of the moraine, the Torlea flats.

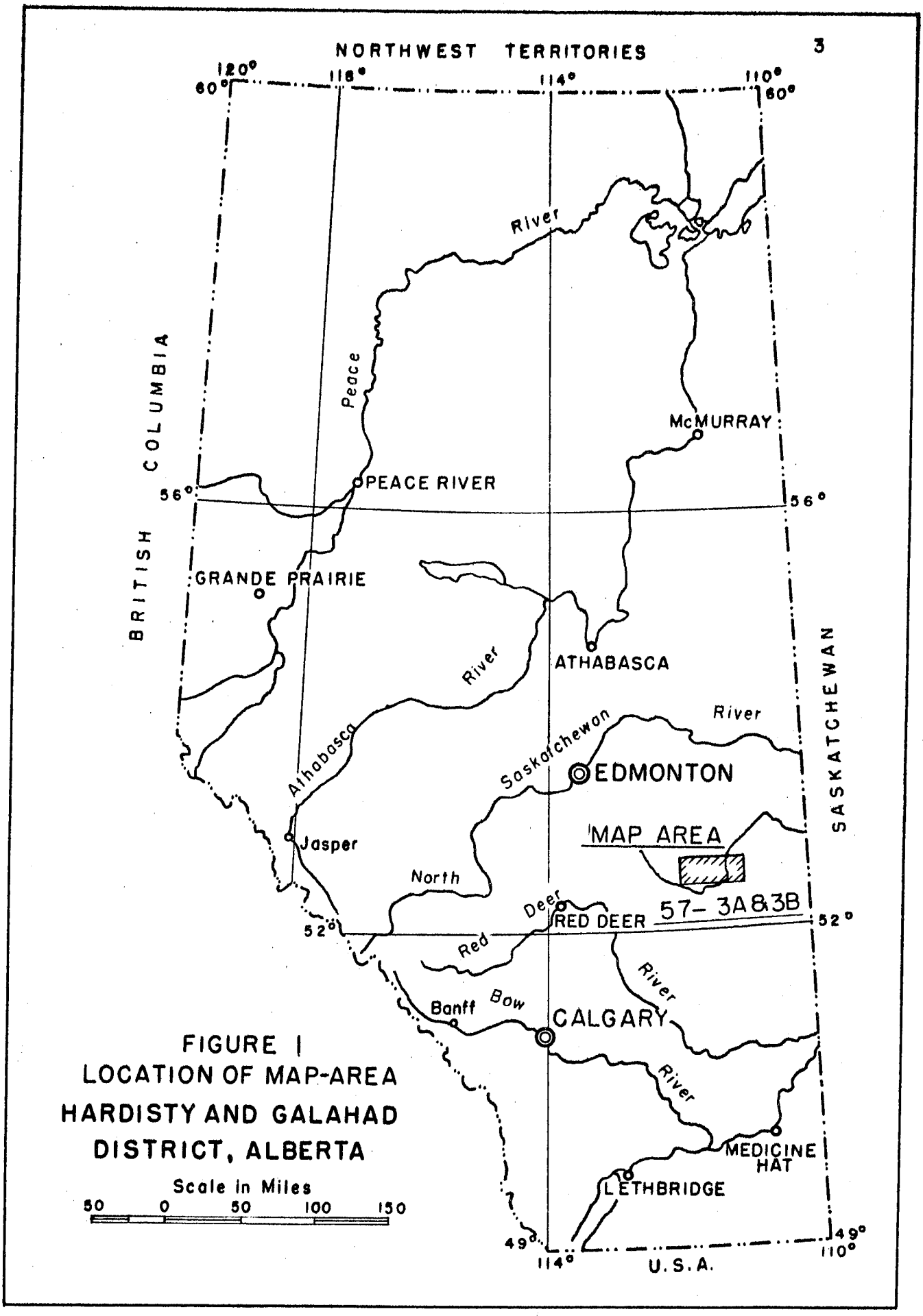


FIGURE 1
LOCATION OF MAP-AREA
HARDISTY AND GALAHAD
DISTRICT, ALBERTA

More detailed reports on the glacial geology of adjacent districts have been made by Gravenor and Bayrock (1955a), Gravenor (1956), Gravenor and Ellwood (1957), and Bayrock (1957).

The soils of the region have been mapped by Wyatt, Newton, Bowser and Odynsky (1944) on a scale of three miles to one inch. J.A. Allan wrote an appendix to this report describing in general terms the bedrock geology, water supply and origin of surfical materials.

Field Work

The field work was carried out during the summer of 1956. Information was collected by the examination of road cuts and river sections, supplemented by shallow digging and hand auger boring. Aerial photographs obtained from the Department of Lands and Forests, Government of Alberta, aided in the mapping. Additional data was obtained by drilling with a 60-foot auger-type power drill.

Acknowledgments

Mr. S.J. Groot, draftsman-compiler for the Research Council of Alberta, prepared the accompanying maps and excellent field assistance was provided by R. Vaughan.

CHAPTER II

PHYSIOGRAPHY

General Statement

The surface of the Galahad district is made up of relatively flat ground moraine which supports a few kames and crevasse fillings. Stream-trenches are numerous in the northeastern portion of the district.

West of the Battle River in the Hardisty district the topography is hilly due to a large number of anastomosing stream-trenches which form a continuation of the stream-trench system of the Galahad district. The topography between the stream-trenches is gently rolling. West of the Battle River the surface deposits are composed of hummocky dead-ice moraine and associated extensive plains of glacial outwash. Sand dunes of recent origin are common on the outwash.

Flat Ground Moraine

Relatively flat ground moraine extends from the western boundary of the Galahad district to about range 11. Between range 11 and the Battle River the ground moraine is gently rolling. The topography of the ground moraine has been severely modified by a large number of interconnected stream-trenches west of the Battle River, in the Hardisty district and the northeastern portion of the Galahad district. The flat ground moraine supports a relatively large number of broad and shallow kettle holes. The thickness of the till of the flat

ground moraine area varies between 20 and 60 feet.

Hummocky Dead-Ice Moraine

Hummocky dead-ice moraine covers a large portion of the Hardisty district. To the south and north the hummocky dead-ice moraine of the Hardisty district joins similar regions of dead-ice moraine of the Alliance-Brownfield and Sedgewick districts, respectively. This hummocky dead-ice moraine was mapped by Warren (1937) as part of Viking moraine.

The greater part of the hummocky dead-ice moraine in the Hardisty district consists of till knobs separated by kettles. Moraine plateaus and moraine ridges are rare. Many of the knobs have a gigantic doughnut-shape, and they have been called prairie mounds (Gravenor, 1955). A small number of moulin-type sandy kames are found scattered throughout the moraine. Generally the hummocky dead-ice moraine of the Hardisty district has well-defined borders except in Tp. 43, R. 10 and Tp. 41, R. 10 where it is gradational to the surrounding ground moraine.

