DEPARTMENT OF THE INTERIOR
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QUARTERNARY STRATIGRAPHIC SECTIONS WITH RADIOCARBON DATES KILLIK RIVER QUADRANGLE, ALASKA

by

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SUMMARY

Twenty organic samples from 18 localities in the Killik River quadrangle range in age from more than 39,000 to about 1000 radiocarbon years B.P. The dates, combined with fossil assemblages and measured stratigraphic sections, provide significant insights into regional climatic changes and related events, particularly those of the past 13,000 years.

A date of more than 39,000 yr B.P. confirms the inferred great age of higher terrace deposits north of the Brooks Range. These deposits have been dissected deeply by streams, which have cut to the base of terrace gravels and into underlying bedrock. Two dates of about 13,000 to 12,000 years B.P. on peat above younger outwash provide minimum limits for abandonment of late Pleistocene outwash terraces. The dates coincide with a 1000-year interval near the close of the Pleistocene during which woody shrubs were particularly abundant in northern valleys of the Brooks Range.

Filling of depositional basins behind end moraines of Walker Lake age at the north flank of the Brooks Range was taking place by 10,900 yr B.P. in Okokmilaga Valley, with stagnant glacier ice still present at that time. A younger episode of alluviation took place between about 8000 and 5600 yr B.P. in the Killik Valley following early Holocene incision into ice-stagnation deposits. A late episode of river downcutting through the sand fill in the Killik Valley occurred sometime prior to 1750 yr B.P. Filling of the Kurupa basin was taking place by 4800 yr B.P. and continues to the present.

Alluvial history of upper valleys may have been controlled primarily by episodic growth of fans at the mouths of cirque-headed tributary streams. Enlargement of such fans may have taken place at times of glacier and rock-glacier expansion in the cirques; downcutting of fans and adjoining sectors of mountain valleys probably occurred during interstadial times. Radiocarbon dates from valley segments deep within the Brooks Range suggest a long-lasting episode of alluviation that began before 3000 yr B.P. and continued until sometime after 2000 years ago.

Buried peat layers suggest an interval of possibly milder climatic conditions about 1200 to 1000 years ago that was preceded and followed by episodes of more intensive frost churning and solifluction. Similar buried peats and soils elsewhere in the Brooks Range date between 1600 and 800 yr B.P., suggesting a long-lasting interstadial within the late Holocene Neoglacial interval. Samples from subsurface horizons of finely divided humic matter confined above permafrost show a wider scatter of dates; burial of this material may have taken place by surface processes unrelated to climatic changes.

The frequency distribution of 78 radiocarbon dates from northern valleys of the central Brooks Range shows irregularities that may have important paleoecologic implications:

1. No finite dates lie between 30,000 and 13,200 yr B.P., suggesting that conditions were unfavorable for growth of woody shrubs and peat-forming plants during this interval in much of northern Alaska.

2. A large cluster of dates between 13,200 and 10,500 yr B.P. coincides with the time range of the Bølling and Allerød interstadials in the European pollen record, suggesting a widespread major interval of climatic warming and glacier retreat.

3. Fewer dates between 10,500 and 6,500 yr B.P. may reflect reversion to colder summer conditions and perhaps glacier readvances in some upper valleys of the central Brooks Range.

INTRODUCTION

The Killik River 1:250,000 quadrangle includes portions of the north-central Brooks Range and the Arctic Foothills beyond the north flank of the range. North-flowing streams drain the area; these consist primarily of the Killik River and its tributaries to the east and the Etivluk drainage system to the west. The region contains a complex record of Quaternary and probable late Tertiary glacial advances separated by episodes of river incision and pedimentation (Hamilton, 1979a, 1980a). Although most of the record lies beyond the range of radiocarbon dating, 20 dates obtained from 18 river bluffs, bank exposures, archeological sites, and test pits within the quadrangle provide information on environmental history during the latest Pleistocene glaciation and postglacial time (table 1 and plate 1).

