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DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 69-28

KLUANE LAKE, YUKON TERRITORY, ITS DRAINAGE AND ALLIED PROBLEMS (115 G, and 115 F E)

(Report and 8 figures)

H. S. Bostock

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ABSTRACT

Changes of level of Kluane Lake suggest that the lake has not always drained through the Kluane River as it does today but has, during the Hypsithermal, drained through the Slims River valley into the Kaskawulsh River. This drainage theory was first published by the writer in 1952 and the present paper includes data which has become available since that time. Features of change of level as well as possibilities of drainage reversal are here discussed and it remains the writer's conclusion that the drainage changes suggested in his original paper did indeed occur.

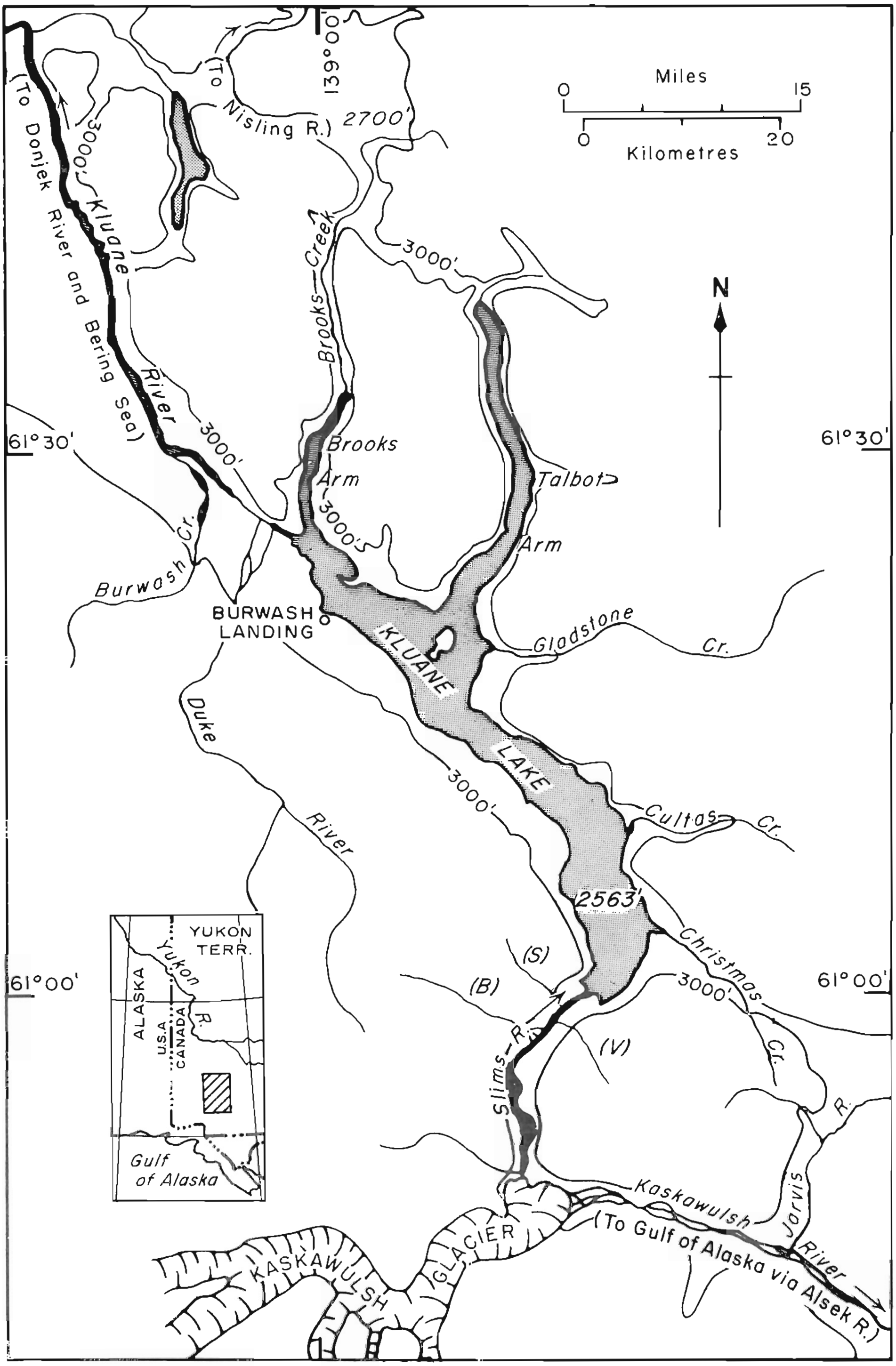


Figure 1. Drainage routes in the area of Kluane Lake, Yukon Territory. (S Sheep Creek, B Bullion Creek, V Vulcan Creek)

KLUANE LAKE, YUKON TERRITORY,

ITS DRAINAGE AND ALLIED PROBLEMS

(115G, and 115F E)

INTRODUCTION

Kluane Lake lies in the Shakwak Trench in southwestern Yukon Territory (Fig. 1) and presents the researcher with a wealth of problems in regard to its origin and history. Slims River, which flows from the western edge of the Kaskawulsh Glacier terminus, is the main source of water. On leaving the lake, water has to travel about 1,400 miles by the Kluane-Yukon river system to the Bering Sea. In contrast, waters from the eastern part of the Kaskawulsh Glacier terminus drain through the Kaskawulsh River to reach the sea in the Gulf of Alaska by way of the Alsek River in about one-tenth of the distance. The main problem discussed in this paper is whether or not Kluane Lake has always drained as it does today or whether, after the last major Pleistocene advance – called by Denton and Stuiver (1966, p. 581) the Kluane Glaciation – it drained to the Gulf of Alaska through the valleys of the Slims, Kaskawulsh and Alsek rivers. Such a course, if formerly open, would have been blocked by the advance of the Kaskawulsh Glacier during the Neoglacial Period, at which time the present drainage via the Kluane River was probably established.

Various features around Kluane Lake suggest that the lake has undergone significant changes in level since the retreat of the Kluane ice and that its outlet by way of the Kluane River is very recent. Some of these features were outlined by the writer in 1952 in a report based on his field work in 1945 (Bostock, 1952, pp. 6 to 8), and the theory that the drainage of the lake has changed from the Kaskawulsh River to the Kluane River was first put forward there.

Since then, new aerial photographs of the area have been produced and new topographic and other mapping has been done. Considerable research in allied scientific disciplines has also been carried out and a number of papers that bear on the problems of the Kluane Lake drainage have been published. In view of the suggestion by Raup (Johnson and Raup, 1964, p. 27) that the history of Kluane Lake, as outlined in the original paper of 1952, should be modified, the writer has considered these sources of new data. Further, he revisited the area in 1966 and, in addition to certain examinations on the ground, made aerial observations of the lake, the glacier terminus and the rivers involved in the drainage pattern. Examination of all these sources tends to support his original theory of the changes in the drainage pattern of Kluane Lake.