Dead-Ice Kame Moraine

The kame moraine west of the town of Hardisty is a hummocky dead-ice moraine composed of about 50 per cent or more of glaciofluvial fine-to medium-grained sand. Gravel is rare, although some small pockets have been found. The moraine is made up of a series of knobs, some of which apparently are composed entirely of till, and the

remainder of stratified materials.

Stream-trenches

A complex system of interconnected stream-trenches exists west of the Battle River in the Hardisty district and in the north-east portion of the Galahad district. In some localities where two or more stream-trenches join, as in the southwest corner of Tp. 43, R. 10, the valleys of stream-trenches may attain a width of over one mile.

As a rule the stream-trenches are covered with till except where they are very wide, and in such instances it is common to find glacio-fluvial materials near the centre of the stream-trench, (e.g. Sec. 4, Tp. 43, R. 10). All stream-trenches of the district seem to have drained to the Battle River.

The Battle River valley in the Hardisty district is exceptionally wide and in township 42 attains a width of over four miles. The valley is partly covered with hummocky dead-ice moraine (Tp. 41). In other places it contains a great amount of coarse glacial outwash material. The history of the valley of the Battle River is very complex and at present has not been completely unravelled.

CHAPTER III

DESCRIPTION OF MATERIALS

Bedrock

The bedrock of the area is Upper Cretaceous in age. A representative section given below shows the strata recorded in Canadian Gulf N.J. Ellis No. 4 well, (Lsd.4, Sec.10, Tp.38, R.20) in the Stettler area (after Lockwood and Erdman, 1951).

Formation	Thickness, feet	Description
Recent and Pleistocene	70	Glacial and recent deposits, sand, silt and clay.
Edmonton	646	Sands, silts, shales, clay and coal with silty shale predominating. Thin irregular siderite bands, scattered bentonite bands, tuff, and thin calcite bands are also present.
Bearpaw	269	Chiefly dark-grey to grey-black fissile, micro-micaceous shale, in part glauconitic and carbonaceous. A sandstone member, the Bulwark sandstone, is present.
Belly River	875	Predominantly shales and sandstones. Limestone, coal, siderite and bentonite bands are common throughout the formation.

In the Galahad-Hardisty district the above formations have a gentle dip to the southwest. The Belly River formation underlies the Pleistocene deposits of most of the Hardisty district and the northeast corner of the Galahad district. The southwest corner of the Hardisty

district and most of the Galahad district are underlain by the Bearpaw formation. The Edmonton formation is present in the southwest corner of the Galahad district. All the formations are unconsolidated, or only partially consolidated, and bentonitic in character.

Till

The till of the area is uniform in composition as judged by hand specimen examinations and is very similar to the till of adjacent districts to the north and the south. The till of the Alliance-Brownfield district contains about 38 per cent sand and 62 per cent silt and clay (Bayrock, 1957). The predominant clay mineral of the till of east-central Alberta (Bayrock, 1955) is montmorillonite which imparts to the till a "gumbo"-like consistency and makes it relatively impervious to water. Small sand and gravel lenses are commonly found in the till.

The upper part of the till--20 to 40 feet--is oxidized and is light-to dark-brown in color. The oxidized till passes downward gradually or abruptly into unweathered till of grey to dark-grey color.

Crevasse Filling and Kame

Crevasse fillings and kames have been mapped according to the definition, "...Linear ridges composed primarily of till are called crevasse fillings, and mounds or elliptical hills composed of more than 50 per cent washed material are called kames" (Bayrock, 1957). Lack of adequate exposures sometimes makes it impossible to determine the composition of some hillocks and accurate mapping is difficult.

Crevasse fillings and kames are rare. One small field of crevasse fillings is located in Tp. 43, R. 14, where the crevasse fillings are sub-parallel and are oriented north 45 degrees west. Single crevasse fillings exist at a number of localities and have diverse orientations.

The lack of pebbles and boulders in the till of the district suggests that the ice-transported debris was poor in these constituents. As a consequence, kames are composed predominantly of fine-to medium-grained sand with only minor amounts of gravel. As a general rule, therefore, kames are not a potential gravel source.

Esker

The esker located about two miles west of the town of Hardisty consists of two segments and is composed predominantly of coarse sand and gravel. The esker located in Tp. 43, R. 8 was not examined as it is located in the Buffalo Park Reserve, but judging by aerial photographs it is believed to contain commercial quantities of gravel. The three eskers found in Tp. 42, R. 8, are portions of a single discontinous esker. The southernmost segment of the esker is composed primarily of sand, but gravel pockets are common. The middle segment on the surface is composed of fine sand, silt and clay, some of which was apparently deposited in a lacustrine environment. It is believed that during the later phases of the formation of this esker the ice collapsed and dammed the outflowing water, thus creating a temporary lake. The northwest segment of the esker has a relief of over 150 feet in places,

and is composed of very bouldery gravel with a large number of blocks 10 feet or more in diameter. The southernmost end of a large northwesterly-trending esker system is located in Secs. 35 and 36, Tp. 43, R. 9. This end of the esker system is composed predominantly of sand.

Spillway Deposit

Two spillways exist in the Galahad-Hardisty district. The first occupies a broad valley in Tp. 41, R. 8 near the town of Amisk. The deposits found in the spillway are composed of fine-to medium-grained sand. The valley is a part of the glacial drainageway which deposited the intermittent esker in Tp. 42, R. 8 described above.

The second spillway is located in Secs. 1, 2, 11 and 12, Tp. 42, R. 10 and Sec. 36, Tp. 41, R. 10, in the valley of the Battle River. It is believed that this spillway is genetically related to the Gwynne outlet (Gravenor and Ellwood, 1957; Bayrock, 1957) and that the deposits were laid down during the early stages of activity of the Gwynne outlet. The deposits found in the spillway are composed of fine-to medium-grained glacial sand.

There are other fluviatile deposits of sand and gravel located in the stream-trenches of the district. They have been classified as outwash and were probably deposited either from glacial meltwaters which created the stream-trenches, or from meltwaters from ice blocks which existed in the trenches during the late stages of stream-trench development.

Outwash

Outwash deposits of the district can be divided into three general classes on the basis of mechanical composition: (1) those composed mainly of sand, (2) those composed of sand and gravel, and (3) those composed mainly of gravel. There are two large sand outwash deposits in the district. The first, located in Tp. 43, R. 8 and in the northern part of Tp. 42, R. 8, is a small segment of a very large sand outwash plain that stretches for many miles to the east and northeast, and covers an area of more than 10 townships. This sand deposit has not as yet been completely mapped and hence its history and areal extent are not thoroughly known. The portion of this sandy outwash which occurs in the Galahad-Hardisty district is composed of well-sorted, fine-to medium-grained sand.

