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THAW LAKES, THAW SINKS AND SOILS IN NORTHERN ALASKA*

Abstract

Thaw lakes and thaw sinks are present in the aeolian silts just south of Umiat, Alaska. Through headward erosion, thawing of perennially frozen ground and filling, most lakes have undergone partial drainage exposing the lake floors. The lake floors are in step-like fashion, usually with 1 to 5 feet in elevation between the steps. The steps are a result of a complex of downcutting of drainage channels and collapse of underlying ground together with erosion and filling along the lake margins. Two C-14 dates from buried organic matter in the aeolian silts yielded ages of 9325 and 9130 yr. B. P. whereas one date from the 5-foot depth of the exposed lake floor yielded an age of 4590 yr. B. P.

Whereas the original aeolian silts were once virtually organic-free, the sediments of the lake floors have a considerable quantity of organic matter mixed throughout the substrate. This increased organic matter content in the lower positions is reflected in the soil morphology.

Thaw lakes and thaw sinks are recognized in numerous sectors of Alaska where the flat, poorly drained terrain is underlain by perennially frozen ground (Wallace, 1948; Hopkins, 1949; Hopkins and Karlstrom, 1955; Detterman, *et al.*, 1959; Tedrow, 1962 and others).

This report describes the occurrence of thaw lakes, thaw sinks and properties of attendant soils, in a sector centered about 10 miles south of Umiat (Fig. 1), The area under discussion is underlain by the Seabee formation (Colville group) of Late Cretaceous age and consists mainly of gray clay shales, siltstones, argillaceous sandstones and bentonite (Whittington, 1956). In the Umiat area (Fig. 1) the heavily braided Colville River flows generally eastward in a valley about 4 miles wide. The upland on the south side of the Colville River rises some 200 to 300 feet above the valley floor and

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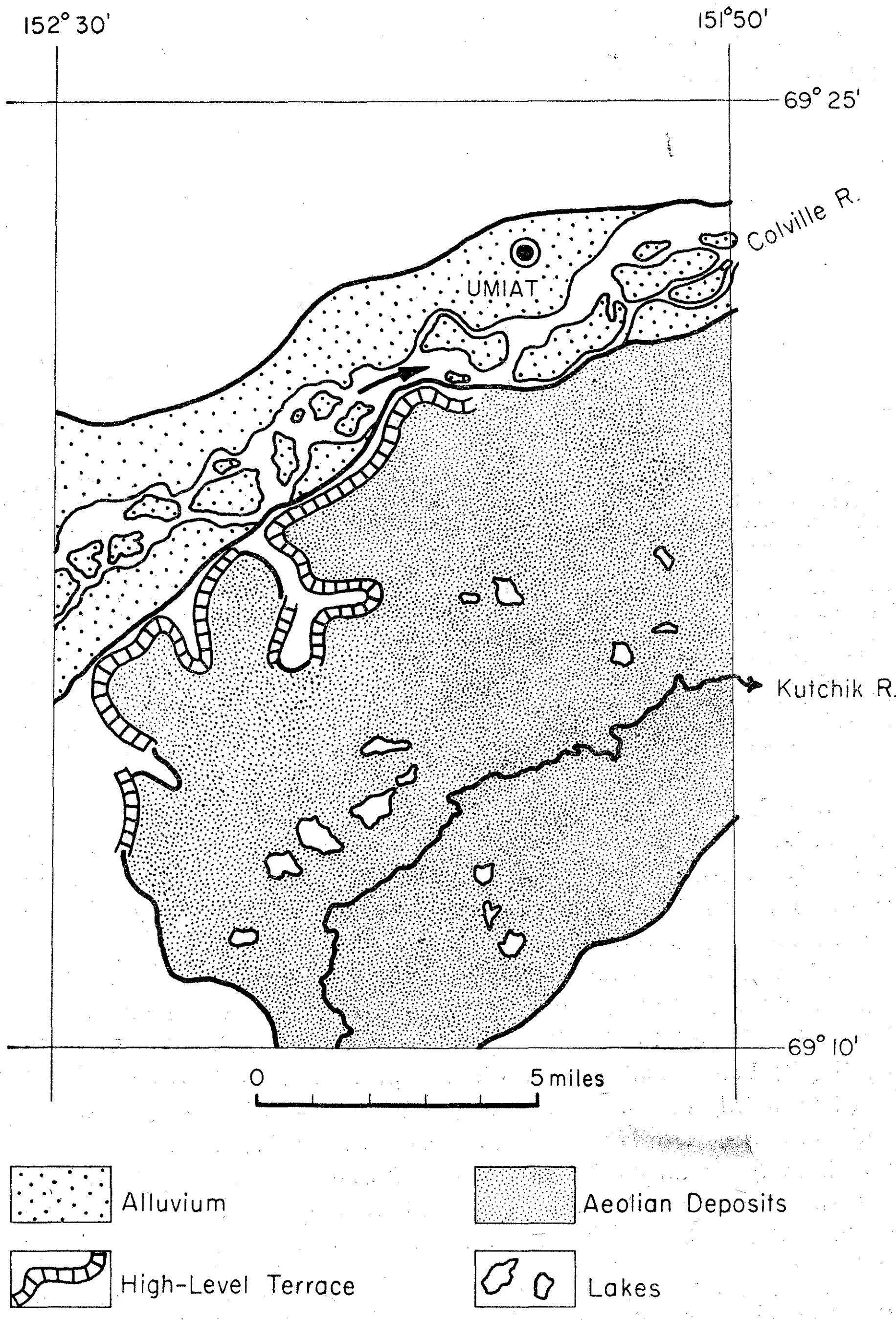