Studies of the Quaternary glacial succession in the Killik River quadrangle were initiated in 1949-1953 by R.L. Detterman (Detterman and others, 1958; Chapman and others, 1964). Later studies of modern soils and buried organic horizons were carried out by J.C.F. Tedrow and several associates, who also obtained the first radiocarbon dates reported from the region (Tedrow and Walton, 1964; Tedrow, 1965). My studies of surficial geology in the region were initiated in 1968 during a boat traverse down the Killik River to its mouth. Systemetic mapping of surficial deposits throughout the quadrangle was carried out during 1977-1979 as part of the NPRA (National Petroleum Reserve in Alaska) and Arctic Environmental Studies programs of the U.S. Geological Survey. A surficial geologic map of the quadrangle was published the following year year (Hamilton, 1980a). This map should be consulted for definitions, locations, and interrelationships of the geologic deposits discussed on the following pages.

Nomenclature used for glacial advances follows Hamilton (1980a) except for the youngest major advance of the late Pleistocene Itkillik Glaciation (Table 2). This event, which has been dated between 24,000 and 11,800 yr B.P. in the Koyukuk drainage of the south-central Brooks Range (Hamilton, 1982), is termed the Walker Lake Substage.

Table 1. Radiocarbon dates from the Killik River quadrangle, Alaska.

Exposure No.	Coordinates	Date and Lab No.	Material Dated	Comments
OK-1	68° 47.5'N 153° 26'W	12,770 ±360 (I-11,378)	Peat with twigs	
OK-2	68° 24.2'N 153° 04.7'W	10,910 ±170 (I-11,398)	Wood (rootlets)	
OK-3	68° 22.5'N 153° 04.5'W	10,730 ±150 (I-11,395)	Wood (roots)	Identified as Salix (1)
OK-4	68° 16.5'N 153° 04.4'W	3005 ±90 (I-11,452)	Wood fragments	
KI-1	68° 29.5'N 154° 00'W	8505 ±215 (AU-53)	Peat	
		6030 ±110 (I-11,421)	Peat with wood	
		1740 ±120 (AU-52)	Wood	
KI-2	68° 20.2'N 154° 35'W	8010 ±130 (I-10,275)	Wood	Identified as Salix (2)
KI-3	68° 28'N 154° 02'W	5650 ±230 (I-1006)	Wood	Salix and Alnus present (Tedrow and Walton, 1964)
KI-4	68° 14'N 154° 07'W	2410 ±190 (AU-50)	Peat	
KI-5	68° 11'N 154° 08'W	1970 ±175 (AU-48)	Wood fragments	
KI-6	68° 29'N 154° 06'W	2310 ±110 (I-1005)	Organic sand	Pollen includes Betula, Alnus, Salix, Ericaceae, and Gramineae (Tedrow, 1965)
KU-1	68° 37.3'N 155° 09.5'W	>39,000 (I-11,456)	Wood	Wood identified as Salix, and Alnus (2). Pollen and spores of Betula, Alnus, Salix, Ericaceae, and Sphagnum (3)
KU-2	68° 20.2'N 154° 35'W	4760 ±115 (I-11,402)	Peat	Bryophyte-sedge peat; includes Sphagnum (1)
KU-3	68° 21'N 154° 35'W	3540 ±80 (WSU-2532)	Charcoal	From archeological test pit. K.M. Schoenberg, personal commun., 3/4/82
EA-1	68° 43.4'N 155° 54.5'W	11,700 ±180 (I-11,419)	Peat	Traces of Salix and Cyperacene pollen (3)
EA-2	68° 39.5'N 155° 50'W	1055 ±90 (I-11,501)	Peat	Contains trace amounts of Betula, Picea, Alnus, Salix, and Cyperaceae pollen (3)
EA-3	68° 24.7'N 155° 48'W	7620 ±95 (DIC-1589)	Charcoal	From Mesa archeologic site. M.L. Kunz, written commun., 1980
NI-1	68° 06.5'N 155° 55.5'W	1155 ±80 (I-11,276)	Peat	
AW-1	69° 00.7'N 155° 58.5W	4210 ±90 (I-11,454)	Organic silt	

(1) Identified by author
(2) Identified by Forest Products Laboratory, Madison, Wisconsin
(3) Identified by T.A. Ager, U.S. Geological Survey

Table 2. Glacial advances of middle and late Quaternary age in the central Brooks Range.