The second sand outwash plain is located in Tp. 43, Rs. 12 and 13 in the Galahad district and consists of poorly-to moderately-sorted, fine-to medium-grained sand. It is located on the southern slope of a very broad bedrock valley or depression of the Sedgewick district. The thickness of the sand of this outwash plain is generally about 40 feet and is believed to be underlain by till. A number of smaller sand outwash deposits are scattered throughout the district. They are generally thin (20 to 40 feet), of small extent, and overlie till. The small sand outwash deposits are usually fine-to medium-grained and poorly-to moderately-sorted.

Outwash deposits of sand and gravel are found in a number of places in the Hardisty district. The two largest deposits, located on opposite sides of the Battle River in Tps. 41 and 42, are very similar. They are composed of medium-to coarse-grained sand which contains a number of lenses and beds of poorly-to moderately-sorted gravel. Field observations suggest that the depth of sand and gravel in these deposits is on the order of 20 to 40 feet. The only difference between these sand and gravel deposits is that the western one has a greater proportion of sand to gravel.

The sand and gravel outwash deposit which is located in Tp. 42, R. 8, covers an area of about eight square miles. The gravel fraction of this deposit is usually found in separate lenses and beds. The thickness ranges from 20 to 30 feet and the deposit overlies till. The deposit located in Sec. 13, Tp. 43, R. 10 is about two square miles in area, is composed of poorly-to moderately-sorted, medium to coarse sand on the surface, and contains many small poorly sorted gravel lenses. Its thickness could not be ascertained in the field but is judged to be of about 40 feet. Another deposit of this group is located on the north bank of the Battle River in Tp. 43, R. 9. It is quite variable in thickness and composition.

Of the outwash deposits composed mainly of gravel, the largest one is located east of the town of Hardisty in Tp. 43, Rs. 8 and 9. It covers an area of approximately five square miles. The thickness

of this deposit has not been ascertained in the field but is believed to be on the order of 30 or more feet. The gravel has a coarse sand matrix and is poorly sorted. Judging by the position of the gravel with respect to other glacial deposits of that locality, it is believed to be underlain by till. The next largest gravel outwash deposit is located in and around the town of Hardisty. It contains moderately-to well-sorted gravel, well-bedded and about 20 to 40 feet in thickness. Other outwash deposits of gravel in the Galahad-Hardisty district are small in area and quite variable in composition as compared to those mentioned. Most of the gravel outwash deposits are covered by a veneer of sand up to five feet in thickness.

Glacio-Lacustrine Deposit

Glacio-lacustrine deposits of the Galahad-Hardisty district are generally found in local depressions, and probably received sedimentation for a substantial period of time after the disappearance of the ice from the district. No varved clays were observed and bedding was only rarely seen. In composition the deposits range from sand to clay and are poorly to very poorly sorted.

Recent Deposits

Aeolian Deposit

In general, Recent wind-blown sands mantle the surface of outwash east of the Battle River in the Hardisty district. The sand outwash plain in Tps. 43 and 42, R. 8 has many dunes which are still-active.

The dunes are of the U-shape type and were probably developed under semi-arid conditions. The dunes are composed of fine-to medium-grained glacial sand which was derived from the underlying glacial outwash. The sand dunes were produced by winds which blew from a north 50 degrees west direction, the same direction as determined in the Sedgewick and Alliance-Brownfield districts (Gravenor and Ellwood, 1957; Bayrock, 1957). The aeolian deposits developed on gravel outwash deposits and on sand and gravel, are not so extensive as those developed on outwash sand. Some of the outwash sand was driven a short distance beyond its source area into adjacent areas of ground moraine, as in range 8. This aeolian sand cover on the ground moraine averages from two to five feet in thickness except where there is actual dune development. Glacial outwash adjacent to the Battle River has been modified only slightly by wind action. The outwash sand in Tp. 43, Rs. 12 and 13 in the Galahad district has been considerably modified by wind, but the sand has not spread far beyond the source area.

Bottomland and Lacustrine Deposits

Recent bottomland deposits are found in closed depressions occupied by ponds or formerly occupied by ponds, along drainage courses and around the shores of lakes. Recent alluvial deposits are encountered along flood plains of the Battle River and Iron Creek. Bottomland and alluvial deposits range in composition from clay to sand. As a rule organic matter does not form a major portion of the constituents.

Recent lacustrine deposits range in composition from clay to sand and commonly have some associated organic material. All ponds and lakes of the area which have poor drainage are generally high in salt content.

Colluvium

Colluvial deposits are those which have been transported downslope, mainly by gravity. The materials were lubricated by water but running water and ground ice played a secondary role in transport. As a rule colluvial deposits are limited in extent in east-central Alberta. The colluvial deposits in the Hardisty district were derived from till and bedrock, and as a result are composed of a mixture of both. In hand sample the colluvium looks like a silty to sandy till.

CHAPTER IV

GLACIAL HISTORY OF THE AREA

Preglacial Topography

It is difficult to reconstruct the preglacial topography of the district because, (a) the preglacial surface has been contorted and eroded by glacial action, (b) glacial and possibly interglacial drainage channels have modified the bedrock surface, and (c) the bedrock surface is buried under varying depths of glacial deposits about which only very meagre data are available.

Nevertheless, a very general picture of the preglacial bedrock topography can be presented utilizing field observations, bore-hole data, and topographic maps. The Galahad district is underlain by a generally even bedrock surface which is found between 20 and 70 feet below the present surface. It is believed that glacial erosion removed uniform amounts of the bedrock of the Galahad area, and consequently the flat bedrock surface is similar to the preglacial topography of the district. The only exception is a monadnock-like bedrock hill--the Bellshill--which is located in the southeast corner of the Galahad district. It is assumed that the Bellshill is a preglacial erosion remnant. In some instances stream-trenches may follow older drainage lines, but for the most part they are of glacial origin.

The Hardisty district is more complex. The Battle River

valley to the east and south of the town of Hardisty attains a width of over four miles, and is bounded by buried bedrock valley-walls. The history of the Battle River valley in the Hardisty district has not been completely deciphered, but it is possible that part of the valley is pre-glacial in origin. The bedrock surface east of the Battle River is uniformly flat and of roughly the same elevation as that of the Galahad district.

Glacial Advance

No signs of multiple glaciation were found in the Galahad-Hardisty district or adjacent areas. Nevertheless, since multiple glaciation is known to have occurred in other parts of the province, it is assumed that the district under discussion was covered more than once by continental glaciers. The last ice to cover the district was of Wisconsin age, as judged by the fresh topography and the shallow soil development of the district.

One radiocarbon date (Gravenor and Ellwood, 1956) made on a log found by a farmer in the Smoky Lake district while digging a water well gave an age of $21,000 \pm 900$ years. The log, found in till belonging to the last glaciation, is assumed to have been knocked down and incorporated by the last glacier, and deposited shortly afterwards. The time of the onset of the last glaciation in the Galahad-Hardisty district is probably of the same magnitude because of the proximity of the two districts.