Fig. 1. Map of the Umiat area showing the location of the high-level terrace and aeolian deposits

attains an altitude of about 600 feet (Fig. 2). This upland is capped with a high-level terrace of Early Pleistocene or possibly Tertiary age (Chapman, *et al.*, 1964). Warner and Patterson (1953) described this high-level terrace. This terrace is about 10 or more feet thick and consists of an unconsolidated, somewhat weathered deposit of sand and gravel derived from the Brooks Range and the Arctic Foothills. The particle-size distribution curves of the $<$ 2 mm. fraction from the terrace (Fig. 3) show the fluvial character of the material. The terrace in turn is mantled with aeolian silts up to 30 or more feet thick. Detterman *et al.* (1958) described aeolian silts with thermokarst lakes on the arctic slope of Alaska, including the general sector under discussion. Thaw sinks and thaw lakes now occupy about one-half of the aeolian-mantled landscape shown in Figure 1. The aeolian character of the deposit is indicated by field appearence and by the particle-size distribution curves shown in Figure 3.

Hopkins (1949) in the Seward Peninsula, reported that the floors of some of the drained lakes became the sites of new thaw lakes. Such a condition exists in the aeolian deposits just south of Umiat. The once extensive group of lakes had been partially drained by tributaries of the Kutchik River as well as by frost thaw processes (Fig. 1). Some of the smaller lakes persisting in the original lake floor in turn became partially drained, leaving secondary lake floors exposed.

Numerous thaw lakes now exist at several levels within the old lake floors. In certain sectors these lakes are actively cutting into the adjacent banks while filling-in is taking place near other portions of the lakes. In effect, the more recently formed thaw lakes as well as those lakes persisting in low positions within the old lake floor, are now slowly migrating over the landscape. Some of the banks alongside the lakes are being cut back at an estimated rate of about 1 foot per year. This value is based on observations in one location over a 14-year period. A kitchen midden, some 15 feet in diameter, on the edge of a thaw lake in 1953, had been totally reclaimed by the lake in 1967. Plates 1 and 2 show examples of modern caving along the lake edges. The lake water, lapping against the frozen bank, undercuts the bank for a distance of 10 or more feet, ultimately leading to collapse of the bank.