ACKNOWLEDGMENTS

In July 1966 the writer visited the Ice Field Ranges Research Project of the Arctic Institute of North America located at the south end of Kluane Lake. Flights were made up Slims River, over the terminus of the

Kaskawulsh Glacier, around Kluane Lake and down the Kluane River to Burwash Creek. For these flights the writer is deeply indebted to Walter A. Wood and the staff of the Research Project. In addition, the writer visited by boat the site at Striation Point where he had originally recognized some raised beaches of Kluane Lake in 1945. He also expresses his gratitude to Dr. J. P. Johnson of the Department of Geography, Carleton University, Ottawa, who accompanied him on this trip and verified the occurrence of these beaches.

OUTLINE OF FIELD OBSERVATIONS

Summary of previously presented data

The following information relevant to the present paper has already been presented in the 1952 report:

- The modern beaches indicate lake level fluctuations of from 10 to 12 feet during recent decades (Bostock, 1952, p. 6).
- Much greater variations are indicated by the raised beaches, creek estuaries - notably those of Gladstone and Christmas creeks - and the presence of stumps of drowned forest in the shallow parts of the lake (Bostock, 1952, pp. 6, 7). All these indicate levels both higher and lower than the present one.
- As the glacier recedes, the steeper gradient of the Kaskawulsh River - as well as the lower level of its head - is resulting in it capturing waters from the Slims River. If this process continues it could result in the complete capture of the Slims River - and possibly Kluane Lake itself - by the Kaskawulsh.

Summary of new, amended and additional data

Lake level

The level of Kluane Lake as measured by the Geodetic Survey of Canada (Canada Dept. of Mines and Technical Surveys, Datum Publication 24-B, 1960) is 2,563 feet asl - 38 feet higher than the level accepted at the time the writer carried out his original field work. This new level was confirmed as being roughly accurate for the summer of 1966 at which time it was measured by the gauge of the Water Resources Branch, Dept. of Energy, Mines and Resources (personal communication M. E. Alford, 1967). It has been accepted as being roughly accurate for the summer of 1945 also.

Raised beaches

The observed locations of raised beaches around the lake are shown on Figure 2. Those originally recognized by the writer in 1945 - two distinct beaches or wave-cut terraces, one three feet above the other - are located on the steep hillside about one-half mile west of Striation Point. The highest one lies 30 feet above the present normal lake level. Aerial reconnaissance in 1966 revealed widely scattered beaches at this same elevation,

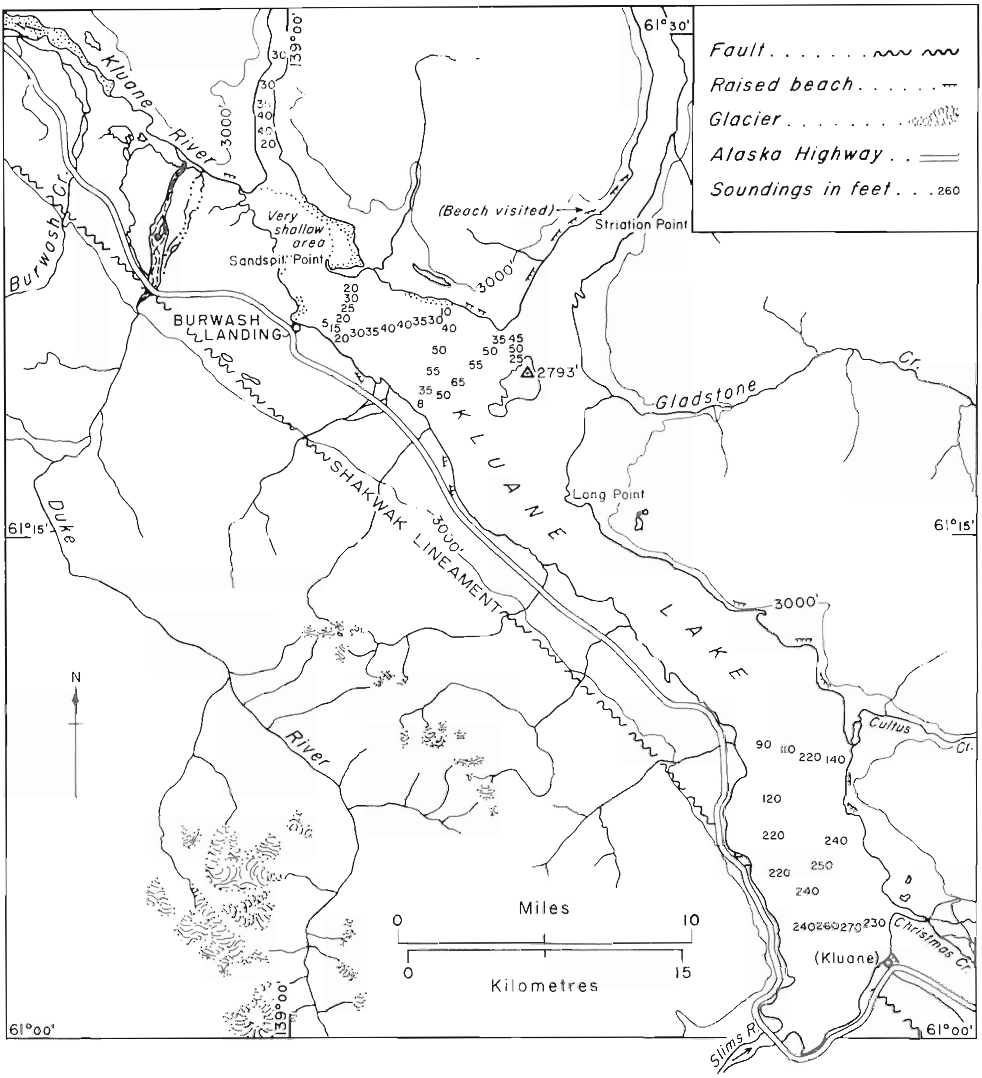


Figure 2. Kluane Lake, Yukon Territory, showing water depths, the locations of raised beaches and of the Shakwak Lineament.

especially on the northeast shores of the lake between Long Point and the abandoned site of the old settlement of Kluane where these raised beaches are particularly well developed.

The beach locality west of Striation Point was the only one closely examined. No excavations were made but there was no indication that volcanic ash, so widespread in this area (see Bostock, 1952, pp. 36 to 38) is associated with these beaches. If this is correct, it would suggest that the ash was removed in the formation of the beaches and that they must, therefore, be younger than 1,425 ± 50 radiocarbon years B. P. – the indicated time of the ash fall (Stuiver, Borns and Denton, 1964, p. 260).

