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DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 213

SEQUENCE OF GLACIAL LAKES IN NORTH-CENTRAL ALBERTA

D. A. St-Onge

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PREFACE

As part of its contribution to the Earth Survey Program of the Department of Energy, Mines and Resources, the Geological Survey carries out studies designed to assist in effective use and conservation of resources and in the management and preservation of man's environment throughout Canada.

This brief report provides a description of the postglacial history of a large part of central Alberta including the sequence of glacial lakes that were an important part of that history.

Y. O. Fortier,
Director,
Geological Survey of Canada

Ottawa, January 21, 1971

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Illustrations

ABSTRACT

Information on the glacial history of north-central Alberta has been accumulating since the end of the last century and it is now possible to indicate a series of phases representing the ice frontal positions and the sequence of glacial lakes.

The levels of glacial lakes are determined by the elevation of deltas and outlets. What was formerly known as Glacial Lake Edmonton is demonstrated to be a series of overlapping lakes controlled by outlets ranging in elevation from 3,200 to about 2,000 feet.

C^{14} dates suggest that ice retreat was relatively rapid and that periglacial conditions do not play an important role in shaping the present relief of north-central Alberta.

RÉSUMÉ

La masse d'informations sur l'évolution glaciaire dans le centre-nord de l'Alberta augmente graduellement depuis la fin du siècle dernier et il est actuellement possible d'isoler une série de phases représentant les positions du front glaciaire et la succession des lacs glaciaires.

Les niveaux des lacs glaciaires sont déterminés d'après l'élévation des deltas et émissaires. On constate que l'ancien lac glaciaire Edmonton correspond à une série de lacs se chevauchants, dont le niveau était commandé par des émissaires étagés entre 3,200 et environ 2,000 pieds.

Les résultats de la datation au carbone 14 indiquent que le retrait des glaces se fit relativement rapidement et que les conditions périglaciaires ont peu influé le relief actuel de la région.

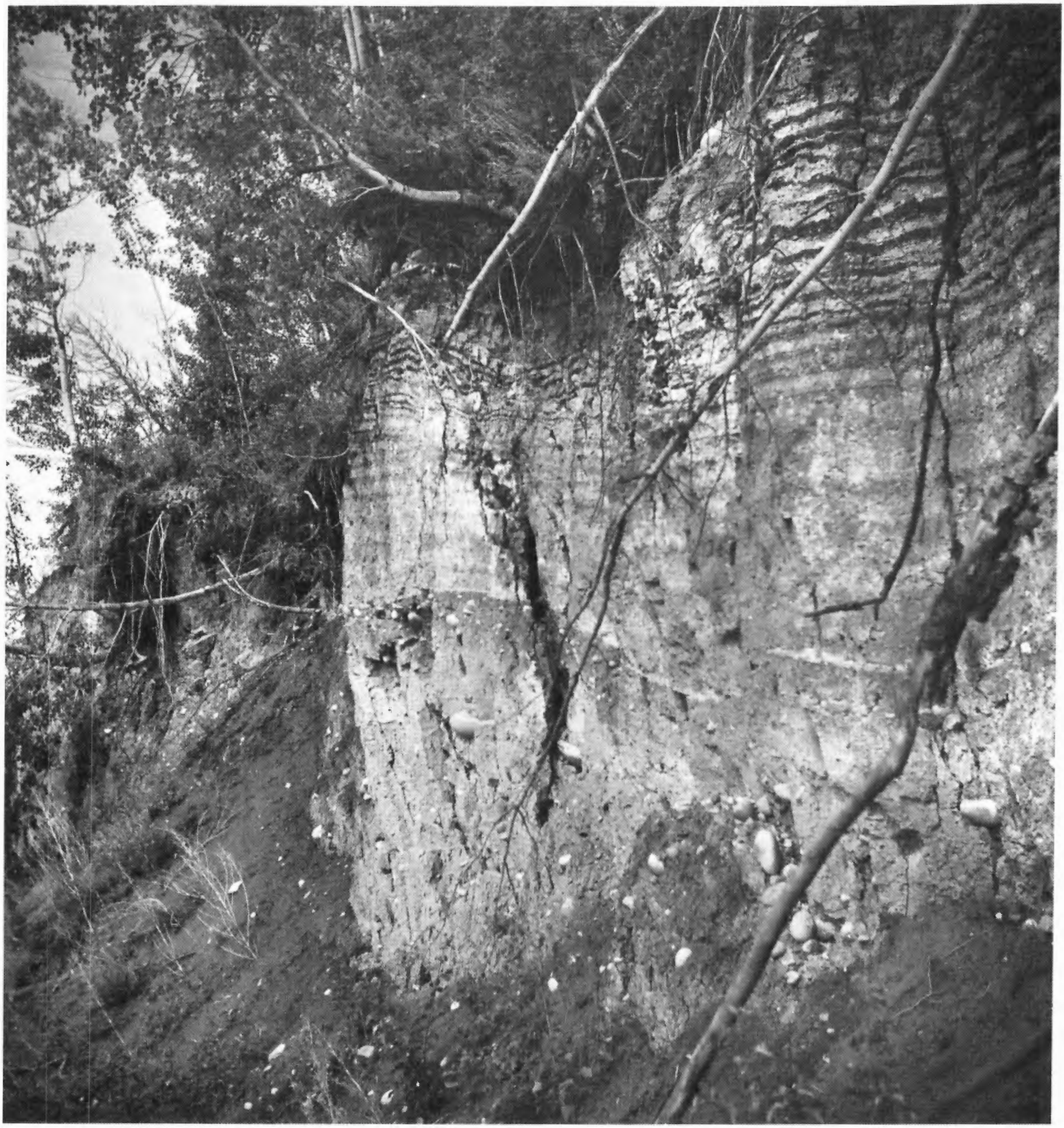

Figure 1. Section along the north side of Athabasca River valley, 5 miles downstream from Blue Ridge. Resting on a stony till unit is 6 feet of varved sediments deposited in the upper reaches of Glacial Lake Leduc (Phase 4). G.S.C. 124213

SEQUENCE OF GLACIAL LAKES IN NORTH-CENTRAL ALBERTA

INTRODUCTION

This paper brings the works of several authors together to form a composite, coherent picture of the history of deglaciation of north-central Alberta, from Red Deer northwest to Watino and east to Lac la Biche (Fig. 2). The sequence of events depicted cannot in any way be considered definitive, but by presenting a broad regional picture, it is hoped that future field work can be more precisely oriented.