Hamilton and Porter, 1975	Hamilton 1980a	This paper	
Fan Mountan	Fan Mountain Phase II Phase I	Fan Mountain Phase II Phase I	Holocene
Itkillik Glaciation Alapah Mountain phase } Itkillik "III" phase } Itkillik II phase Itkillik I phase	Itkillik Glaciation late Itkillik } Phase II } Phase I	Itkillik Glaciation } Walker Lake Substage } Unnamed Substage(s) }	late Pleistocene
Sagavanirktok River Glaciation	Sagavanirktok River Glaciation younger advance older advance	Sagavanirktok River Glaciation } younger advance } older advance }	middle Pleistocene

ACKNOWLEDGEMENTS

Four organic samples obtained during my surficial geologic studies along the Killik River in 1968 were dated by William Reeburgh and Margie Young at the University of Alaska's Institute of Marine Science. Twelve samples collected during 1977-1979 were dated by Isotopes, Inc. under the supervision of James Buckley. Wood collected for dating was identified by the Forest Products Laboratory at Madison, Wisconsin, and peats were examined for pollen by Thomas A. Ager of the U.S. Geological Survey. Bryophytes (mosses) from peat samples were identified by Jan A. Janssens at the University of Alberta. I am indebted to Peter M. Bowers, Robert Gal, and Michael L. Kunz (Bureau of Land Management), and to Kenneth M. Schoenberg (National Park Service) for information on two additional dates obtained from archeologic sites near Iteriak Creek and Kurupa Lake.

STRATIGRAPHIC SECTIONS

Okokmilaga Valley

The Okokmilaga River Valley, near the eastern margin of the Killik River quadrangle, contains drifts spanning the entire northern Brooks Range glacial sequence of late Tertiary to late Holocene age (Hamilton, 1980a). Because of limited source areas within the upper valley, glaciers were smaller than in major drainages to the west and east, and the most extensive drift sheets extend only 25 km beyond the north flank of the Brooks Range. Four dated exposures along the valley floor provide a general north-to-south transect from proglacial outwash and loess fronting the outermost Itkillik moraines through a sandy infilling of a basin dammed by moraines of Walker Lake age at the front of the range into deposits related to late Holocene alluviation of upper mountain valleys.

Exposure OK-1 (fig. 1), a north-east facing cutbank near the mouth of Okokmilaga River, consists of sandy gravel (unit 1) overlain by peaty to stony silt (unit 2). The gravel contains rounded stones up to large cobble size; the largest stones and most of the smaller ones consist of conglomerate and quartzite assignable to the Upper Devonian Kanayut Conglomerate which crops out near the valley head (Brosgé and others, 1979). The gravel forms a terrace about 3 m high that becomes higher upstream and is traceable into end moraines of Itkillik age near the north flank of the Brooks Range. Toward the downstream end of the cutbank, the gravel is overlain by 40 cm of stony silt that has been oxidized dark brown (7.5YR 3/4). Weathering has affected the clasts within the gravel to a depth of about 1.2 m below its contact; they bear coatings of iron oxide and are etched along fractures, bedding planes, and grain boundaries. Farther south along the bank, the gravel is overlain by a thicker deposit of ice-rich organic sit (unit 2 in fig. 1) that has accumulated in part by solifluction. The silt contains peat lenses which have been deformed by growth of ice wedges. Peat near the base of unit 2 contains twigs that date 12,770 ±360 yr B.P.

Exposure OK-2 (fig. 2) is situated upvalley from end moraines of Walker Lake age within sandy basin fill containing deep (15-20 m) kettle depressions. Gravel at the base of the section (unit 1) contains stones up to small boulder size, and may have formed as recessional outwash during final wastage of late Pleistocene glaciers. Stones near the top of the gravel are slightly weathered, suggesting a hiatus between deposition of units 1 and 2. Unit 2 consists of horizontally bedded sand and silt, with rootlets locally abundant. *In situ* rootlets near the base of the unit date 10,910 ±170 yr B.P. Variegated gray to reddish sediments higher in the section evidently formed under alternating oxidizing and reducing conditions, implying formation on a marshy floodplain subject to periodic inundation.

Exposure OK-3 (fig 3), the west-facing cutbank of a sharp meander bend, is situated 3 km south of OK-2 on the same broad, kettle-pocked, sandy basin floor of Okokmilaga Valley. The cutbank intersects an erosion remnant that is conspicuously higher than postglacial fans derived from the valley walls. It stands to about the same height (17 m) as OK-2, and contains similar horizontal beds of sand that began to form sometime before 10,730 ±150 yr B.P. The exposure lacks the basal gravel of exposure OK-2. Coarse clastic deposits may have accumulated locally rather than throughout the basin during ice wastage at the close of Walker Lake time.