The slope cut above the beaches in their development, is steeper and less clothed with vegetation than the hillsides formed above it since the

Kluane Glaciation. Below them, large spruce trees grow down to the present shoreline. At present, the beaches are protected from wave erosion by their elevation above the lake, but at the time they were formed, the high level of the lake exposed their localities to wave action and, in view of their unconsolidated material, they could have developed quickly.

The existence of these raised beaches has been questioned by Raup (Johnson and Raup, 1964, p. 23) because, along the shores of Kluane Lake where he made his observations, he did not recognize them, and because he believed that the fine textured silts present on much of the low ground on the southwest side of the lake would have been removed in the formation of such beaches and the accompanying flooding. As the writer indicates, the duration of this high water stage was probably very brief.

Creek estuaries

As already stated in the 1952 report, estuaries, or drowned creek valleys occur at several places around the lake and are evidence of earlier, lower water levels. The most prominent estuaries are those of Gladstone and Christmas creeks, the former being the larger (Bostock, 1952, p. 6). Soundings in the inner[1] part of the estuary showed that it was more than 20 feet deep but the gradient of the creek and length of the estuary suggest that its outer end is 40 feet or more deep and that the earlier level of the lake was at least as much as this below the present level. Gladstone Creek has cut a deep broad valley through surficial deposits for some miles above the estuary and material from these deposits must have been built into a large delta beyond the estuary. The same features are common to Christmas Creek, a markedly underfit stream that occupies a major meltwater channel incised to about the 3,050-foot level asl into the divide separating the Jarvis River drainage from that of Kluane Lake. Glacial Lake Kloo (Kindle, 1953, p. 17) may have used this channel as an outlet, a fact which, if correct, would suggest that the estuary of Christmas Creek began to be cut at the end of the Kluane Glaciation, about 12,500 to 9,800 B. P.

Lake depths

Lake soundings taken by the writer's party in 1945 are shown in Figure 2. The few soundings taken in the shallow areas west of Sandspit Point indicate depths of less than 20 feet and are not shown. Most of the bottom in this shallow area at the northwest end of the lake can be seen clearly in the aerial photographs taken in 1950 at 10,300 feet and can still be

1 Due to an unfortunate transposition of phrases, the opposite meaning is conveyed in the 1952 report (p. 7). That sentence should read:

"The inner part of the estuary was observed to be more than 20 feet deep. The creek gradient and length of the estuary suggest that it is 40 feet or more deep in the outer part, and that the former level of the lake was at least that much below the present level."

The underlined words represent the correction of the original statement.

seen vaguely in the 1957 photographs taken at 35,000 feet. Because they give a panoramic view of the whole outlet area the 1957 photographs were selected for Figure 3. Close to the west shore of the lake there is a channel leading into the Kluane River (see Fig. 6) but nothing suggests that this channel is more than 10-15 feet deep. It is certainly not forty feet deep and therefore, could not have served as an outlet during the lowest stage of Kluane Lake. Near the northeast shore is also another channel leading southwest from Brooks Arm and now blocked by Sandspit Point.

Drowned forest

Under suitable light conditions, stumps of a drowned forest are visible beneath the water in places west of Sandspit Point in the shallow areas at depths to at least 10 feet. Soft, stained, porous wood forms the bulk of the driftwood along the northeastern shore. In many places around the shore stumps still project above the water (Fig. 4).

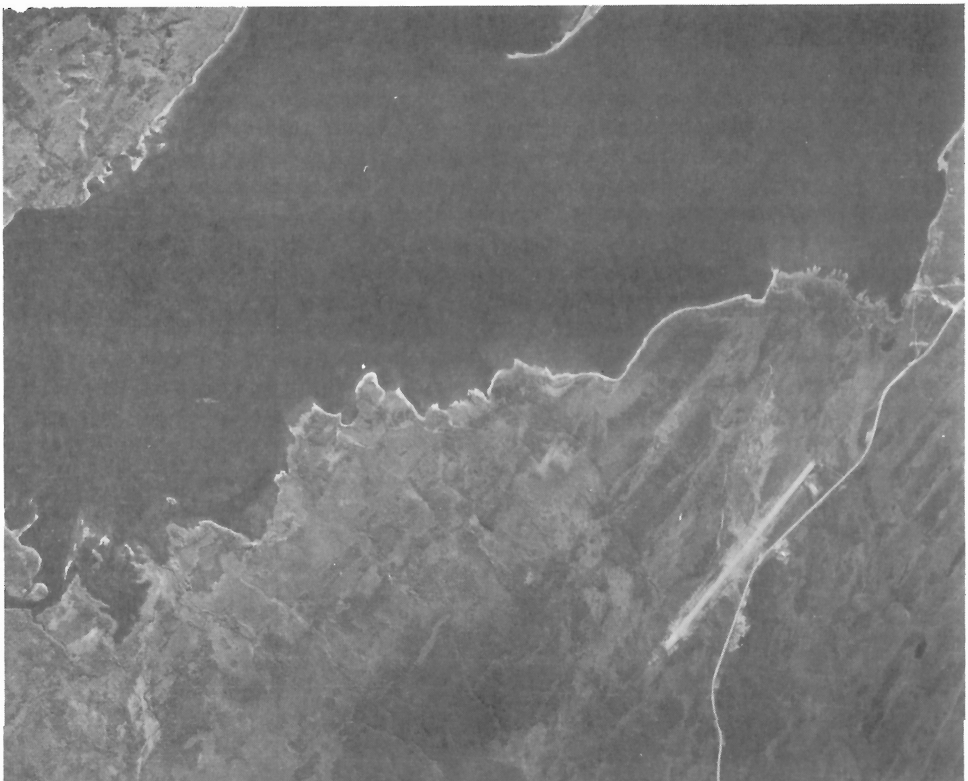
Stumps of the drowned forest are common in Christmas Bay where in 1967, wood from a spruce stump was collected for age determination (GSC-867, collected by J. Look and R. Klaubert for O. L. Hughes). This sample was partly imbedded in beach gravel six feet below the present normal high water level, on the south side of Christmas Bay 36° 03. 5'N; 122° 56'W). The stump was excavated to a depth of 18 inches below the gravel surface and was then sawn off. The depth to the base of the stump below the original surface of the gravel is not known but is probably less than 5 feet. The age of this stump, as determined by radiocarbon dating is 340 ± 130 years B. P. Such features indicate how recent has been the rise of the lake to its present level.