The thickness of the last glacier to cover the district was probably on the order of 3,500 feet at its maximum (Bayrock, 1957). The regional direction of the ice advance in the district was probably north 20 to 30 degrees west (Gravenor and Bayrock, 1955b).

Deglaciation

Most of the glacial features in the district except the ground moraine were developed during deglaciation and can be assigned to one of three groups, (1) ice contact features produced from stagnant ice, (2) features produced by the erosive action of glacial meltwater, and (3) features produced by deposition of materials from glacial meltwaters but not built in contact with the ice. The ice contact features account for the greater part of the landscape. They are the kettle holes and till knobs, till crevasse fillings, kames, eskers, and all features of hummocky dead-ice moraine. Erosional features produced by glacial meltwaters are stream-trenches and spillways. Features produced by deposition of materials of ice meltwaters not in contact with the ice include outwash deposits of sand, sand and gravel, and gravel; some of these are of large enough area to be called outwash plains.

Deglaciation of adjacent districts has been interpreted as taking place by large-scale stagnation of the ice (Gravenor and Ellwood, 1957; Gravenor and Bayrock, 1956; Bayrock, 1957); a similar approach to deglaciation is taken in the Galahad-Hardisty district. First, the glacier downwasted, became immobile, and meltwaters produced on the

surface of the ice gathered into large rivers which cut not only through the ice but also incised deeply into bedrock, producing stream-trenches. Some of the stream-trench ice banks collapsed during this process forcing the waters to seek new channels. In this manner, it is believed, the stream-trenches acquired the anastomosing or interconnected pattern. After most of the ice had wasted away the remainder warmed up through climatic change and became mobile. The warm ice spread out as a viscous fluid conforming to topography, and in this manner the stream-trenches were partly covered with till.

During the final stages of deglaciation of the area meltwater from the warm ice deposited the sand and gravel outwash plains over till east of the Battle River and around the Battle River. Crevasse fillings and kames of the district are also believed to have formed at this late stage of ice wasting.

The Battle River valley of the area is a part of the Gwynne spillway which drained Lake Edmonton and probably was active for some time after the disappearance of the ice from the Galahad-Hardisty district.

Recent Modifications

In many instances Recent drainage systems have been established in glacial meltwater channels--stream-trenches and spillway valleys.

Post-glacial erosion and deposition is very limited in the district. Aeolian modification has resulted in the production of U-shaped dunes on sandy materials. The sand was not carried far beyond the source area. Mass wasting is limited to steep slopes and generally is quite localized. Badlands exist on a limited scale in Tp. 42, R. 11. A thin veneer of colluvium covers most of the steep slopes but does not modify or obscure the topography. Bottomland deposits are not of sufficient depth to modify markedly drainage or topography. All in all, it can be said that the surface of the district has been modified very little since glaciation.

REFERENCES CITED

Bayrock, L. A. (1955): Glacial geology of an area in east-central Alberta; Res. Coun. Alberta Prelim. Rept. 55-2, 46 pages.

_____ (1957): Glacial geology, Alliance-Brownfield district, Alberta; Res. Coun. Alberta Prelim. Rept. 57-2, 56 pages.

Bretz, J. H. (1943): Keewatin end moraines in Alberta, Canada; Bull. Geol. Soc. Am., Vol. 54, p. 31-52.

Broecker, W. S. (1957): Evidence for a major climatic change close to 11,000 years B.P.; Geol. Soc. Am. 1957 Ann. Meeting Program, p. 33-34.

Gravenor, C. P. (1955): The origin and significance of prairie mounds; Am. Jour. Sci., Vol. 253, p. 475-481.

_____ (1956): Glacial geology, Castor district, Alberta; Res. Coun. Alberta Prelim. Rept. 56-2, 23 pages.

Gravenor, C. P. and Bayrock, L. A. (1955a): Glacial geology, Coronation district, Alberta; Res. Coun. Alberta Prelim. Rept. 55-1, 38 pages.

_____ (1955b): Use of indicators in the determination of ice movement directions in Alberta; Bull. Geol. Soc. Am., Vol. 66, p. 1325-1328.

_____ (1956): Stream-trench systems in east central Alberta; Res. Coun. Alberta Prelim. Rept. 56-4, 11 pages.

Gravenor, C. P. and Ellwood, R. B. (1956): A radiocarbon date from Smoky Lake, Alberta; Res. Coun. Alberta Prelim. Rept. 56-3, 17 pages.

_____ (1957): Glacial geology, Sedgewick district, Alberta; Res. Coun. Alberta Prelim. Rept. 57-1, 43 pages.

Lockwood, R. P. and Erdman, O. A. (1951): Stettler oil field, Alberta,

Canada; Bull. Am. Assoc. Petroleum Geol., Vol. 35, p. 865-884.

Rutherford, R. L. (1941): Some aspects of glaciation in central and southwestern Alberta; Trans. Roy. Soc. Can., Vol. 35, Sec. 4, p. 115-124.

Warren, P. S. (1937): The significance of the Viking moraine; Trans. Roy. Can. Inst., Vol. 21, Pt. 2, No. 46, p. 301-305.

_____ (1954): Some glacial features of central Alberta; Trans. Roy. Soc. Can., Vol. 48, Sec. 4, p. 75-86.

Wyatt, F. A., Newton, J. D., Bowser, W. E. and Odynsky, W. (1944): Soil survey of Wainwright and Vermilion sheets; Univ. of Alberta, Coll. of Agr., Bull. 42, 122 pages.

APPENDIX A

GRAVEL DEPOSITS

All gravel deposits located in the area are of glacial origin. Spillway type gravels are reasonably well sorted, large in volume and thickness. Outwash gravels are moderately-well sorted and bouldery; consequently their economic utilization often requires considerable crushing. Kames are of secondary importance because of their heterogeneous character, and large variations in mechanical composition over short distances. Esker deposits of the area are well sorted but of variable composition, ranging from extremely bouldery to sandy.

The reader is advised to use the following descriptions in conjunction with the included map, in order to arrive at areal extent of the deposit in question. All descriptions have been made solely on field observations conducted during the field season of 1956. The primary purpose of the following description is to facilitate development of the known deposits and to promote development of new potentially economical deposits. It would be advisable to conduct an exploration program before venturing into development. If available, additional information regarding any particular deposit of the map area can be obtained on request from the Research Council of Alberta. The following descriptions are limited only to deposits which have or could have economic use or could be regarded as such. Consequently, descriptions of most gravel deposits of no apparent economic use whatsoever have been omitted. The

uninitiated reader is advised to refer back to the report for descriptions of the general characteristics of different types of deposits.