Although geological investigations of this area date back to the end of the last century (McConnell, 1893), the systematic mapping of Quaternary deposits is relatively recent. The information available is varied in origin (Fig. 3A) and unequal in quality, and often the author had to rely solely on airphoto mosaics or topographic maps at scales of 1:50,000 and 1:250,000. Boundaries of glacial lakes between Edmonton and Edson have been largely delineated by the altitude of their outlets rather than by the precise mapping of deposits. Thus, the areas shown as glacial lakes correspond approximately to lake basins but not necessarily to areas mantled by glacial lake sediments.

SEQUENCE OF GLACIAL LAKES

Since the land generally slopes down from the Rocky Mountains toward Hudson Bay, it has long been known that large proglacial lakes formed in front of the northeasterly retreating ice front. As many of these lakes would overlap, leaving a more or less continuous cover of lacustrine deposits over large areas, a continuous silt-clay sheet can cover areas of several hundred feet of local relief. In such places, however, the lacustrine deposits of the higher areas are older than those at lower altitudes and belong to an earlier lake phase.

In 1960 Taylor published an article outlining some glacial lakes of northern Alberta and much of this paper is concerned with what he called Glacial Lake Edmonton (map p. 169). Although he indicated the main outlets, he did not attempt to distinguish the various phases which the numerous outlets must represent. The name Edmonton is retained here for the glaciolacustrine deposits extending from Bickerdike to Redwater and from Whitecourt to Leduc. New names are suggested for each phase of this complex sequence, however (Table I).

PROGLACIAL DRAINAGE IN NORTH-CENTRAL ALBERTA

Phase 1. Glacial Lakes Miette and Edson (Fig. 3B)

"McEvoy (1901, p. 25-42) reported silt terraces on the valley walls along parts of upper Athabasca, Miette, and Fraser valleys from 22 miles below Brulé Lake westward nearly to Moose Lake, in the Fraser River headwaters" (Taylor, 1960, p. 168). Kindle (1929, p. 32) subsequently named the lake Miette and traced its limits. It is noteworthy that Roed (1970) does not indicate lacustrine deposits along the Athabasca valley, which Glacial Lake Miette is said to have occupied.

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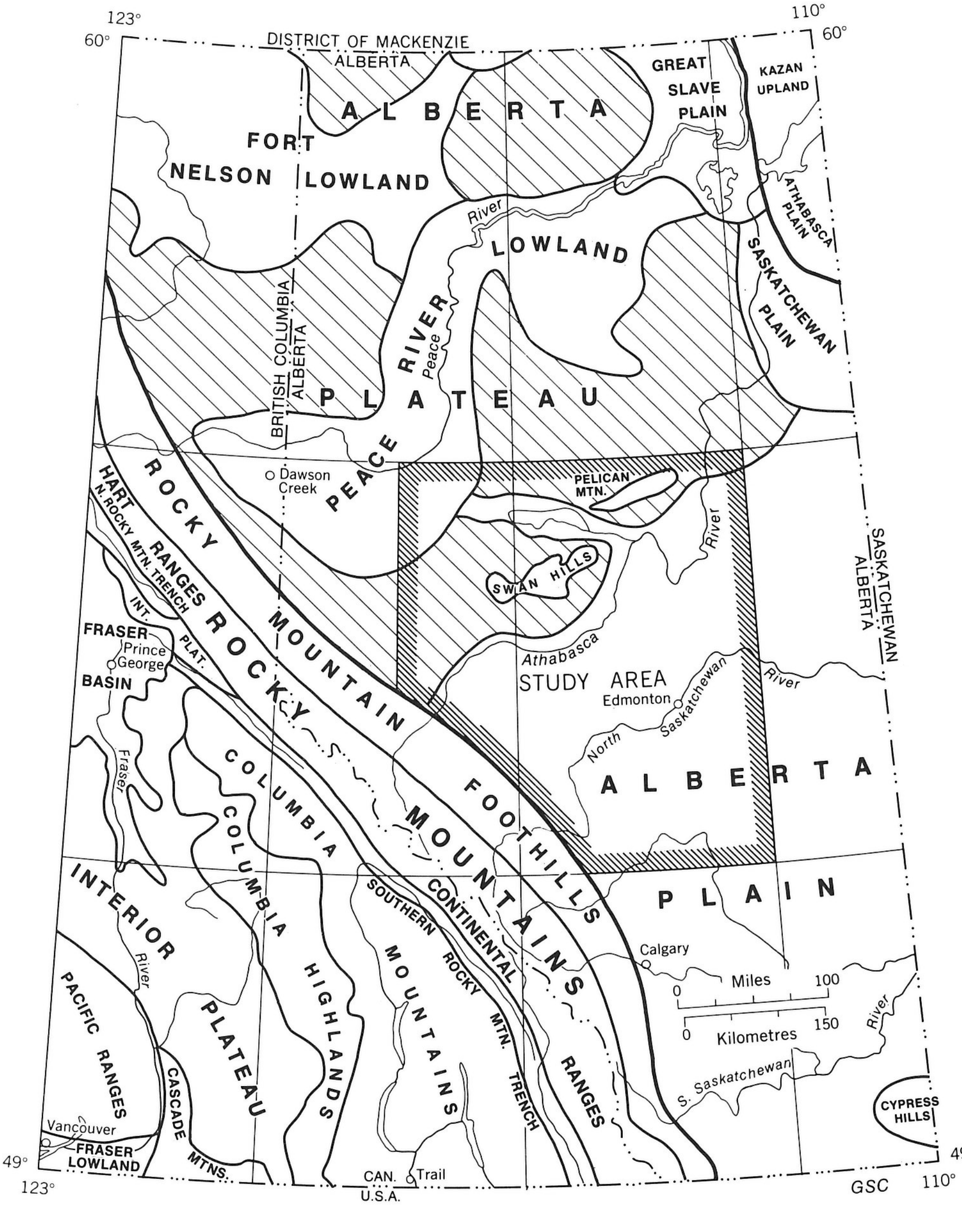

Figure 2. Relationship of study area to physiographic divisions of Alberta and southeastern British Columbia.