Exposure OK-4 (fig. 4), a west-facing river bank 11.5 km farther up Okokmilaga Valley, lies beyond the limit of basin-filling sand deposits. It occupies a narrower part of the upper valley where alluviation and downcutting are controlled largely by growth of alluvial fans at the mouths of tributary streams. The exposure lies within an area of marsh or lacustrine deposits confined behind the large fan of Inikaklik Creek. The 5.5-m-high bank consists entirely of frozen silt and peat intersected by ice wedges. Wood fragments within peat 2 m above river level date 3005 ±90 yr B.P.

Killik Valley

During repeated Pleistocene glaciations, the Killik Valley developed into a master glacial drainage system into which flowed most of the ice generated within a 75-km-wide sector of the northern Brooks Range. Glacial deposits along the east and west flanks of the valley form massive compound lateral moraines more than 300 m high that begin at the north margin of the range and extend 30 to 50 km farther north into a series of terminal moraines that cross the valley (Hamilton, 1980a). Three dated river bluffs, each about 20 m high, are situated within the depositional basin that formed near the range front behind end moraines of Walker Lake age. An additional date in this area was obtained on buried organic material at shallow depth in a test pit. Two dates were obtained from lower (5-6 m) river banks farther upstream where the Killik River flows through a narrower mountain valley. The history of alluviation and downcutting within this sector of the upper valley was largely controlled by episodic growth of large alluvial fans at the mouths of cirque-headed tributary streams.

Exposure KI-1 (fig. 5), a south-facing cutbank of the Killik River, 0.5 km south of Lake Udrivik, lies within the sand-filled basin enclosed by end moraines of Walker Lake age. Unlike banks of similar height in Okokmilaga Valley, KI-1 is lower than kettle-pocked sand and gravel deposits on the floor of the Killik Valley; it may represent a younger generation of valley filling. Sandy peat at the base of the section (unit 1) contains repetitive near-horizontal lenses and layers of sand that resemble modern floodplain deposits along this stretch of the Killik River. The sand beds may have been deposited on a marshy river floodplain at times of high river discharge. Peat located 4.3 m above river level dates 6030 ±110 yr B.P.; and an approximate age of about 8500 yr B.P. (AU-53) was obtained on peat about 1.5 m lower in the section. The overlying dune sand (unit 2) contains abundant *in situ* remains of willow or alder shrubs that were buried by the accreting sand body. The largest shrub exposed in 1979 was 4 cm in diameter and stood 85 cm high. Wood within unit 2 farther west along the bank dates about 1750 yr B.P. The eolian sand in that locality extends down to river level, therefore it had accumulated after the Killik River cut down through the basin-filling deposits to a level at or below its modern position.

Exposure KI-2 (fig. 6), 10.5 km farther up the Killik Valley near the mouth of Akmalik Creek, intersects sand deposits that postdate incision of the Killik River into basin-filling sediments of late Walker Lake age. The exposure is a vertical face of frozen sand and peat, deeply undercut at the base by Akmalik Creek, that was thawing and collapsing when visited in 1977. The bluff face was sketched, photographed, and described from a distance, and a sample of wood for radiocarbon dating was hastily snatched from the basal unit. Near-horizontal beds of basin-filling sand at the base of the exposure were accumulating by 8010 ±130 years ago; these pass upward into sandy organic-rich floodplain deposits, into which a channel about 6 m deep subsequently was eroded by Akmalik Creek. The incision later was filled by crossbedded fluvial sand which passes upward into gleyed organic-rich deposits of a marshy floodplain. Subhorizontal beds of eolian sand cap the section.

Exposure KI-3 (not illustrated), along the west bank of the Killik River was described by Tedrow and Walton (1964). Although those workers reported more than 20 m of water-laid poorly stratified sand overlain by about 3 m of eolian sand, the section appears to be a largely eolian in character. It forms part of a dune complex that accumulated along the edge of the river channel and encroaches on a former flood plain. Remains of alder and willow occur about 12 m below the top of the bluff within an organic-rich bed about 30 cm thick that dates 5650 ±230 yr B.P. Tedrow and Walton (1964) stated that alder does not presently grow along this portion of the Killik Valley, and that its presence in the dated organic bed could indicate a milder climate during middle Holocene time. However, alder shrubs were found to be abundant within a few km of exposure KI-3 during field investigations in 1968 and 1979; the fossil alder therefore has little paleoclimatic significance.