OUTLET POSSIBILITIES

In searching for Kluane Lake outlets other than the Kluane River, there are three possibilities within the range of levels dealt with here, i. e. roughly between 2,500 feet and 2,600 feet elevation:

- the valley system connecting the two northern arms of Kluane Lake to the Nisling and Donjek drainage systems;
- the Slims River-Kaskawulsh River system – discussed in the 1952 report;
- in the northwest, the wide floor of the Shakwak Trench south of the Kluane River.

The first of these may be eliminated as topographic maps show the divides on these valley floors all lie above the 2,700-foot contour.



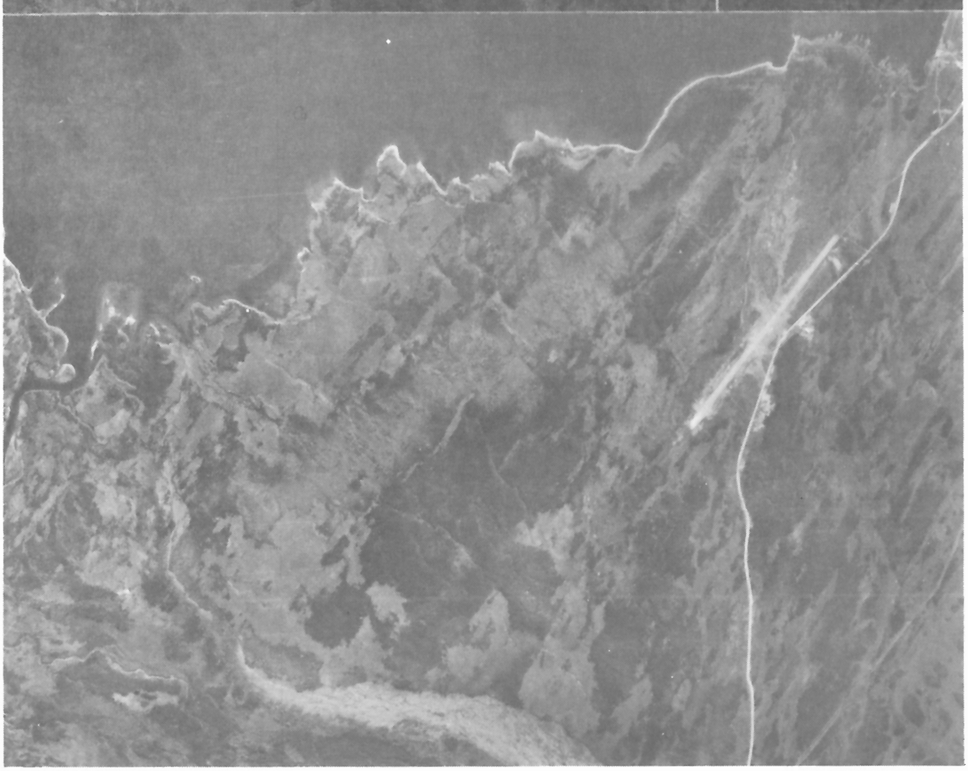


Figure 4. Kluane Lake, looking east to Striation Point. In the foreground, stumps of drowned forest rise above the water.

(opposite page)

Figure 3. The northwest end of Kluane Lake. This stereoscopic pair of vertical photographs shows Kluane River outlet, the coastal channel leading to it, the broad areas of shallow water offshore and, in the right-hand photograph, the tip of Sandspit Point. The Burwash Landing airstrip and the Alaska Highway are seen near the bottom of the photographs. The tip of the Duke Meadows fan appears near the outer edge of the left-hand photograph. Also evident are the northwest-southeast trend characteristic of the surrounding topography and the northeast-trending valleys of the seasonal streams. (Photos: courtesy National Air Photographic Library, Nos. A 15739-53 and 54).

Figure 5. View taken in 1941 looking north from the stagnant terminal ice of the Kaskawulsh Glacier at an elevation of 20,000 feet. Slims River, seen at the left, drains generally northward to Kluane Lake which is faintly visible in the distance. The Kaskawulsh River, lower right, drains east from the eastern tip of the glacier. Between these two rivers lie the debris-filled gap and the forest-covered knoll surrounded by moraines. (Photo: courtesy U.S.A.A.F., negative 41-F-28-R-79 and Geological Survey of Canada, negative 104 188).

Slims-Kaskawulsh outlet

The junction of the Slims and Kaskawulsh valleys, here referred to as the 'valley fork,' lies about 15 miles south of Kluane Lake (Fig. 1) and is dammed by the Kaskawulsh Glacier whose Neoglacial terminal moraines and outwash curve around a drift and bedrock knoll that stands well out in the valley, separated from the mountains to the northeast by an outwash-filled gap about one-third of a mile wide (Fig. 5). This knoll projects about 400 feet above the outwash in the gap whose surface slopes down from the Kaskawulsh lobe of the glacier to Slims River, from 2,682 feet asl. The waters of Slims River issue in several headstreams from the western part of the glacier. The most easterly of these streams pierces the outermost moraine at an elevation 75 feet above the level of Kluane Lake (Fahnestock, R.K., personal communication). In 1966 the writer measured by barometer, the difference in level between the outwash surface adjacent to the head of the ''eastern' branch of the Slims River, about one-quarter of a mile north of the knoll, and the outwash surface on the Kaskawulsh River side close to the knoll, at the northeast front of the ice. The outwash surface of the Slims River, given by Fahnestock as about 2,660 feet (personal communication) was 90 feet higher than the outwash surface of the Kaskawulsh River. Farther out in the Kaskawulsh Valley other headstreams of the river are reported to be more than 100 feet below the Slims River head (Collins, S.G., personal communication). It is mainly the glacier ice that prevents Kaskawulsh River from capturing Slims River. Indeed, in 1967, the Kaskawulsh was reported to be receiving subglacially a good deal of water which in previous years had flowed into the Slims (Hughes, O.L. and Johnson, J.P., personal communication). These elevations show that the head of the Kaskawulsh River is close to the level of Kluane Lake.

Topography suggests that the knoll in the valley fork was formerly part of the mountain slope to the northeast and that some stream or glacial diversion led to the cutting of the gap. This gap has been used and filled with outwash by meltwater flowing into the Slims River from the Kaskawulsh lobe of the glacier during the recent Neoglacial advance (Borns and Goldthwait, 1966, p. 606, Fig. 4; Fahnestock, R.K., personal communication). Though now filled, the gap would be large enough to contain a buried bedrock canyon sufficiently deep to carry water through at the Kluane Lake level. The existence of such a canyon could be proved by seismographic sounding but the author knows of no such soundings at present.

Some seismographic work has been done in the last few summers by Collins, Fahnestock and Goldthwait (personal communication) on the Kaskawulsh Glacier itself and in the Slims Valley up to a mile north of the glacier. This work indicates that the depth to bedrock in the Slims Valley to this point, as well as under the glacier, is well below the level of Kluane Lake and would permit a stream 40 feet or more lower than the present lake to flow around the valley fork into the Kaskawulsh Valley.