The well-defined outlet of Glacial Lake Miette, now occupied by Sundance Creek, had a sill elevation of 3, 450 feet. The location of this major outlet makes it necessary to modify the ice margin shown by Prest (1969) between Hinton and Windfall, as its position would not permit the existence of a glacial lake or of a meltwater channel as shown in Figure 3B, (in pocket). By shifting the ice margin of the Cordilleran glaciation of 10, 300 years ago at least 30 miles to the southwest, this problem could be overcome.

The Sundance outlet and the meltwater channel carved in the gravel-covered upland south of Windfall flowed into a glacial lake in the McLeod valley near Edson. This lake, called Glacial Lake Edson by Roed (Williams and Bayrock, 1966, p. 110), was the first important phase in the sequence of lakes that have been called Glacial Lake Edmonton. The lake had an elevation of about 3, 200 feet, as indicated by the delta south of Bickerdike and by its outlet along Rat Creek, which has a sill elevation slightly below 3, 200 feet.

The work by Taylor (1960, p. 169), by the Soil Survey of the Research Council of Alberta (Lindsay et al., 1964), and the map by Roed (1970) do not elucidate the history of this lake. Thus, although its existence is well documented by detailed mapping, its history is as yet poorly understood.

Phase 2. Glacial Lakes Sakwatamau, Windfall, Peers, Drayton Valley, and Red Deer (Fig. 3C)

This phase is much better documented than Phase 1 as a result of work by Stalker (1960), Collins and Swan (1955), and St-Onge (1967, 1969). The major changes from the previous phase were the appearance of the Swan Hills above the ice mass and the spreading of stagnant ice over extensive areas in Freeman River basin.

Meltwaters from the ice front lying a few miles south of Fox Creek carved two channels across the bedrock ridge north of Athabasca valley: one, southeast of Fox Creek, is now occupied by Pass Creek; the other, 20 miles west, is a segment of Little Smoky River valley.

Meltwaters ponded on the north side of the then exposed Swan Hills eroded numerous small channels across the plateau summit, clearing the way for water to flow across stagnant ice to Freeman valley. An ice-marginal channel carried the meltwater to Glacial Lake Sakwatamau (St-Onge, in preparation), which in turn overflowed into Glacial Lake Windfall. Both these lakes were dammed by a small ice lobe extending upstream in Athabasca and McLeod valleys.

Athabasca and Little Smoky Rivers constructed a large delta complex at the western end of Glacial Lake Windfall, between 2, 950 and 2, 800 feet above sea level. This lake drained south into Glacial Lake Peers through an outlet 16 miles southwest of Whitecourt, which has a sill elevation of about 2, 800 feet and is now occupied by Goodwin Lake.

The limits of Glacial Lake Peers are, in part, based on the map by, Collins and Swan (1955) and on recent soil maps by Lindsay et al. (1968). During this phase, the ice front was just north of Chip Lake, where Collins and Swan show "beached and washed till," and the hilly upland south of Whitecourt was covered by stagnant ice. A large delta at Peers, constructed by McLeod River at an altitude of about 2, 800 feet, indicates the altitude of the lake.

TABLE I. GLACIAL LAKES IN NORTH-CENTRAL ALBERTA

Phase	Name	Named by	Altitude (feet)	Outlet
1	Miette	Kindle, 1929	3,450 +	Sundance Creek
	Edson	Roed in Williams and Bayrock, 1966	3,200	Rat Creek
2	Sakwatamau	this paper	2,900	Not named
	Windfall	this paper	2,900-2,800	Goodwin Lake
	Peers	this paper	2,800	SE of Wildwood
	Drayton Valley	this paper	2,775	Battle Lake
	Red Deer	Stalker, 1960	2,700	Parlby Creek
3	Iosegun I	this paper	2,775	Pass Creek
	Wildwood	this paper	2,700-2,600	Wizard Lake
	Malmo	Stalker, 1960	2,700-2,600	Bashaw
	Buffalo	Stalker, 1960	2,700-2,600	Tail Creek
	Lowden	Stalker, 1960	2,700-2,600	Hebert Lakes
	Gough	Stalker, 1960	2,700-2,600	Leithead Creek
4	Iosegun II	this paper	2,700	Pass Creek
	Leduc	this paper	2,600-2,400	Gwynne outlet
	New Norway	Stalker, 1960	2,600-2,400	Meeting Creek
	Red Willow	Stalker, 1960	2,400	Slough Creek
5	Iosegun III	this paper	2,600	North of Swan Hills
	Sangudo	this paper	2,300	Near Busby
	St. Albert	this paper	2,300	Gwynne outlet
6	Fahler I	Henderson, 1959	2,250	Lesser Slave Lake
	Fawcett	this paper	2,250-2,100	Redwater
	Bruderheim	this paper	2,150-2,075	Vermilion River
7	Chisholm	this paper	2,100	Near Fawcett
	Jarvie	this paper	2,100	Redwater

A broad passage southeast of Wildwood, resembling a slow-flowing river more than a lake, joined Glacial Lake Peers to Glacial Lake Drayton valley. The current was too swift to allow lacustrine sedimentation but too slow and diffuse to entrench a well defined channel. On Collins and Swan's map this area is also shown as "beached and washed till".