The literature tends to emphasize the erosional processes of the thaw lakes, but of equal importance is the filling-in along certain of the lake margins. Once the banks along the lake edges collapse

(Pl. 1), the mineral and organic material become suspended in the lake water with subsequent deposition in another sector of the lake. It appears that most of the sediment is deposited along the lake margins. In lakes with exterior drainage, some of the suspended sediment obviously continues into the drainage channels and beyond. A number of lakes, however, do not have outlets. Plate 3 shows organic matter together with a small amount of silt, recently deposited along a lake margin. The finely divided organic-rich sediment accumulated from the lake water. Accumulation of organic debris

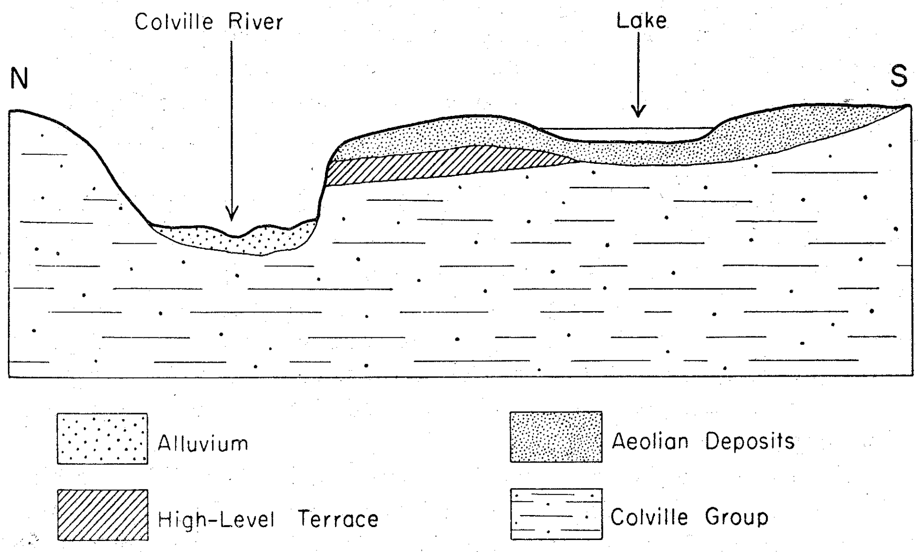

Fig. 2. Diagrammatic North—South cross section of the terrain in the vicinity of Umiat

Local relief is about 300 feet. Relative thickness of surficial deposits is exaggerated

is a fairly common condition along the lake shores and the deposit may have a width of 50 or more feet and extend as much as one-half mile long along the lake. Whereas the organic material as shown in Pl. 3 is finely divided, in other locations clumps and slabs of matted peat are deposited intact. Silt in varying quantities is also deposited in quiescent waters of the lakes.

In the littoral sectors of the lakes, emergent aquatics and bottom-dwelling plants produce a catchment basin effect for the accumulation of both inorganic and organic sediment (Pl. 4). In positions colonized by aquatics, peaty material also forms *in situ*, building up a gyttja deposit.

As a result of frost-thaw activity, caving, filling, and headward erosion, as many as 4 levels have formed within the old lake floors. Differences in elevation of the lake floors varies from 1 to 5 feet. Some of the floors result from the subsidence of the lake waters, others are aggraded surfaces. Plate 4 shows lake floors at 2 levels