Denton and Stuiver (1966, p. 581) have shown that the Kaskawulsh Glacier retreated to at least 13.7 miles above its present terminus during the period following the Kluane Glaciation - starting some time between 12,500 B.P. and 9,780 B.P. and ending about 2,640 B.P. - and was thus well clear of the valley fork and nearly thirty miles from Kluane Lake at this time. Although the Neoglacial advance began about 2,640 B.P., Denton and Stuiver (1966, p. 594) are of the opinion that the glacier probably did not finally block the valley fork until about 420 B.P. to 300 B.P. The valley fork could therefore, have been open to drainage from Kluane Lake from the end of the Kluane Glaciation, through the Hypsithermal interval as defined by Deevey and Flint (1957, p. 182), and until about 400 years ago. This correlates well with the radiocarbon date given above as the age of the drowned stump from Christmas Bay.

While the level of the bedrock in the valley fork is a crucial factor, other phenomena along the Slims Valley should also be considered. The valley is flanked by a number of alluvial fans, notably those of the Vulcan, Bullion and Sheep creeks which lie within the first few miles upstream from

Kluane Lake. These fans have been mapped and described by Borns and Goldthwait (1966, p. 602, Fig. 2) who draw attention to the fact that they nearly or completely coalesced across the valley during the dissipation of the Kluane Glaciation ice from the Kluane Ranges. They consider that the present fans are formed of post-Hypsithermal alluvium but that the 'early fans' were constructed 'during late Kluane time.' They do not say whether or not the 'early fans' could have been built in contact with or over bodies of ice lying in Slims Valley. The existence of a drainage channel 40 feet below Kluane Lake level along the valley when bodies of ice still remained is suggested by the likelihood that Christmas Creek estuary formed part of the spillway for Glacial Lake Kloo when, as Kindle (1953, p. 17) notes, ice was still blocking Jarvis River valley. As the Slims River flows between the present fans without steepening its gradient (Fahnestock, 1966, p. 64), it is possible to envisage a stream from Kluane Lake, at a level 40 feet below the present lake level, flowing southward through the valley with little hindrance from the fans.

It is interesting to speculate what the valley was like before the closing of the valley fork by the Kaskawulsh Glacier, if Kluane Lake never drained along the valley. The valley floor is now covered from side to side by Neoglacial outwash, modern fluvial deposits, and it slopes with Slims River down to Kluane Lake. The levels and the grade in the gap do not suggest that the Kaskawulsh River ever flowed into Kluane Lake, so there must originally have been a divide. This would have led to the impounding of Slims River until its water had eroded the obstruction. With all the studies made during the last few years no sign of a lake from this impounding has been reported, so the divide must have been low and easily eroded. Considering the mass of outwash borne from the glacier by Slims River now (Bostock, 1952, p. 8) the valley must have contained space in the form of lake basins to accommodate this material at or below the level of Kluane Lake.

To the east of Kluane Lake area, Glacial Lake Champagne flooded great stretches of the valleys presently drained by Alsek River during the end of the Kluane Glaciation (Kindle, 1953, pp. 15, 16). This lake left many miles of beaches at elevations between 2,300 and 2,800 feet. Most of the beaches shown on the map accompanying Kindle's report are close to or below the 2,500-foot contour. Of the beaches attributed to Lake Champagne, the nearest one to the valley fork is mentioned by Wheeler (1963, marginal notes) who states "Terraces at an elevation of 2,550 feet about two miles northwest of the mouth of the Jarvis River were probably formed by this lake."[1]

The topographic maps show that if Lake Champagne lay at 2,800 feet, many courses would have been open for its drainage - including one through the Kaskawulsh valley, around the valley fork and through Kluane Lake, provided there was an ice-clear passage. When Lake Champagne dropped to below 2,600 feet it could only drain by Alsek River or a valley to the east. Had there been a channel around the valley fork, Kluane Lake would have drained into Lake Champagne by way of the Kaskawulsh. The relative timing of the dissipation of the ice and the cutting of channels through and around the ice in the various valleys remains unresolved.

[1] In the context of the notes, a mistake makes 'this' read as if another lake were meant, but the statement actually refers to Lake Champagne (Wheeler, J.O., personal communication).

Northwest Outlet area

On leaving Kluane Lake, Kluane River follows a narrow channel close to the northeast side of the Shakwak Trench for 6 miles. The floor of the trench throughout this stretch is about 5 miles wide and, as far west as the mouth of Duke River, slopes generally down to the northeast from the mountains on its southwest side. West of Duke River this slope flattens about a mile from the northeast side. On the southwest side, against the mountains, much of the surface of the trench floor is formed by alluvial fans extending out from gulches. Beyond this, the surface is composed of northwesterly-trending drumlinoid ridges and hollows, more than half of which are eroded or covered by the past and present courses of the larger streams flowing north to Kluane River. Duke River is outstanding among these streams, with Burwash Creek farther west being the next in importance. The surface features of this area are shown on Figure 6. This drawing and the interpretations made on it are based on data extracted from aerial photographs, from information on the 1:50,000 topographic map (Duke River, 115G/6), from reconnaissance field work during 1945, and from one flight over the area in 1966. For a thorough understanding of the area, much ground work and study are still required.

The information available, however, brings out some interesting points. East of the present course of Duke River, the floor of the Shakwak Trench is mantled by wide, braided, former courses of the Duke River. Raup (Johnson and Raup, 1964, p. 28) refers to these courses or channels as outwash fans and says that they are progressively younger from east to west. He further adds: "The earliest one formed what is now nearly all of the shore of Kluane Lake from Burwash Landing to Kluane River. It was just off this shore that Bostock took his 20-foot soundings[1]. Most of the surface of this fan is forested. It also has volcanic ash on it and some Kluane Silt[2] indicating that it was deactivated while the deposition of this silt was going on. Farther west lie the 'Duke Meadows'[3], a natural grassland on an adjacent fan that has neither ash or Kluane Silt showing that it was abandoned at some time within the last 1,600-1,700 years. The present active fan is adjacent to this one, still farther to the west ... It is not impossible that the valley of the Kluane River was considerably deeper when the ice melted out of it than it is now, and that it was gradually filled by these huge gravel fans. Most of this work was done prior to Hypsithermal time. If so, the lake would have started its existence at a relatively low level, as Bostock's evidence indicates that it did. But its history would be one of gradual rise to approximately its present level with no requirement for its drainage through the Slims-Alsek river system. Also, there would be no requirement that it have a level in the recent past, at least for any length of time, that is higher than the present one."