GALAHAD DISTRICT

Location	Extent of Deposit	Description of Deposit
Sec. 26, Tp. 41, R. 13	Very limited, about 7 feet in depth, and 2 acres in area	A very small deposit, of spillway type. Gravel poorly-to moderately-sorted. Very limited economic possibility.
Sec. 25, Tp. 41, R. 13	Very limited, about 5 feet in depth and 3 acres in area	A very small deposit, of spillway type. Gravel poorly-to moderately-sorted. Economic development limited.
Secs. 21 & 28, Tp. 41, R. 14	Limited supply, about 8 acres, and 5 to 8 feet deep	Outwash type, of small extent, very-poorly-to poorly-sorted, contains coal fragments and a large amount of sand. Economic development limited by grade of gravel.
Lsds. 9, 10, 15 & 16, Sec. 4, Tp. 42, R. 11	About 12 acres, 40 feet deep	The gravel is of the outwash type and moderately-sorted. Overburden consists of impure sand 2 to 10 feet thick. Economic development expected but limited by occurrence of groundwater.
Lsds. 13, 14, 15, Sec. 4, Tp. 42, R. 11	About 6 acres, 20 to 30 feet deep	Outwash gravel poorly-to moderately-sorted, containing appreciable amount of sand. Sand overburden from 2 to 10 feet thick. Economic development expected although limited by occurrence of groundwater.
Sec. 10, Tp. 42, R. 12	About 3 acres, 5 feet deep	Very-poorly to poorly-sorted outwash gravel. Overburden

Location	Extent of Deposit	Description of Deposit
		thin. Economic development very limited.
Sec. 15, Tp. 42, R. 12	About 10 acres, 5 to 10 feet in depth	Outwash type of gravel. Degree of sorting variable, better grade expected in the flat portion. Overburden variable and consists of sand. Economic development limited by grade of gravel and overburden.
Sec. 24, Tp. 42, R. 42	About 8 acres, 8 feet deep	Outwash gravel, moderately-sorted. Gravel pit active. Reserves limited.
SE 1/4 Sec. 29, Tp. 42, R. 12	About 3 acres, 5 feet deep	Very-poorly-sorted glacial outwash gravel. Economic development limited by grade of gravel.
Sec. 30, Tp. 42, R. 12	About 5 acres, 5 feet deep	Glacial outwash gravel very-poorly-sorted. Economic development limited.
Sec. 35, Tp. 42, R.12	Limited supply	Poorly-sorted outwash gravel, variable in thickness and composition. Some pockets of well-sorted gravel. Gravel pit in operation.
Sec. 8, Tp. 43, R. 11	About 3 acres, 8 feet deep	Poorly-sorted glacial outwash gravel. Overburden deep in places. Economic development not expected.
Sec. 27, Tp. 43, R. 12	3 acres, 30 feet deep	Kame type of deposit. Gravel moderately-sorted. Sand lenses very common. Gravel pit active. Reserves limited.

Location	Extent of Deposit	Description of Deposit
Sec. 20, Tp. 43, R. 13	5 acres, 7 feet deep	Moderately-sorted outwash gravel. Sand beds and lenses common. Gravel pit partly active. Reserves limited.
Sec. 13, Tp. 43, R. 14	5 acres, 7 feet deep	Moderately-sorted outwash gravel. Sand beds and lenses common. Gravel pits partly active. Reserves limited.
Sec. 16, Tp. 43, R. 14	20 acres, 10 feet deep	Outwash gravel moderately-sorted. Gravel pit active. Supply nearly exhausted.

HARDISTY DISTRICT

Location	Extent of Deposit	Description of Deposit
Secs. 3, 4, 9, 16, 17, Tp. 40, R. 8 Sec. 34, Tp. 41, R. 8	Total area about 1 sq. mile, thickness of deposit variable between 0 and 40 feet	Esker, composed of sand with pockets of well-washed gravel. Development possible but prospecting difficult.
Secs. 8, 17, 19, 20, 29, 30, 31, 32, Tp. 41, R. 9 Secs.5, 6, 7, 17, 18, 19, 20, 29, 30, 31, 32, Tp. 42, R. 9 Secs. 13, 24, Tp. 42, R. 10 Sec. 5, Tp. 43, R.9	About 11 sq. miles, depth from 20 to 40 feet	Outwash composed of sand and gravel. Well-sorted gravel lenses and patches common. Economic possibilities good. Gravel pit in Sec. 30, Tp. 41, R. 9 has extensive reserves.
Secs. 25, 35, 36, Tp. 41, R. 10 Secs. 2, 11, 14, 23, 24, 25, 26, 33, 34, 35, Tp. 42, R. 10	About 6 sq. miles, and from 20 to 40 feet thick.	Outwash composed of sand and gravel. Well-sorted gravel lenses common. Prospecting difficult. Pit active in Sec. 35, Tp. 42, R. 10.
Secs. 3, 4, 5, 6, 7, 8, 9, 10, 16, 17, 18, 19, 20, 21, 28, 29, 30, Tp. 42, R. 8 Secs. 27, 31, 32, 33, 34, Tp. 41, R. 8 Secs. 12, 13, 24, 25, Tp. 42, R. 9	About 8 sq. miles, 20 to 30 feet deep	Outwash sand and gravel, composed of fine-to coarse-grained glacial sand with many gravel lenses. Overburden is aeolian sand, variable from 0 to 20 feet, average 5 feet. Economic development of gravel lenses limited by extremely difficult prospecting condition.
Secs. 19, 20, Tp. 42, R. 8	About 1/4 sq. mile, 50 feet deep	Esker capped with thick deposit of sand and silt. Development not expected because of thick overburden.

Location	Extent of Deposit	Description of Deposit
Sec. 30, Tp. 42, R. 8 Secs. 25, 36, Tp. 42, R. 9	Over 1/2 sq. mile in area, from 50 to 150 feet thick	Esker composed of poorly-sorted bouldery gravel with many large blocks. Small gravel pit located in Sec. 30 not too active. Economic development on a larger scale will require extensive crushing. Pockets of well-sorted gravel are expected to be found.
Secs. 10, 15, Tp. 42, R. 9	About 10 acres in area, 10 to 20 feet deep	Outwash type of gravel, moderately-to well-sorted. Gravel pit active. Reserves almost exhausted.
Sec. 36, Tp. 42, R. 9 Secs. 6, 7, 17, 18, 19, 20, 29, 30, Tp. 43, R. 8 Secs. 1, 12, 13, 24, Tp. 43, R. 9	About 5 sq. miles in area, 20 to 40 feet deep	Outwash type of gravel, poorly-sorted. Extensive sand lenses and beds to be expected. Development expected after considerable prospecting.
Secs. 1, 12, Tp. 42, R. 10	Over 1/2 sq. mile in area, and on the average 30 feet deep	Outwash of sand and gravel. Gravel lenses suitable for development not common. Prospecting not recommended.
Secs. 25, 36, Tp. 42, R. 10 Secs. 6, 7, 8, 17, 18, Tp. 43, R. 9 Sec. 1, Tp. 43, R. 10	About 3 sq. miles in area, about 20 to 40 feet in thickness	Outwash gravel moderately-to well-sorted, well bedded. Sand lenses and beds to be encountered. Overburden up to five feet. Gravel pits present are active and have considerable reserves. More extensive development is expected.
Lsd. 1, Sec. 9, Tp. 43, R. 8	Limited to the kame (hill)	Kame composed predominantly of sand with minor gravel lenses.