Exposure KI-4 (fig. 7), a low (6 m) bank along the west side of the Killik River near the upvalley limit of its sandy basin fill, contains sedge or grass peat (unit 2) buried beneath silty clay (unit 3) and eolian sand (unit 4). The peat, which dates 2410 ±190 yr B.P (AU-50), represents accumulation of marsh vegetation on the valley floor. Later alluviation of silt and clay may have taken place in a slackwater environment caused by growth of alluvial fans a short distance downvalley.

Exposure KI-5 (fig 8), a low (5.5 m) south-facing bank 6.5 km up the Killik River from exposure KI-4, consists of cross-bedded silt and fine sand (unit 1) overlain by a thin cap of eolian sand (unit 2). Wood fragments near the base of the section date 1970 ±175 yr B.P. (AU-48), suggesting that the silty deposits may be contemporaneous with those of KI-4 (unit 3 in fig. 7).

Exposure KI-6 (not illustrated) is a soil pit dug by Tedrow (1965) near Lake Udrivik in the Killik Valley. The pit exposed gray sandy loam that contained a layer of black sandy organic matter at 30 to 45 cm depth. The organic layer dates 2310 ±110 yr B.P. and contains a pollen assemblage dominated by *Betula*, *Alnus*, *Salix*, Ericacaea, Cyperacaea, and Gramineae (Tedrow, 1965).

Other Exposures

Radiocarbon dates ranging in age from infinite to late Holocene are available from seven additional sites west of the Killik Valley. Two bluff localities are situated along Kurupa River and a western tributary, Nogak Creek; two others occur along the East Fork of the Etivluk River. A smaller exposure, in the headwall of an earthflow, is situated near the Nigu River in the extreme southwestern corner of the quadrangle. Three additional localities are artificial excavations: an archeological site near the East Fork of the Etivluk, an archeological test pit near Kurupa Lake, and a shallow soil pit about 1 km north of the quadrangle boundary.

Exposure KU-1 (fig. 9) is a 17.6-m bluff along the east side of Nogak Creek 35 km north of the Brooks Range. The site lies along an outwash terrace that is traceable upvalley into drift of Sagavanirktok River age (Hamilton, 1980a). Black shale bedrock (unit 1) is overlain by coarse outwash gravel (unit 2) that has been strongly oxidized throughout and contains secondary silt that has infiltrated downward to form coatings on upper surfaces of the stones. Logs of willow and alder up to 10 cm diameter within a deposit of clayey silt 1.9 m above the base of the gravel are older than 39,000 radiocarbon years. The wood-bearing sediments are a probable floodplain deposit in which clay may have been incorporated from breakdown of local shale bedrock. Pollen analysis confirms the presence of willow and alder on the former floodplain, and indicates that Betula, Ericacaea, Cyperaceae, and Sphagnum also were present (T.A. Ager, written commun., January 27, 1981). Overlying ice-rich silt (unit 3) forms ampitheater-like "thermocirques" (Czudek and Demek, 1970) by vertical recession of rapidly thawing exposed faces.

Exposure KU-2 (fig. 10), 3 km upvalley from Kurupa Lake, lies within a basin dammed by end moraines of Itkillik age at the north flank of the Brooks Range (Hamilton, 1980a). The basin was filled initially by a high-level stage of Kurupa Lake, which contracted to its present size following downcutting of its outlet. The exposure consists entirely of horizontally-bedded peat and silty peat. A radiocarbon date of 4760 ±115 yr B.P. near its base indicates progressive infilling of the upper lake basin by marsh deposits since at least middle Holocene time.

Exposure KU-3 (not illustrated) is an archeologic test pit near the south shore of Kurupa Lake. Charcoal dating 3540 ±80 yr B.P. forms a hearthlike concentration at 10 to 20 cm depth in the pit (K.M. Schoenberg, personal communication, March 4, 1982). The charcoal is associated with artifacts assignable to the Arctic Small Tool tradition of Irving (1962).

Exposure EA-1 (fig. 11), along the stream-cut edge of a low terrace on East Fork Etivluk River, exposes alluvium (unit 1) overlain by ice-rich peat and silty peat (unit 2). Peat sampled 20 cm above the base of unit 2 dates 11,700 ±180 yr B.P; it yielded trace amounts of willow and sedge pollen (T.A. Ager, written commun., January 27, 1981). Stones scattered within the peat are most abundant near its top. No local stream is present on the terrace surface, therefore the stones must have been deposited by the East Fork, either during high flood stages or when its channel was filled with aufeis.