The level of Glacial Lake Drayton valley was controlled by a spillway southeast of Breton, with a sill elevation at about 2,775 feet. As the present land surface drops rapidly to the northeast, this spillway must have originated as an ice-marginal channel. It carried water from lakes to the northwest into Glacial Lake Red Deer (Stalker, 1960, p.81). The latter, in turn, drained southeast from Ponoka (2,675 feet) towards Alix, where the water entered an area of stagnant ice and left no clear indication of its passage.

Phase 3. Glacial Lakes Iosegun I, Wildwood, Malmo, Buffalo, Lowden, and Gough (Fig. 3D)

The dominant features of Phase 3 are a large glacial lake to the northwest and a long, relatively narrow body of water extending southeast from Whitecourt beyond the limits of this study area. Although the former had been named Glacial Lake Rycroft by W.H. Mathews (Henderson, 1959, p. 74), at his suggestion, in this paper it is called Iosegun I (Mathews, 1971, pers. com,).

Glacial Lake Iosegun I occupied the valleys of Goose and Iosegun Rivers, as well as the middle reaches of Little Smoky River. It is an early phase of Glacial Lake Peace (Taylor, 1960, p. 171-173). The writer earlier described the development of this lake as follows: "This vast body of water, which is known as Glacial Lake Rycroft, extended northwestward into Peace River valley. It emptied into the Athabasca valley through the Pass Creek spillway. Continuing rapid sedimentation in the Marsh Head Creek depression, combined with a comparatively low level of Lake Rycroft, now caused the Little Smoky River to change its course. The flow across the ridge south of Smoke Lake was reversed from south to north, and the river flowed into Glacial Lake Rycroft" (St-Onge, 1967). Two small lakes, Glacial Lake Allan (op. cit.) and one in the headwater region of West Prairie River, also drained south into Glacial Lake Iosegun I. At the same time, several smaller glacial lakes occupying deep valleys on the north side of the Swan Hills spilled over into Freeman valley through a complex system of channels (St-Onge, 1969). From Freeman valley, water flowed southwest over stagnant ice.

Glacial Lake Wildwood extended from the large delta of Athabasca River near Windfall southwest to Thorsby. It was retained by ice lying north and east of Lake Wabamun. Deposits put down along this former ice front suffer from a surfeit of names and insufficient careful study. Warren (1937, p. 305), first used "Duffield moraine" and Rutherford (1941, Fig. 1) showed the feature on his map without naming it. In his excellent paper, Bretz (1943, p. 36) defined the problem well when he wrote, "For a width of 8 miles it is composed (at least to the bottom of all cuts) almost wholly of silt, a considerable proportion of which is stratified;" he suggested the name "silt moraine." The problem, therefore, is to explain a hummocky or "morainic" topography composed of silt and fine sand. In a later article, Warren (1954, p. 83) argued that the Duffield moraine was constructed of interglacial sand and silt from an ice lobe from the north. Collins and Swan confused the issue somewhat when they introduced a new name, "The Carvel moraine," and stated (1955, p. 12) "This till is conspicuous because of its light buff colour when dry and its extremely silty texture. At certain localities that have been described as being typical of the deposit, the till was entirely devoid of stones, raising problems as to the origin of this 'moraine'." To add to the confusion, Bayrock and Hughes (1962, p. 13) described the feature as a "pitted delta," a hypothesis which had earlier been considered and discarded by Bretz (1943, p. 46).

Hummocky moraines composed of silt and sand that probably originated as lacustrine and/or fluvial deposits on anchored, stagnant ice are commonly found in Alberta. Subsequent melting created hummocky topography. This hypothesis accounts for the combination of lacustrine or fluvial deposits and morainic topography.

The level of Glacial Lake Wildwood was controlled by a spillway southeast of Thorsby with a sill elevation of 2,600 feet. Through this outlet water flowed southeast into a string of glacial lakes in the Ponoka-Stettler region (Stalker, 1960, p. 84).

Phase 4. Glacial Lakes Iosegun II, Leduc, New Norway, and Red Willow (Fig. 3E)

Down-cutting of Pass Creek Channel lowered the level of Glacial Lake Iosegun I to 2,700 feet or less. Islands that appeared in the lake display wave-cut benches (St-Onge, 1967). The level of the bedrock floor of the channel is not known, but augering indicates that it is now covered by at least 15 feet of colluvium.

Glacial Lake Allan still drained southwest into Glacial Lake Iosegun II. Other lakes north of Swan Hills probably drained eastward, mostly over ice, past the northeast end of the hills, and then southward on or around stagnant ice masses. At the same time, a complex system of channels was being carved between Coutts and Saulteaux Rivers. The location of the ice front at that time is shown by a belt of hummocky moraine in the Goose Lake-Connor Creek region, 12 miles east of Blue Ridge.

The Athabasca and Pass Creek drainage system built a large sand delta in Glacial Lake Leduc near Whitecourt while it stood between 2,500 and 2,400 feet. This lake, at that time at its maximum extent, covered an area in the Edmonton region extending from Stony Plain to Fort Saskatchewan and from Leduc to Morinville. This large lake drained southeast through the Gwynne outlet (Bayrock and Berg, 1966, p. 11) into Glacial Lake Norway (Stalker, 1960, p. 87) to eventually join Battle River south of Alliance.

The Gwynne outlet was deepened from an altitude of 2,500 to 2,300 feet. At the same time, large deltas were constructed by Athabasca River in the Whitecourt area and by North Saskatchewan River in Devon and Stony Plain regions. These were called early North Saskatchewan River deposits by Bayrock and Hughes (1962), and pitted deltaic deposits by Lindsay et al. (1968, p. 20). It would seem that large quantities of deltaic sediments were deposited over stagnant ice which, upon melting, produced the hummocky topography.

Phase 5. Glacial Lakes Iosegun III, Sangudo, and St. Albert (Fig. 3F)

A retreat of the ice front on the northern slope of Swan Hills exposed the lower ground and caused the Pass Creek Channel of Glacial Lake Iosegun II to be abandoned. This phase of Glacial Lake Peace (Taylor, 1960, map p. 171) is called Glacial Lake Iosegun III. Glacial Lake Iosegun III drained north and east around Swan Hills by a system of Channels cut across valley spurs. A number of small lakes in the valleys of Driftpile, Swan, Sawridge and Otauwau Rivers acted as sediment traps. Water from Glacial Lake Iosegun III was thus lowered in a series of steps from 2,600 feet at the mouth of the outlet to 2,450 feet near Saulteaux River area. From there it flowed, mostly over stagnant ice, to Glacial Lake Sangudo where a delta of coarse gravel and sand was built about 4 miles north of Fort Assiniboine.