Location	Extent of Deposit	Description of Deposit
Lsd. 9, Sec. 9, Tp. 43, R. 8	Limited to the kame (hill)	Kame composed predominantly of sand with minor gravel lenses.
Lsds. 12, 13, Sec. 9, and Lsd. 4, Sec. 16, Tp. 43, R. 8	Limited to the kame	Kame composed predominantly of sand with some minor gravel lenses.
Sec. 15, Tp. 43, R. 8	Limited to the kame	Kame composed predominantly of sand with some minor gravel lenses.
Sec. 19, 20, 30, Tp. 43, R. 9	Over 1/2 sq. mile in area, up to 80 feet in thickness	Esker composed of sand and gravel. Development expected.
Secs. 17, 20, 21, 22, 23, 26, 27, 33, 34, 35, Tp. 43, R. 9	About 2 sq. miles in map area, very variable in depth	Outwash sand and gravel, variable in thickness and composition, poorly- to moderately-sorted. Development on large scale not expected.
Sec. 36, Tp. 43, R. 9	About 1/4 sq. mile in map area, variable in thickness	Outwash sand and gravel poorly-to moderately-sorted. Development on large scale not expected.
Secs. 4, 9, 10, Tp. 43, R. 10	About 1/2 sq. mile in area and about 20 feet deep	Poorly sorted outwash gravel. Development on a large scale not expected.
Sec. 5, Tp. 43, R. 10	About 1/2 sq. mile in area and up to 40 feet deep	Moderately to well-sorted outwash gravel. Gravel pit active. Reserves large.
Sec. 3, Tp. 43, R. 10	About 10 acres, 40 feet deep	Esker composed of coarse sand and gravel. Economic development expected.
Sec. 6, Tp. 43, R. 10	About 10 acres, 10 to 20 feet deep	Kame composed of poorly-sorted sand and gravel.

Location	Extent of Deposit	Description of Deposit
		Gravel pit partly active. Reserves limited by grade of gravel.
Secs. 9, 15, 16, Tp. 43, R. 10	About 1 sq. mile, on the average about 20 to 30 feet deep	Outwash sand and gravel, poorly-sorted. Some small exploitable gravel patches expected to be found. Prospecting very difficult.
Secs. 10, 11, Tp. 43, R. 10	About 20 acres, and up to 40 feet deep	Esker composed of coarse sand and gravel. Some economical gravel lenses to be found.
Secs. 10, 11, 13, 14, 15, Tp. 43, R. 10	About 1 sq. mile in area, and on the average 20 feet deep	Outwash gravel, poorly-sorted. Patches of sorted gravel are expected to be found. Sand overburden variable from 2 to 10 feet.
Sec. 17, Tp. 43, R. 10	About 10 acres in area, variable in thickness	Outwash gravel, poorly-sorted.

APPENDIX B

DRILL HOLES

Drill Hole No.	Location	Depth, feet	Description of Material
1	SW corner, Lsd. 4, Sec. 32, Tp. 43, R. 11	0 - 5	Brown clayey till
		5 - 11	Dark-brown clayey till
		11 - 15	Light-brown stratified silt and clay
		15 - 20	Brown stratified silt and clay
		20	Water table
		20 - 40	Light-brown very fine, well-sorted sand
		40 - 43	Dark-blue clayey till
2	SE corner, Lsd. 1, Sec. 21, Tp. 43, R. 11	0 - 5	Dark-brown clayey till
		5 - 5.5	Light-brown, moderately-sorted coarse glacial sand with pebbles up to 2 inches
		5.5 - 38	Dark-brown clayey till
		38 - 60	Dark-blue-grey clayey till
3	SW corner, Lsd. 12, Sec. 3, Tp. 41, R. 11	0 - 3	Dark-brown clayey till
		3 - 4	Dark-brown sandy till
		4 - 35	Dark-brown clayey till
		35 - 50	Dark-blue-grey clayey till
4	SE corner, Lsd. 1, Sec. 4, Tp. 43, R. 11	0 - 4	Grey-brown clayey till
		4 - 10	Dark-brown clayey till
		10 - 35	Bedrock, brown fine-grained, well-sorted sand
5	Lsd. 13, Sec. 16, Tp. 43, R. 12	0 - 5	Dark-brown clayey till
		5 - 7	Light-brown clayey till
		7 - 19	Dark-brown sandy till
		19 - 22	Banded brown-grey and green clayey till
6	NE corner, Lsd. 16, Sec . 22, Tp. 43, R. 12	0 - 5	Brown stratified silt and clay lacustrine deposit
		5 - 23	Dark-brown clayey till
		23 -25	Banded-brown and grey clayey till
		25 - 60	Dark-blue clayey till

Drill Hole No.	Location	Depth, feet	Description of Material
		32 - 45	Blue, medium-grained, well-sorted sand, bedrock
14	NE corner, Lsd. 16, Sec. 8, Tp. 43, R. 13	0 - 12	Dark-brown clayey till
		12 - 20	Light-brown medium-grained sand, bedrock
15	Lsd. 13, Sec. 27, Tp. 43, R. 13	0 - 6	Brown, clayey glacial sand
		6 - 25	Light-brownmedium-grained glacial sand
		25 - 27	Brown clayey till
		27 - 60	Light-brown to dark-brown medium-grained sand
		60	Water
		60 - 68	Light-grey medium-grained sand
16	Lsd. 16, Sec. 22, Tp. 43, R. 14	0 - 35	Brown clayey till
		35 - 40	Greyish-brown clayey till
		40	Water
		40 - 50	Grey medium-grained sand
17	Lsd. 4, Sec. 3, Tp. 43, R. 14	0 - 22	Brown clayey till
		22	Water
		22 - 25	Brown sandy till
		25 - 40?	Grey clayey till
		40?- 50	Dark-grey bentonite shale, bedrock
18	Lsd. 1, Sec. 32, Tp. 43, R. 12	0 - 2	Brown impure, medium-grained sand (aeolian)
		2 - 5	Brown clayey till
		5 - 7	Brown medium-grained sand
		7 - 9	Brown clayey till
		9 - 55	Brown medium-grained sand
19	Lsd. 16, Sec. 16, Tp. 41, R. 11	0 - 6	Brown clayey till
		6 - 10	Brown medium-grained sand
		10 - 11	Brown, fine-grained clayey sand
		11 - 45	Brown medium-grained sand