As Figure 6 shows, this over simplifies the picture and fails to recognize the drumlinoid features northwest of Burwash Landing. In view of this, some of the old channels in this area may be bare of Kluane Silt (Loess) and even volcanic ash and so may have not been abandoned by the Duke River before the end of the Hypsithermal interval or even before the ash fell 1,425 ± 50 years B.P.

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1 see Figure 2 of present paper.
2 also called 'Kluane Loess' by Denton and Stuiver (1966, p. 578).
3 see Figure 7 of present paper.

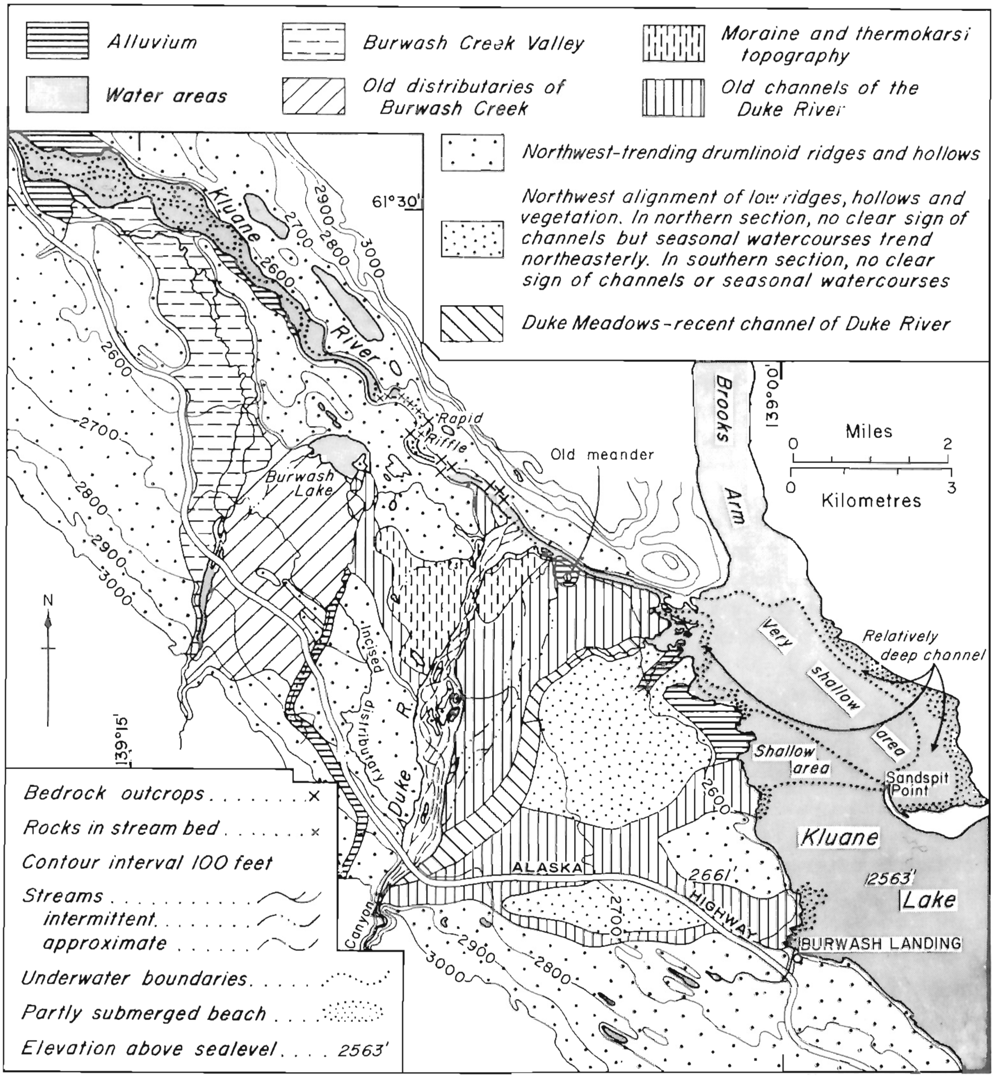


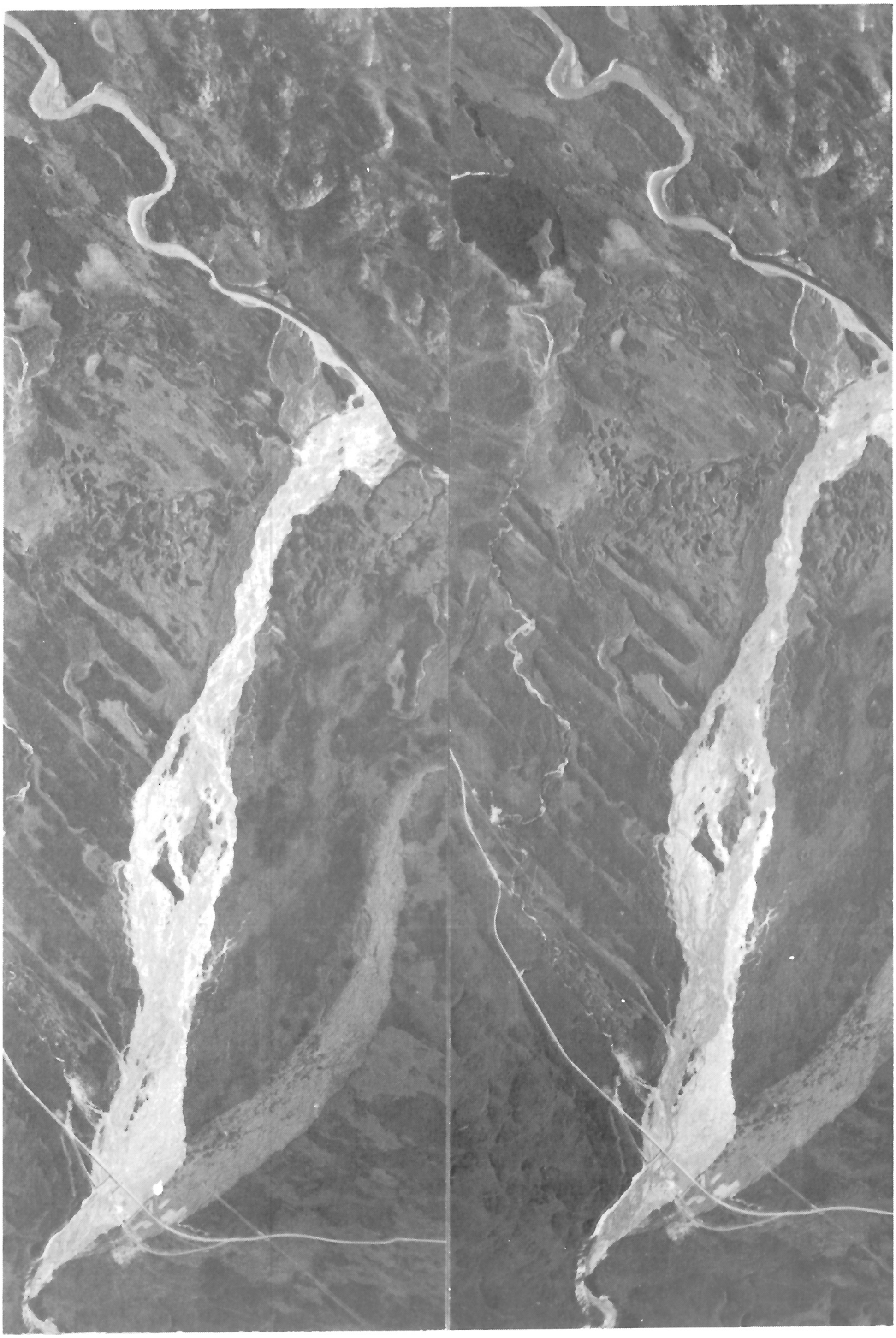
Figure 6. Geomorphic features in the vicinity of the present outlet to Kluane Lake.