Glacial Lake Sangudo was dammed by a lobe of ice in Barrhead area. A large hummocky moraine, the "Thunder Lake Moraine," now marks the position of that lobe from Tiger Lily south to Pembina River and then east to Lac la Nonne. The wide, shallow stretch of water east of Busby connecting Glacial Lake Sangudo to Glacial Lake St. Albert, marked the low stage of Glacial Lake Leduc. The floor of the Gwynne outlet had now reached its lowest elevation, approximately 2,300 feet. As no glacial lakes remained in the Red Deer-Stettler region, drainage from the glacial lakes to the north was carried southeasterly along Battle River Channel, the extension of Gwynne outlet (Stalker, 1960, p. 88).

The large delta of North Saskatchewan River that was started in Glacial Lake Leduc continued to grow throughout the St. Albert phase, with the result that a large area between Devon and Stony Plain is mantled by deltaic sediments (Bayrock and Hughes, 1962; Lindsay *et al.*, 1968, p. 20, map 23).

Phase 6. Glacial Lakes Fahler I, Fawcett, and Bruderheim (Fig. 3G)

A further retreat of the ice front of some 10 to 20 miles brought about major changes as it exposed low ground north and east of Swan Hills and uncovered the Lesser Slave Lake-Athabasca valley depression. Drainage through this corridor ended the history of Glacial Lake Iosegun. Its successor was Glacial Lake Fahler I (Henderson, 1959, p. 75) which was coexistent with Glacial Lake Fawcett. Several deltas show that the water level dropped from 2,250 feet to slightly less than 2,150 feet during the life of these lakes.

The delta just east of Fawcett is interpreted here as having been built into Glacial Lake Fawcett by streams draining an extensive area of dead ice that covered Pelican Mountain and the highland west of Athabasca. The very coarse gravel and large boulders on the east side of the Athabasca, upstream from Chisholm, were probably deposited on the east shore of Glacial Lake Fawcett during this stage as well.

Glacial Lake Fawcett drained to the southeast through the Pibroch-Redwater depression into Glacial Lake Bruderheim. A large delta was constructed west of Redwater where water from this channel and meltwater from the ice to the east flowed into Glacial Lake Bruderheim. North Saskatchewan River also constructed a delta directly northeast of Edmonton (Bayrock and Hughes, 1962, map 62-6B). Both these deltas indicate that the elevation of

Glacial Lake Bruderheim, which drained southeast through Vermilion River Channel, varied from 2,150 to 2,075 feet.

Phase 7. Glacial Lakes Chisholm and Jarvie (Fig. 3H)

The next phase depicts the Athabasca Lobe occupying the Tawatinaw lowlands. Glacial Lake Fahler I had now largely drained and, at present, only Lesser Slave Lake, occupying the eastern part of the basin of that former glacial lake, is left of the long series of glacial lakes which had formed northwest of Swan Hills. No attempt is made on Figure 3H to represent the position of the ice front or of glacial lakes northwest of Lesser Slave Lake as too little is known about that area.

Glacial Lake Chisholm extended into the area now occupied by Lesser Slave Lake. It drained southeast through Glacial Lake Jarvie into North Saskatchewan River via Redwater Channel, which was being actively cut. North Saskatchewan River had established its present course and was excavating its modern valley.

The glacier tongue occupying the Tawatinaw lowlands, herein called the Athabasca Lobe, was flanked by meltwater channels; Long Lake to the west and White Earth to the east (Fig. 4). Water flowing in the latter built a delta-fan complex east of Smoky Lake. The hummocky moraine east of the lobe is part of the "Viking Moraine" (Warren, 1937, map p. 301; see also Rutherford,1941, Fig. 1; Bretz, 1943, Pl. 3; Warren, 1954, p. 82).

CHRONOLOGY

The sequence of deglaciation depicted above can be compared to a series of still photographs, taken at more or less regular intervals, in the continuum of deglaciation in central Alberta.

Events, sometimes important, sometimes not, occurred after each phase but are not shown because of insufficient knowledge to make a detailed, coherent sequence possible. For instance, a thin till in the Tawatinaw lowland indicates that the Athabasca Lobe represents a re-advance, possibly as a surge (L.A. Bayrock, pers. comm., 1969) from a position somewhere north of the town of Athabasca. However, since the relation of this event to others in neighbouring areas is not known, it is deemed best not to discuss it in the general sequence.

Since 1965, several C^{14} dates have been obtained from organic samples collected in the Iosegun, Whitecourt, and Tawatinaw map-areas. All these are listed in Table II, even though not all of them are completely relevant to the problem of dating the retreat of the ice sheet from central Alberta. Figure 3I, on the other hand, shows only the oldest postglacial dates obtained between the Little Smoky and Lac la Biche areas, along with two dates obtained from postglacial river terraces (GSC-1195 and GSC-1207).