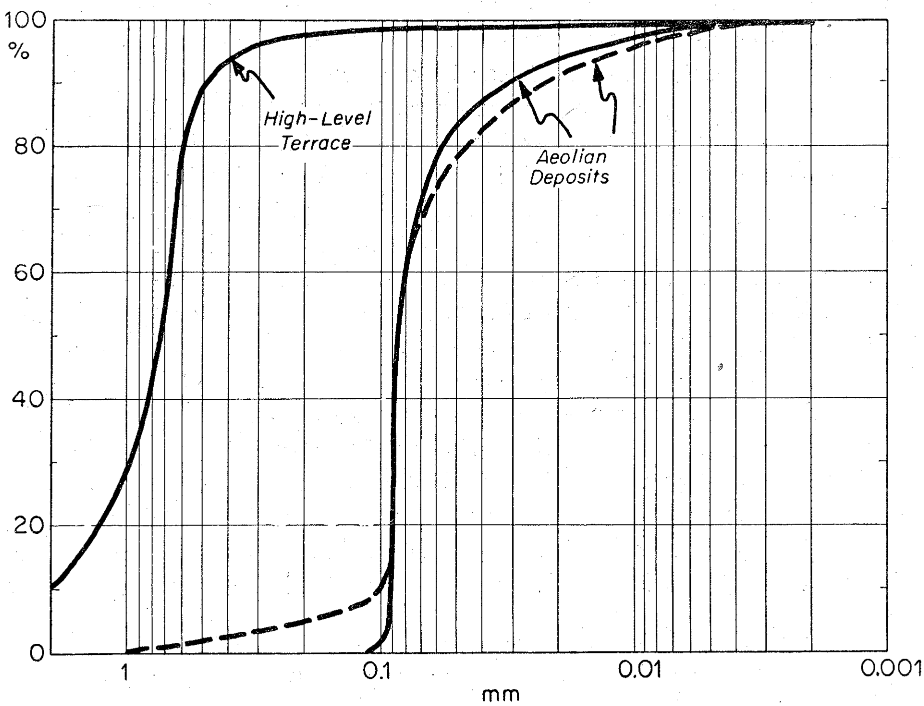

Fig. 3. Grain size of the aeolian silts and terrace deposits shown in Figs. 1 and 2

with a third forming in the littoral area. The original aeolian-mantled surface is shown on the horizon of the photograph.

On the original aeolian-mantled surface, ice wedges are of sizeable dimensions — 3 to 4 feet wide — and extend down into the silts some 6 to 7 feet. Ice wedges on the highest lake floor, however, are somewhat smaller than those of the adjacent uplands. In the case of the lower, recetly formed lake floors the ice wedges are comparatively small and in some situations there is usually no evidence of ice-wedge polygons being present. String bogs are sometimes present on the lowest water-saturated deposits. Relative size of ice wedges at various lake bed levels is shown diagrammatically in Figure 4.

The aeolian deposits (Fig. 1) are mantled almost continuously with Upland Tundra soil (Tedrow *et al.*, 1958), but the low, basin positions have sluggish drainage and are therefore much wetter and have Meadow Tundra and Bog soils present. Upland Tundra soils form on gentle convex slopes whereas Meadow Tundra and Bog soils form on the wide flats and concavities with poor drainage.

A cross section of the area under discussion is shown in Figure 4. There is < 1 pct. organic matter in the parent loess but once there has been recycling of the sediments by caving and subsequent sedimentation along the lake margins, a considerable quantity of organic matter becomes incorporated in the reworked deposit (Tedrow, 1962). After the first erosion—deposition cycle has been completed, the organic content of the substrate increases from < 1 pct. to about the 20 pct. level. In cases where the second erosion—deposition cycle has been effected, organic matter content in the substrate increases to about the 50 pct. level. Therefore in these step-like areas of the old lake floors, as one goes to the lower levels the parent material contains more and more organic matter, which coupled with generally poorer drainage gives rise to Bog-like soils in the lowest positions. Whereas the majority of the organic components in the lowest positions of the old drained lake area are inherited from the suspension, other organics are synthesized *in situ* from the emergent aquatics. The high organic content of the recycled sedim-