As suggested by Raup, the old channels shown on Figure 6 leading eastward from Duke River canyon and reaching the lake shore at points along the coast from Burwash Landing to two and one-half miles to the north, appear to be the first ones used by the river and are certainly the broadest. Their unusual course, turning almost at right angles as they leave the canyon, implies that at the time of their formation the river channel was obstructed by some large feature athwart the natural route straight northward into the Kluane River valley. This feature was probably drift as there are no bedrock outcrops immediately north of the canyon except along the Kluane River. This also attests to the priority of these channels, as the drift would have had to be removed before a northward course could be established. From the existence and location of these channels it may be judged that the river was handicapped in filling or occupying any deep former outlet leading westward from the lake. A number of other old channels have also been occupied at various times by Duke River, including one lying west of its present channel. Some of these channels may have been used by only part of its water or only for a short time. Such appears to have been the case for the Duke Meadows channel and for the old channel which flowed into Burwash Lake but did not fill it. The Duke Meadows channel is comparatively narrow relative to the present Duke River bed (Fig. 7) and leads to a narrow inlet rather than to a delta projecting into the shallows of Kluane Lake. The present channel ends in a 'delta' that holds the Kluane River against the outcrops on its northeast bank. A short stretch of an older channel on the west side of the 'delta' is covered with brush but may have been abandoned quite recently, perhaps twenty years before the aerial photographs were taken. It is uncertain whether Duke River, when it first reached the north side of the Shakwak Trench, turned eastward to Kluane Lake or westward down the present course of Kluane River to Burwash Creek.

For more than six miles below Kluane Lake, Kluane River follows a narrow, relatively fresh channel and the question arises as to whether at an earlier stage it followed another course through this area. Burwash Lake, to judge from its shape on the map, might be part of an abandoned river channel. If so, this channel extended from the Kluane River, somewhere between Kluane Lake and the present mouth of the Duke River, and possibly flowed through the two areas of 'Moraine or thermokarst topography' (Fig. 6) to Burwash Lake and thence down Burwash Creek valley. In support of this theory it is noted that Burwash Creek has a broad valley, about one mile wide, which continues as that of the Kluane River below the confluence of these two streams. However, until it reaches the lower Burwash valley, this course lies above the 2,600-foot contour and the theory assumes improbable and prodigious amounts of deposition by the Duke River and Burwash Creek in a comparatively short period of late post-Kluane Glacial time. It also assumes the damming of the outlet stream to above the 2,600-foot level resulting in its re-routing to the present channel of the Kluane River. From aerial photographs and from the air Burwash Lake could be a kettle hole rather than an oxbow lake (Fig. 8). The peninsula in it has neither the form of a river bar nor a crowfoot of an old channel of Duke River or Burwash Creek. It is probably an original proglacial topographic feature. Furthermore, no sign of such a river course to the east has been detected on the aerial photographs or among the soundings of Kluane Lake (Fig. 2) where it should be deep enough to have permitted the formation of estuaries similar to those at the mouths of Gladstone and Christmas creeks.

Turning again to the Kluane River, its channel is narrow and has few bars or meanders for two miles above and below its junction with the Duke River. Aerial photographs show an old, dry meander (indicated on Fig. 6) on the southwest bank between the outlet of Kluane Lake and Duke River. This meander seems to be at a higher level than the present Kluane River but which way the water flowed it is not apparent from the photographs.

Judging by aerial photographs taken during the summers of 1950 and 1957, Kluane River is not particularly swift immediately below its junction with the Duke, a state that might naturally have been expected if Duke River



were overloading it. Rather, the swift water occurs from one to two and one-half miles below their confluence at a location where bedrock outcrops in its banks, and, apparently, in its bed (personal communication, E. B. Owen, 1962). About four miles downstream from its confluence with the Duke, Kluane River begins to widen its valley floor, cutting back high banks of drift and developing broad gravel bars. By the time it reaches Burwash Creek valley its floor is a mile or more in width and continues so for several miles downstream.

STRUCTURAL MOVEMENT

The Shakwak Lineament, which is assumed to mark a major fault, (Bostock, 1952, pp. 8 and 9; Muller, 1967, pp. 93-96) trends northwest-southeast, extending southeast from near the International Boundary (141st Meridian) to beyond Kluane Lake (Fig. 2). The trace of this fault is depicted on geological maps as a single fault that follows a line of mounds on the southwest side of the Shakwak Trench. These mounds, clearly visible on trimetrogon photographs taken looking along the fault, continue across a variety of topographic features except where streams have cut them away. On the Donjek River, some twenty-four miles northwest of Kluane Lake, they still project as a ridge out onto the floodplain and have not yet been completely eroded away. This suggests that they mark a movement on the fault that took place in recent centuries.

Even if structural faulting were considered as the underlying cause of the changes in lake level inferred from the occurrence of the estuaries, the drowned forest and the raised beaches, the fact still remains that the level of the outlet of Kluane Lake must have changed from 40 feet below to 30 feet above its present level before finally establishing its present elevation. Such changes of lake level are difficult to account for by any simple movement along the fault.

(opposite page)

Figure 7. Stereoscopic pair of vertical photographs showing the junction of the Duke and Kluane rivers. The Duke Meadows fan lies to the east (right) of the present Duke River channel, and an old channel, now covered with vegetation lies to the west (left) of the present junction of the two main rivers. Burwash Lake lies in the upper left corner of the right-hand photograph and, extending south-eastward from it, two areas of moraine and thermokarst topography lie on either side of Duke River. The northwest-southeast trending drumlinoid topography is evident on the left bank of Duke River and traces of old channels may be seen on the right. (Photos: courtesy National Air Photographic Library Nos. A 15739-52 and 53, taken 1957 from 35,000 feet).