Drill Hole No.	Location	Depth, feet	Description of Material
20	Lsd. 1, Sec. 18, Tp. 41, R. 11	0 - 23	Brown clayey till
		23 - 42	Brown, medium-grained sand with Limnaea and pelecypod fragments
21	Lsd. 5, Sec. 7, Tp. 41, R. 11	0 - 5	Brown, impure, medium-grained sand
		5 - 7	Brown clayey till
		7 - 80	Brown medium-grained sand
22	Lsd. 4, Sec. 6, Tp. 42, R. 11	0 - 17	Brown clayey till
		17	Water
		17 - 20	Brown clayey till
		20 - 60	Dark-grey clayey till
23	Lsd. 4, Sec. 6, Tp. 42, R. 12	0 - 30	Brown clayey till
		30 - 50	Grey clayey till
		50	Water
		50 - 65	Grey clayey till

RESEARCH COUNCIL OF ALBERTA

LEGEND

QUATERNARY

RECENT

12 — Alluvial fan: sand, silt and clay

11 — Aeolian: sand and silt (5 feet or more in thickness) overlying outwash sand

PLEISTOCENE

GLACIO-LACUSTRINE

10 — Clay, silt and sand

GLACIO-FLUVIAL

9 — Outwash: gravel

8 — Outwash: sand

7 — Outwash: sand and gravel (2 to 5 feet in thickness) overlying till

6 — Outwash: sand and gravel (2 to 5 feet in thickness) overlying bedrock

5 — Kame: sand, gravel and silt inclusions of till

GLACIAL

4 — Crevasse-filling: mainly till with local pockets of sand and gravel

3 — Ground moraine: till (2 to 5 feet in thickness) overlying bedrock

2 — Ground moraine: till - unsorted clay, silt, sand and boulders, some lenses of sand gravel

CENOZOIC

MESOZOIC

CRETACEOUS

UPPER CRETACEOUS

1 — Edmonton and Bearpaw formations

Stream-trench and spillway

Gravel pit ..... G.P.

Geological boundary

Geology by L.A. Bayrock

Main highway 13

Local road, well travelled

Local road, not well travelled

Railway

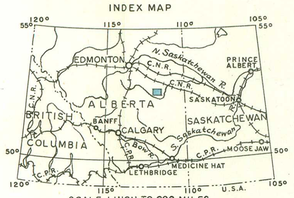
Oil pipe line

Township boundary

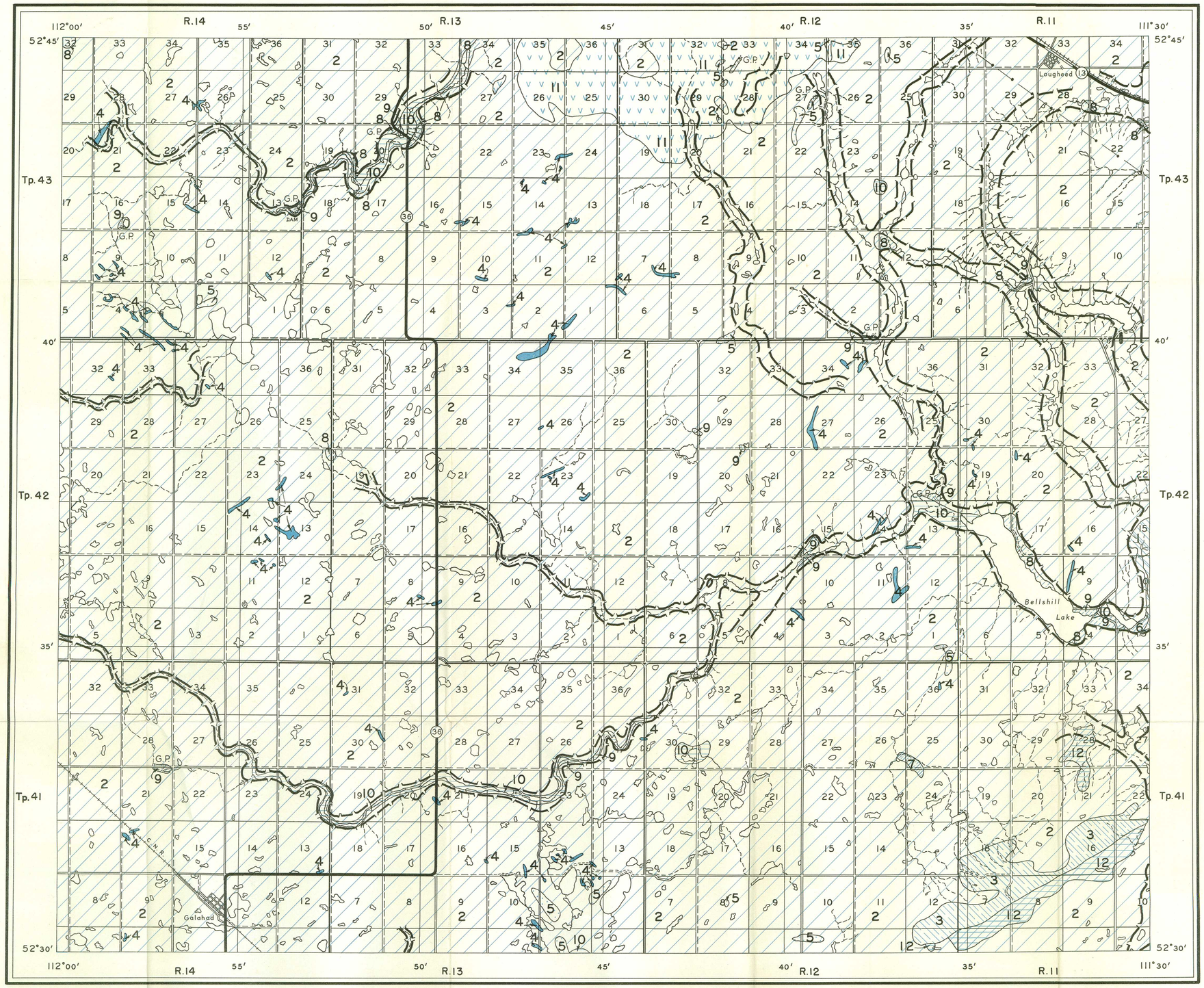
Section line

Cartography taken from Department of Lands and Forests, Alberta, Aerial Survey Sheet No. 73 B/12, 1952