The dates indicate that ice had disappeared from the area south of Lake Iosegun by at least 13,500 C^{14} years ago (GSC-694), from the Tawatinaw lowlands, 10,700 C^{14} years ago (GSC-1093), and by 11,400 C^{14} years ago from the Lofty Lake region (GSC-1049). In other words, there are approximately 2,000 C^{14} years between phase 2 and phase 7 as described in this paper. This implies that the C^{14} dates are internally coherent, but the

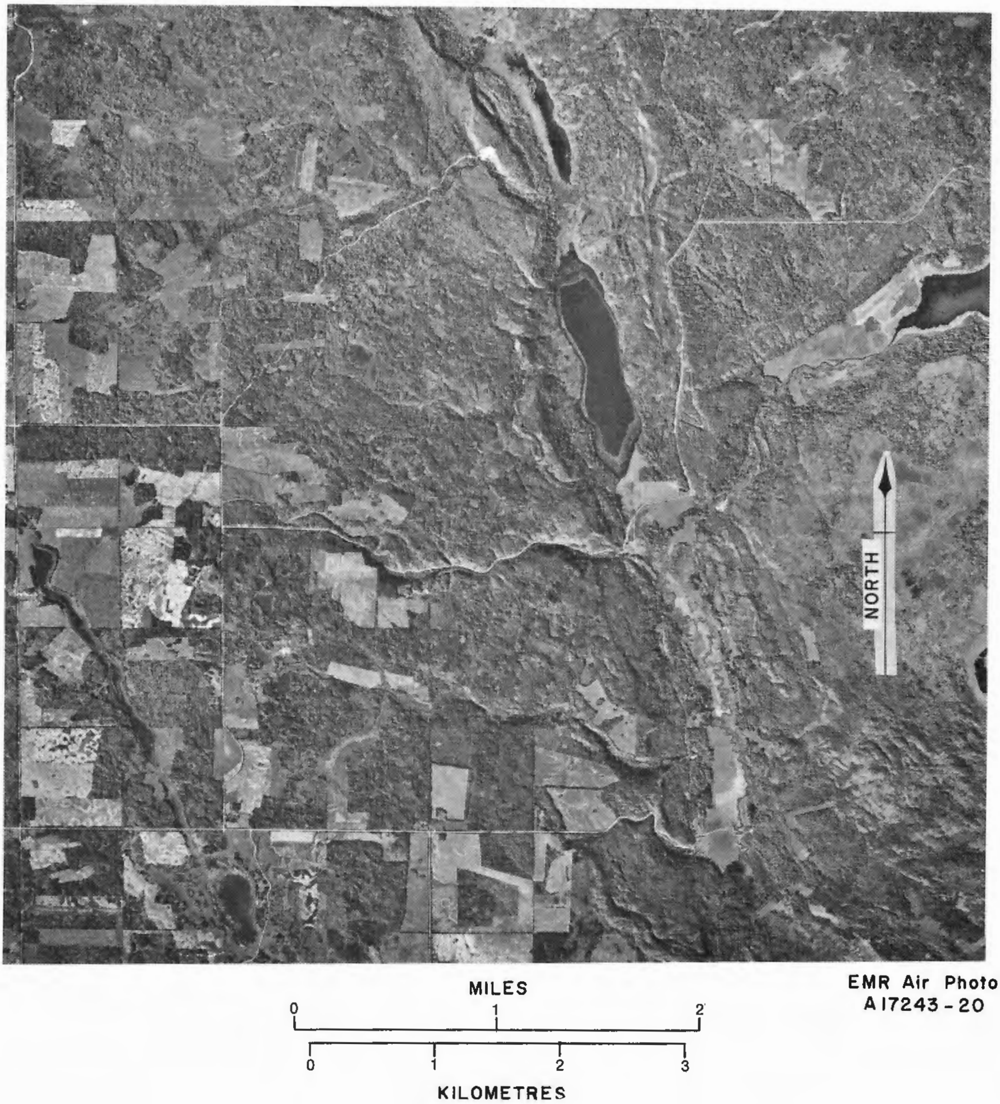

Figure 4. The White Earth meltwater channel 10 miles east of Newbrook. A major element in the landscape, the channel is, in this segment, 125 feet deep and 3/4 mile wide. Notice the profusion of "Prairie mounds" and minor till ridges west of channel; this is typical of the area covered by the Athabasca Lobe (Phase 7).

fact that date GSC-694 is on shells and GSC-1049 on gyttja is a complicating factor. Elsewhere within the study area dates from the same unit obtained from wood (GSC-859) and from shells (GSC-903) have shown a 1,500 C^{14}year discrepancy. Obviously, it would be preferable if all dates were on wood and/or on basal gyttja.

Nevertheless, the dates confirm that deglaciation was, on the whole, a rapid phenomenon: "The time of duration of the Gwynne stage was around

40 years, as evidenced by the number of varves present at a locality from which Lake Edmonton waters were drained only during the final stages of operation of the Gwynne Outlet (L.S.D. 8, Sec. 26, Tp. 51, R.25)" (Bayrock and Hughes, 1962, p. 30).

There is an apparent anomaly between dates GSC-1053, 1093, and 1049 (Fig. 3I). The dates become older from west-southwest to east-northeast, whereas the reverse should be expected. However, GSC-1053 is from Clear Lake, north of Tiger Lily, which is at the contact between a belt of hummocky moraine marking the ice front of phase 5 and patches of hummocky sand and silt. Clear Lake was part of Glacial Lake Sangudo, so that vegetation debris could not accumulate in it until it had become a small, stagnant body. It is also possible that, in its early stages, slumping caused by the melting of stagnant ice blocks buried organic layers. It would be necessary to obtain a sample of basal gyttja from a lake well outside the glacial lake basins to ascertain a reasonable date for the area.

C^{14} dates GSC-1093, approximately 3 miles west of Alpen Siding, and GSC-1049 at Lofty Lake, are easily reconciled in Figure 3H. The Tawatinaw lowlands were occupied by a lobe while the Lofty Lake site was either ice-free or emerging from a dead ice complex.

POSTGLACIAL EVENTS

Formation of Sand Dunes

The lowering and eventual disappearance of the lakes following retreat of the ice exposed large tracts of deltaic sand. Before vegetation could effectively take hold, strong winds had developed large parabolic dunes (Fig. 5). The orientation of the long axis of those dunes is, of course, a reflection of the direction of the winds responsible for their formation. However, as Odynsky states (1958, p. 57-58): "The direction of the effective sand-moving wind is indicated in such dunes rather than the direction of the prevailing wind. The effective wind characteristics depend on the ground conditions (wet or dry) and the velocity of the wind. Powerful winds of short durations [sic] are more effective than gentle winds of long duration."