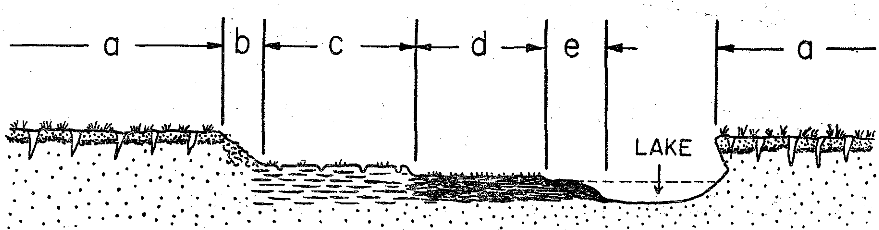

Fig. 4. Diagrammatic cross section of terrain in the vicinity of the thaw lakes

The original landscape is depicted as the highest ground (a) and consists of gray colored silts and a network of large ice wedges. A small solifluction slope is shown (b). The lake floor (c) contains about 20 pct. organic matter and has relatively small ice wedges. The reworked lake floor sediments (d) are peaty with few ice wedges being present. Organic matter approximates 50 pct. The lowest level (e) consists of peat. Note that as lower levels form, the organic content increases ents is somewhat similar to that of black shale solis in the Brooks Range, in which case some of the organic matter of the soil was inherited from the parent rock (U g o l i n i *et al.*, 1963). The organic content in the sediments of the lake floors is depicted diagrammatically in Fig. 4 with the darker shading indicating higher organic content.

In the case of soils formed on the water-saturated, organic-rich substrate, it is virtually impossible in most situations to differentiate the organic matter deposited with the mineral sediment from that contributed by modern plants.

Comparing morphology of Tundra soil formed on the original aeolian deposit to that of the Tundra soil on the reworked organic-rich sediment, the difference is quite striking. Plate 5 shows the normal Upland Tundra soil profile on the original aeolian silts. Idealized morphology follows:

Horizon	*Depth*	*Morphology*
1	4 - 0″	Organic matter.
2	0 - 10″	Light olive brown to gray silt, gleyed. Some organic inclusions present.
3	10 - 12″	Similar to above, but frozen.
4	12 - 18″	Dark brown to black organic mineral material with inclusions of fibrous organic matter.
5	18+	Gray, frozen silts and/or ground ice, with <1 pct. organic matter.

Between the two organic-rich horizons (Pl. 5) and below the lower organic-rich horizon, the silts are gray colored. In the case of Tundra soil forming on the recycled, organic-rich deposits, however, the black color form a somewhat homegenous morphology throughout the profile (Pl. 6).

Age of the original aeolian deposit is confidently assigned to the Pleistocene Epoch, but a more stratigraphic assignment cannot as yet be made. The buried organic-rich zone which is present in virtually all Tundra soils of northern Alaska was sampled at 2 locations within the original aeolian deposit. C-14 data at the 16 to 22-inch depths yielded ages of 9325 ± 205 yr. B. P. (I-354) and 9130 ± 240 yr. B. P. (I-356). These data indicate only that the aeolian deposit is older than 9130 to 9325 yr.

There is unquestionable evidence that lakes at one time were more extensive in the region (Fig. 1) than is now the case. The problem of how long the lake floors in this thaw lake sector have been exposed is uncertain but a single sample of the frozen organic--silt mixture from the 5-foot depth in the highest lake floor yielded an age of 4590 ± 180 yr. B. P. (I-3637). If this 4590 yr. age approximates the time lapse since deposition of the lacustrine sediments on the highest lake floor then the period of major lacustrine transgression in the area would fall within the Hypsithermal Interval. Data on this subject are only fragmental and more information must be accumulated before specific conclusions can be reached.