INDEX MAP



SCALE 1 INCH TO 200 MILES



Map to be used in conjunction with Preliminary Report No. 57-3

Published in 1957

PRELIMINARY MAP 57-3 A

GLACIAL GEOLOGY

GALAHAD DISTRICT, ALBERTA

WEST OF FOURTH MERIDIAN

Scale: One Inch to One Mile = 1/63,360

1 3/4 1/2 1/4 0 1 2 3 MILES

RESEARCH COUNCIL OF ALBERTA

LEGEND

QUATERNARY

RECENT

- 21 — Alluvium and colluvium: sand, silt and clay (2 to 5 feet in thickness) overlying bedrock
- 20 — Slump and landslide: mixture of glacial and bedrock materials
- 19 — Colluvium: sand, silt and clay
- 18 — Bottomland and alluvial deposits: sand, silt and clay
- 17 — Aeolian: sand and silt (5 feet or more in thickness) overlying outwash sand
- 16 — Aeolian: sand and silt (2 to 5 feet in thickness) overlying till
- 15 — Aeolian: sand and silt (2 to 5 feet in thickness) overlying undifferentiated outwash of sand and gravel
- 14 — Aeolian: sand and silt (2 to 5 feet in thickness) overlying glacio-lacustrine deposits

PLEISTOCENE

GLACIO-LACUSTRINE

- 13 — Clay, silt and sand

GLACIO-FLUVIAL

- 12 — Outwash: gravel
- 11 — Outwash: sand
- 10 — Outwash: sand and gravel
- 9 — Outwash: sand and gravel (2 to 5 feet in thickness) overlying bedrock
- 8 — Spillway: mainly sand
- 7 — Esker: sand, gravel and silt
- 6 — Kame: sand, gravel and silt; inclusions of till

GLACIAL

- 5 — Dead-ice moraine: mainly till
- 4 — Kame moraine: mainly sand and till
- 3 — Ground moraine: till (2 to 5 feet in thickness) overlying bedrock
- 2 — Ground moraine: till - unsorted clay, silt, sand and boulders, some lenses of sand and gravel

CENOZOIC

MESOZOIC

CRETACEOUS

UPPER CRETACEOUS

- 1 — Bearpaw and Belly River formations

Stream - trench and spillway

Gravel pit G.P.

Geological boundary (defined)

Geological boundary (undefined)

Geology by L. A. Bayrock

Main highway (13)

Local road, well travelled

Local road, not well travelled

Railway

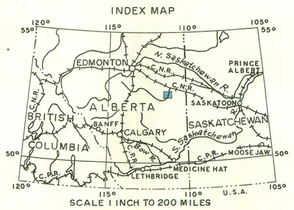
Oil pipe line

Township boundary

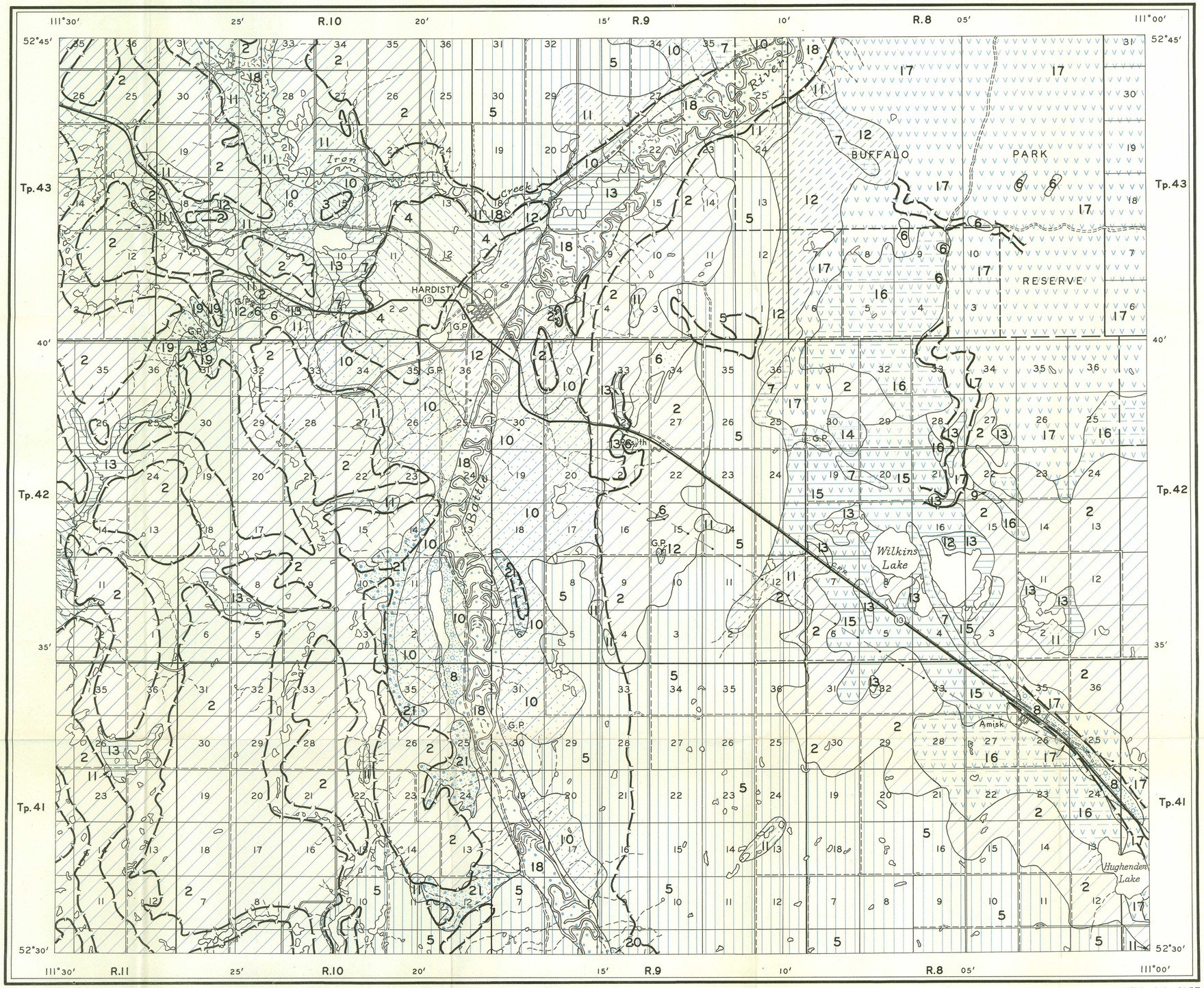
Section line

Cartography taken from Department of Lands and Forests, Alberta, Aerial Survey Sheet No. 73 O/11

INDEX MAP



SCALE 1 INCH TO 200 MILES



Map to be used in conjunction with Preliminary Report No. 57-3

Published in 1957

PRELIMINARY MAP 57-3B

GLACIAL GEOLOGY

HARDISTY DISTRICT, ALBERTA

WEST OF FOURTH MERIDIAN

Scale: One Inch to One Mile = 1/63,360

1 3/4 1/2 1/4 0 1 2 3 MILES