As can be seen from Figure 3I, wind direction as indicated by dune orientation changes from 110° south of Fox Creek to 157° northeast of Athabasca. Although the average southeasterly direction is in "harmony with the present strong wind directions prevalent in [central] Alberta" (Odynsky, 1958, p. 62), the change from an easterly wind direction in Iosegun-Whitecourt area to a southerly direction in Athabasca area is probably related to a gradual shift in the atmospheric pressure system as a result of the retreating ice front and of the opening of the corridor to the northeast. This influence, however, is difficult to distinguish from that of relief, which certainly affected wind direction in deep valleys such as those east of Whitecourt.

Formation of Major Valleys

The ice front and its belt of ever changing glacial lakes exposed ground at lower and lower elevations as they migrated northeastward. The glacial lakes were local base levels for easterly flowing trunk streams, and therefore stream trenching is a corollary to glacial retreat in central Alberta. Isostatic rebound merely accentuated the process.

Following the disappearance of a lake from an area, major rivers, such as North Saskatchewan and Athabasca, were able to carve their valleys

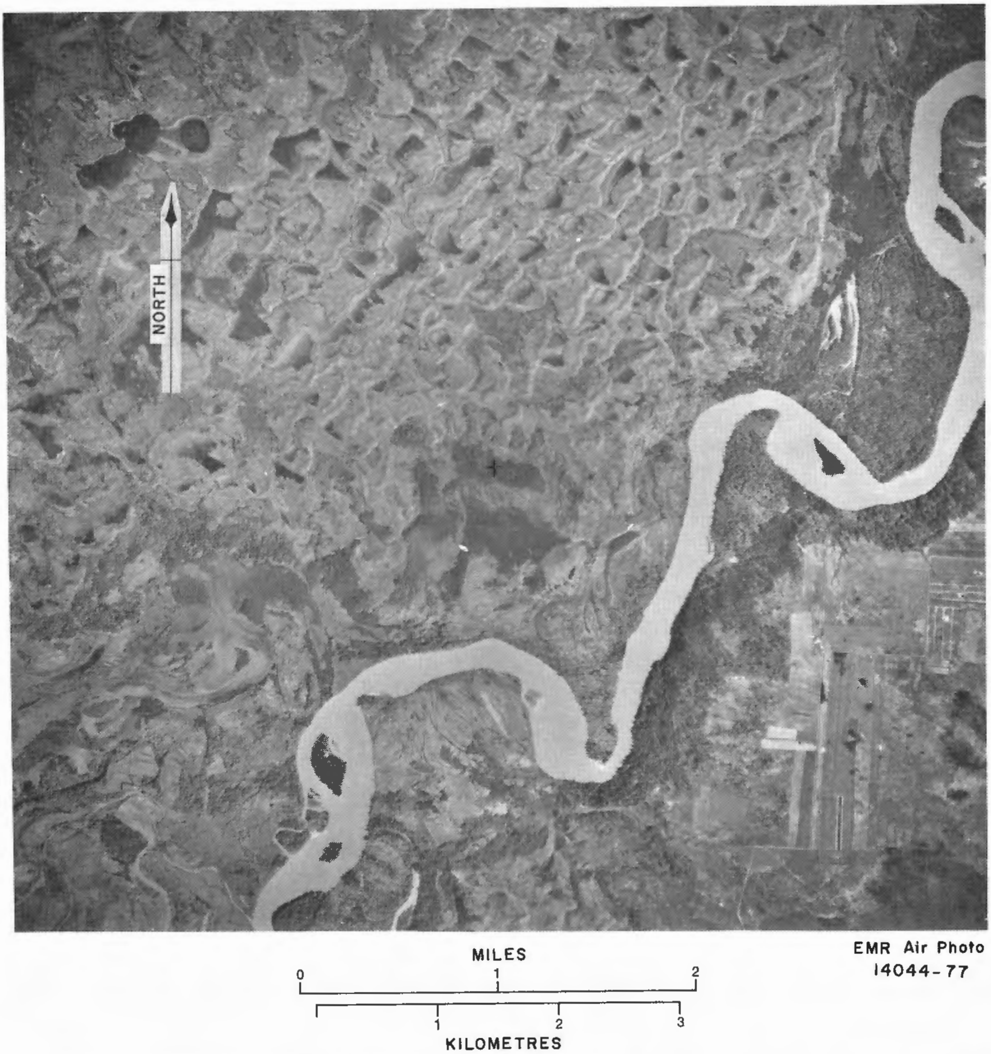

Figure 5. Dunes 6 miles northeast of Fort Assiniboine, Alta. White patches are bogs in blow-out depressions. Inferred wind direction northwest – southeast.

rapidly in the relatively soft sediments. The depths of their valleys were controlled by the levels of the glacial lakes into which the rivers flowed. In turn, the width of the alluvial plain, and hence of the valley, depended on how much downcutting was involved and on the stability of the base level. The relative paucity of high level terraces, excluding deltas, is probably a reflection of the rapidity of glacial retreat and of the short time available for lateral erosion.

One such remnant terrace is on the north side of the valley across the river from the town of Athabasca. Its altitude, as determined from the 1:50,000 topographic map, is between 1,800 and 1,825 feet a.s.l. and it stands 125 to 150 feet above the flood plain. This terrace has been extensively worked for sand and gravel. A gravel pit operator from the Athabasca Landing Co. collected bones that were identified by Dr. C.S. Churcher of the Department of