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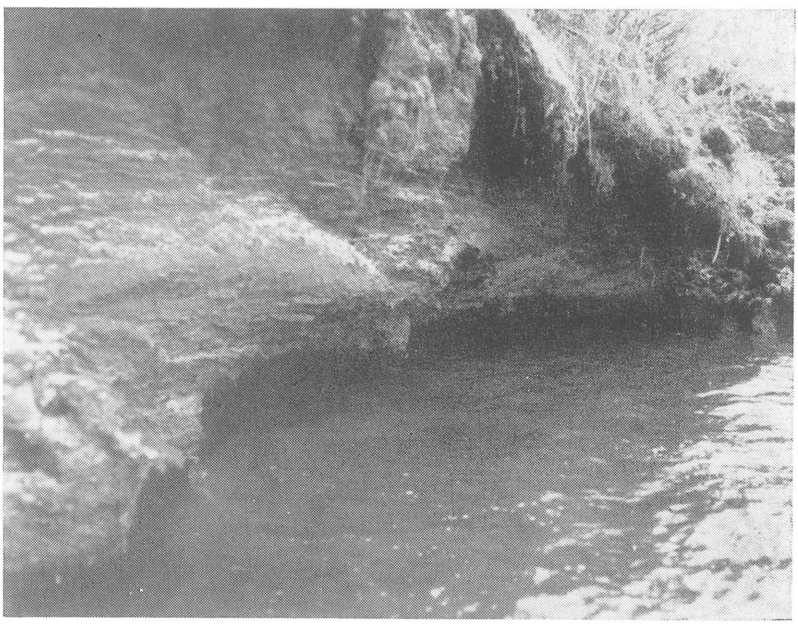
Pl. 1. Collapsed bank along the margin of a lake



Pl. 2. Erosion of a frozen bank at the edge of a lake. The lake waters have undercut the bank about 5 feet

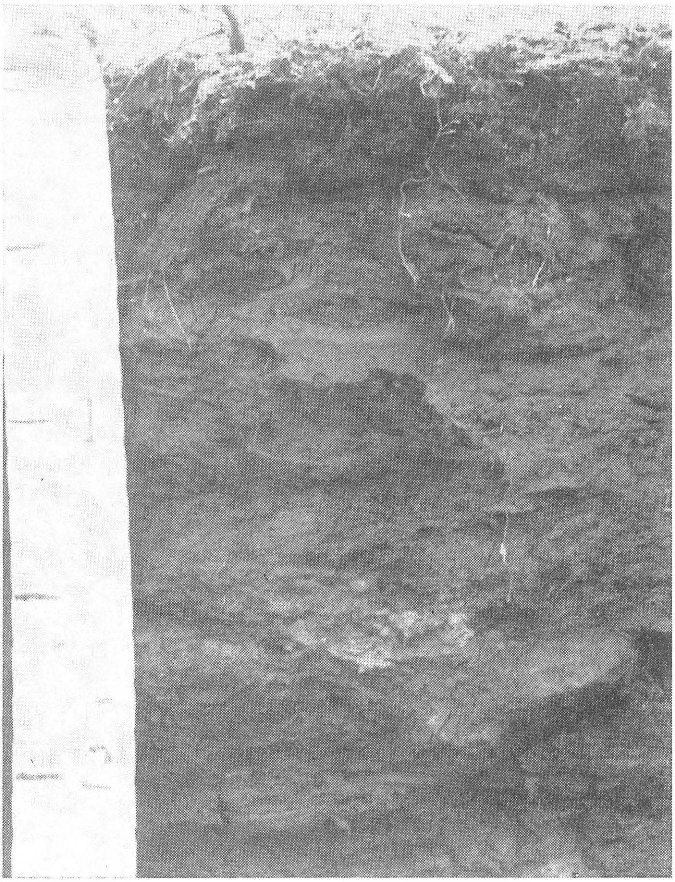
Pl. 3. Recently accumulated organic-rich sediment along the edge of a lake

Pl. 4. View of various levels of lake floors south of Umiat

Land on the right side of the photograph is about 5 feet above the lake. Land in background, which consists of aeolian silts, is about 30 to 35 feet above the lake. Note the spit is about 1 foot above the water level. The emergent aquatics near the shore are forming a new level

Pl. 5. Upland Tundra soil on aeolian silts

Scale is in feet



Pl. 6. Upland Tundra soil on lake bottom sediments. The dark color is due to organic matter inherited from the sediment

Scale is in feet