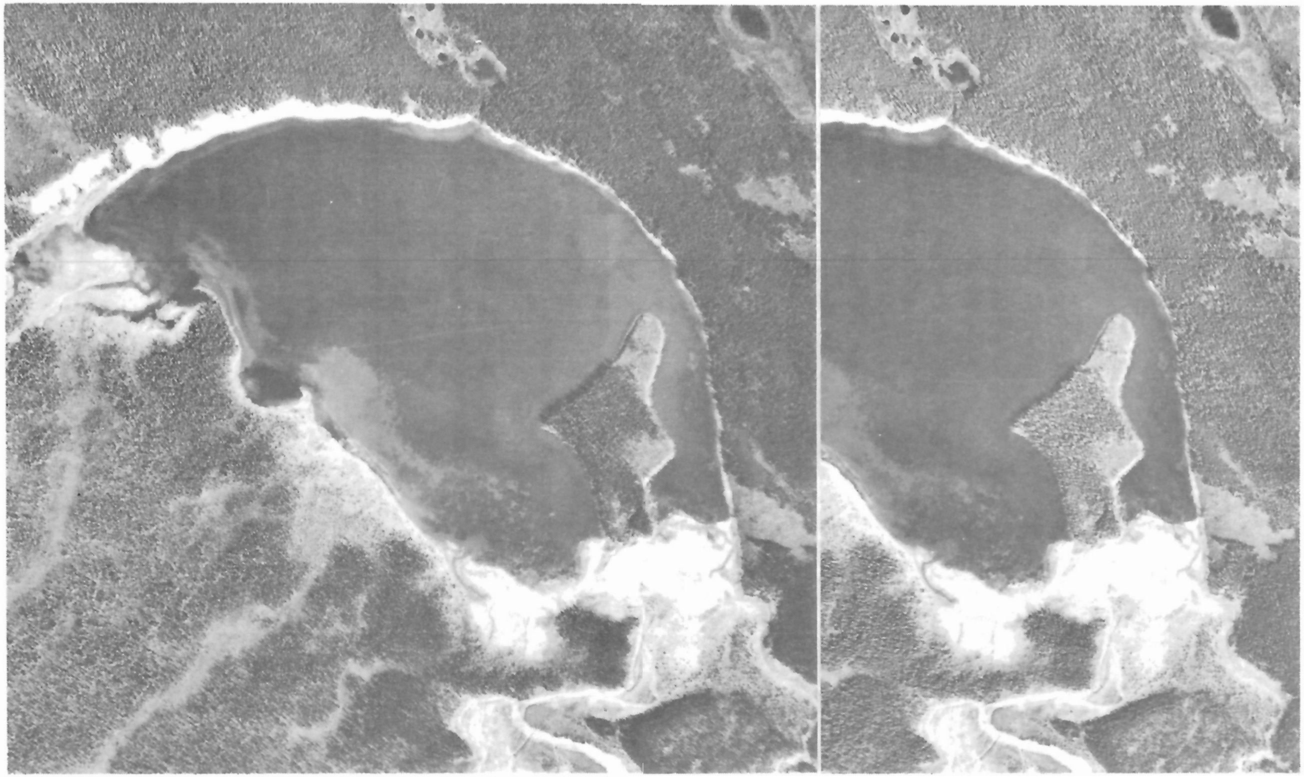


Figure 8. Burwash Lake. Stereoscopic pair of aerial photographs showing the peninsula which is thought to be a proglacial feature. (Photo: courtesy National Air Photographic Library, Nos. A 12957-235 and 236).

CHRONOLOGY

From the phenomena here described, the writer believes the chronology of Kluane Lake to have been as follows:

- With the waning of the Kluane Glaciation, while ice still filled the Kluane Lake basin, a proglacial stream draining from the ice formed both the broad valley of Burwash Creek and the valley of Kluane River below their junction.
- As the ice in the lake basin dissipated, the earliest stage of Kluane Lake developed and drained by way of the valleys of the Slims and Kaskawulsh rivers via an outlet developed through the valley fork.
- By this channel the lake was drained to a level about forty feet lower than at present.
- At the same time, some of the creeks entering the lake cut the valleys that now form estuaries.
- Concurrently, the early fans of the Vulcan, Bullion, Sheep and other creeks were built in the Slims valley, probably partly on bodies of ice, and, on the wasting of this ice, the valley became at first a deep, narrow southern arm of Kluane Lake. Later the creek fans practically coalesced. However, they did not obstruct the outlet stream and probably only increased its gradient and raised the level of the lake by a few feet.
- For a very short period, water from Glacial Lake Kloo spilled over into the head of Christmas Creek, and cut a valley through deep drift deposits.
- The shallow western parts of Kluane Lake became dry land and were later covered by forest.
- The Duke River, joined by a stream from Brooks Arm, flowed eastward across this area into Kluane Lake. Their waters added to the volume discharging into the outlet stream in the Slims River valley.

With the final disappearance of the ice, this last drainage pattern persisted through most of the post-Kluane Glacial time, including the Hypsithermal Period. With the onset of the Neoglacial Period, about 2,640 B. P., glaciers in the St. Elias Mountains began to advance, and about 400 B. P., the Kaskawulsh Glacier reached its Neoglacial maximum and closed the outlet by way of the valley fork. The direction of the Slims River drainage was reversed and the river began to fill the valley with glacial outwash. With the water of Slims River now draining the Kaskawulsh Glacier through the Slims valley, as well as the water contributed by Duke River, Kluane Lake rose rapidly and flooded its basin to 30 feet above its present level before finding an over-flow channel to Burwash Creek along the course of the present channel of the Kluane River. Once this channel was opened, the great volume of water from the lake and the Duke and Slims rivers very quickly cut through the drift deposits and down to the bedrock level that now controls the level of the lake.

As the timing seems to be about right, it is possible that the earthquake that accompanied the movement on the Shakwak Lineament was sufficiently violent to trigger an acceleration in the advance of the Kaskawulsh Glacier and so, indirectly, to close the valley fork.

The Duke River may have found its way north across the northwest outlet area before the closing of the valley fork and may have turned either eastward to Kluane Lake or westward to Burwash Creek (see Fig. 6, "Old channels of the Duke River"). Normally the gravel load from the Duke River is not sufficient to obstruct the Kluane River and thus raise the level of the lake. However, in some seasons the Duke and the Slims rivers may have been synchronized so that their input temporarily raised the lake level as much as ten or twelve feet.

CONCLUSION

In view of the evidence, the author concludes that, prior to the Neoglacial advance of the Kaskawulsh Glacier, Kluane Lake drained south through the Slims Valley into the Kaskawulsh River.

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