TABLE II. C^{14} DATES FROM NORTH-CENTRAL ALBERTA

No.	Location	Material	Altitude (feet)	Age (C^{14} years)
GSC-499	6/35/65/18, W5 Pass Creek Spillway	Peat 7 in. below surface	2,700	3,750±150 (1)
GSC-500	14/11/66/14, W5 Southwest end Swan Hills	Peat from bog bottom	3,750	8,320±260 (1)
GSC-501	12/2/67/19, W5 Goose River	Wood in sand below till	2,400	>42,500 (1)
GSC-525	2/34/59/20, W5 Marsh Head Creek	Peat 310 cm below surface	3,350	8,560±170 (1)
GSC-551	11/35/64/19, W5 Atikkamek Creek	Peat 2 m below surface in (?) alluvial clay	2,475	6,590±150 (1)
GSC-673	7/27/60/20, W5 Marsh Head Creek	Peat 270 cm depth	2,940	8,530±170 (2)
GSC-674	5/27/64/19, W5 Iosegun River	Peat 320 cm below surface	2,450	4,150±140 (2)
GSC-508	14/12/62/21, W5 Little Smoky River	Freshwater gastropod shells	2,700	12,190±350 (1)
GSC-694	14/12/62/21, W5 Little Smoky River	Large clean shells	2,700	13,510±230 (2)
GSC-698	14/12/62/21, W5 Little Smoky River	Small shells	2,700	13,580±260 (2)
GSC-752	1/22/62/8, W5 North of Goose Lake	Peat in centre of "Prairie Mound"	2,475	4,850±130 (2)
GSC-859	11/16/63/7, W5 Freeman River	Wood below 15 ft. of "till-like" material	2,450	10,900±160 (4)
GSC-903	11/16/63/7, W5 Freeman River	Freshwater gastropods	2,450	12,400±600 (4)
GSC-861	13/12/58/8, W5 7 miles east of Green Court	Freshwater gastropods in lacustrine silts	2,300	10,200±170 (4)
GSC-1019	1/18/62/6, W5 Freeman River	Wood in outwash below till	2,150	>40,000 (4)

Table II (cont.)

No.	Location	Material	Altitude (feet)	Age (C^{14} years)
GSC-1019-2	Same as 1019 but high pressure counter			>52,200 (4)
*GSC-1049	8/22/66/17, W4 Lofty Lake	Basal gyttja of 554 cm core		11,400±190 (3)
*GSC-1053	2/15/59/6, W5 Clear Lake north of Tiger Lily	Basal gyttja of 476 cm core		10,400±200 (4)
*GSC-1093	13/8/63/20, W4 3 miles west of Alpen Siding	Basal gyttja of 385 cm core		10,700±170 (4)
GSC-1195-2	6/31/58/15, W4 N. Saskatchewan River, terrace, 33' above alluvial plain	Bone-Bison sp. (vertebrae, sacrum ribs)	1,850	2,800±140**(4)
GSC-1205	5/21/66/22, W4 Uppermost terrace; Athabasca R. 125-150' above alluvial plain	Bone-Bison sp. (2 tibias)	1,800	10,200±160**(4)
GSC-1207	1/29/58/16, W4 Middle terrace, North Saskatchewan R. 65' above water level (Aug. 26/68)	Bone-Bison sp. (1 tibia + 1 rib)	1,875	6,040±140**(4)
GSC-1380	8/9/66/22, W4 1.5 miles south-east of Athabasca in Tawatinaw valley	Freshwater gastropods in lacustrine silts	1,825	10,200±280 (4)

All the samples except those marked with an asterisk (*) were collected by the writer. GSC-1049, 1053, and 1093 were collected by J. Terasmae and R. J. Mott.

**Dates corrected for C^{13}/C^{12} ratios.

(1) Reported in: J.A. Lowdon, J.G. Fyles, and W. Blake, Jr., Radiocarbon, v. 9, 1967, p. 170-171.

(2) Reported in: J.A. Lowdon and W. Blake, Jr., Radiocarbon, v. 10, no. 2, 1968, p. 221-222.

(3) Reported in: Lichti-Federovich, 1970.

(4) Not previously reported.

Zoology, University of Toronto, as Bison (Bison) occidentalis (? plains bison). These bones yielded a C^{14} age of 10,200 years (GSC-1205). One can say, therefore, that the Athabasca River has eroded at least 125 feet in the last 10,200 years or an average of, at least, 1.2 feet per century.

Two dates have been obtained from bones in terraces of North Saskatchewan River near Smoky Lake. An upper terrace, 65 feet above the present alluvial plain, is dated at 6,040±140 radiocarbon years (GSC-1207); a lower terrace 33 feet above the alluvial plain is 2,800±140 radiocarbon years (GSC-1195-2). Between these two levels, North Saskatchewan downcut at an average rate of 1 foot per century. A higher average is indicated from 2,800 C^{14} years to the present but the length of time for which the river has been at its present level is not known.

Paleoclimate

A pollen stratigraphy was established by Lichti-Federovich (1970) on a 5.5-m core from the bottom of Lofty Lake, 32 miles east of Athabasca. The base of the core was dated at 11,400±190 C^{14} years (GSC-1049).

The base of the core shows "a unique assemblage ... characterized by the preponderance of poplar pollen (±50%), associated with *Salix* and *Shepherdia canadensis*" (idem p. 941). "The transition in vegetation from the end of L2 to the end of L4 spanning approximately the time interval 9,200 to 3,500 B.P. suggests a trend to increasing warmth and decreased precipitation reaching a maximum development at about 5,500 to 6,000 BP after which there was a gradual deterioration in climate favouring an increase in the boreal elements (spruce, pine and alder, followed by larch and fir) and a decrease in the grassland elements (non-arboreal types). Such an interpretation accords with the widely recognized Hypsithermal ..." (idem p. 944). The L2 and L4 mentioned by Lichti-Federovich are local zonations, L2 being part of the Anathermal and L4 part of the Megathermal of the global zonation.

CONCLUSIONS

This attempt at elucidating the postglacial history of central Alberta provides a framework which allows for a better understanding of the sequence of glacial lakes in this large region. It also indicates the value of airphoto interpretation as an aid in determining the former extent of lake basins from the elevation of deltas and outlets. In heavily forested regions this is the most practical way of distinguishing lake plains from till plains.

Evidence presented in this study suggests that deglaciation was rapid and that vegetation took hold shortly after the retreat of the ice front, and there is even reason to believe that, in some places, vegetation was growing on top of debris-covered ice. The study also implies that periglacial processes were not an important factor in shaping the landscape of this part of western Canada.

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