Exposure EA-2 (fig. 12), 8 km up the East Fork from Exposure EA-1, is a river bluff 21 m high that contains alluvial gravel (unit 2) above bedrock (unit 1). The alluvium is assigned to a widespread terrace deposit of inferred early to middle Pleistocene age that formed prior to the Sagavanirktok River Glaciation (Hamilton, 1980a); the great antiquity of this deposit is supported by the depth of subsequent incision by the East Fork through the gravel and into the underlying bedrock. A frost-mixed zone of stony silt (unit 3) at the top of the gravel contains peat lenses through its upper 0.5 m. Peat near the base of this interval dates 1055 ±90 yr B.P. and contains trace amounts of Betula, Picea, Salix, and Cyperaceae pollen (T.A. Ager, written commun., January 27, 1981.

Exposure EA-3 (not illustrated) is an archeologic excavation at the Mesa site (Alaska State Archeological Survey Number KIR-102), a bedrock promentory on the east side of Iteriak Creek 25.5 km upstream from its confluence with the East Fork of the Etivluk River. Charcoal, which had to be combined from three hearths or "fire areas" within a radius of 1.3 m in order to yield sufficient datable carbon, is 7620 ±95 years old (Kunz, 1982). The charcoal occurs at the contact between residual bedrock rubble and a thin (±6 cm) cap of sod and silt.

Exposure NI-1 (fig. 13) is the headwall of an earthflow that developed on the sloping surface of ground moraine near the Nigu River. The toe of the flow extends to the east bank of the river, and a solifluction slope rises inland from the crest of its headwall at an angle of 5 degrees. The flow consists of pebbles, cobbles, and a few striated boulders up to 180 cm length in an abundant matrix of silty sand. Its headwall, which stands about 1.5 m high, exposes solifluction debris (unit 3) above the till (unit 1). The two units are separated by a peat layer 7 cm thick (unit 2) that dates 1155 ±80 yr B.P. and provides a maximum age limit on both solifluction and earthflow activity at the site.

Exposure AW-1 (fig. 14) is a soil pit that was dug into a broad silt-covered upland surface north of the Colville River just beyond the northern margin of the Killik River quadrangle. The pit, which was floored on permafrost at a depth of 50 cm, uncovered dark peat and organic silt (unit 1) beneath highly deformed frost-churned silt (unit 2). Peat a few centimeters above the permafrost table dates 4210 ±90 yr B.P.

DISCUSSION

Deeply eroded deposits of oxidized gravel in terraces north of the Brooks Range are older than the maximum time range of radiocarbon dating. These terraces typically are eroded through gravel and into underlying bedrock, which is exposed wherever the terraces are intersected by modern streams. At exposure EA-2, the East Fork of Etivluk River has eroded through terrace gravel to a depth of 12 m into underlying bedrock. A younger terrace with only 4 m of bedrock incision on Nogak Creek (exposure KU-1) was formed more than 39,000 radiocarbon years ago. The presence of wood and pollen of alder, birch, and willow within the gravel at this site suggests that interglacial conditions comparable to the present separated two phases of gravel accretion, presumably during the two glacial advances of Sagavanirktok River age (Hamilton, 1979a, 1980a).

Lower outwash terraces assigned to the Itkillik Glaciation either lack bedrock exposures or have been dissected down to bedrock only locally near the end moraines from which they originated. The gravel in these terraces is overlain by ice-rich peat and silt at sites along the Okokmilaga River (OK-1) and the East Fork of the Etivluk River (EA-1). The 1.2-m zone of weathering in the 3-meter terrace at exposure OK-1 suggests a pre-Walker Lake age for that deposit; the lower gravel surface at EA-1 is of indeterminate age. Peat and wood just above the gravel at the two sites date 12,800 and 11,700 yr B.P. These dates provide minimum age limits for construction of the outwash trains; they also provide approximate dates for beginning of peat accumulation and maximum limiting ages on subsequent growth of Holocene ice wedges. The range in age of the two samples is identical to that of seven dated samples of wood in the Sagavanirktok Valley (12,840 to 11,760 yr B.P.; Hamilton, 1979b). These dates appear to represent a 1000-year interval of climate that was particularly favorable for growth of woody shrubs during waning phases of Walker Lake glaciation.

Sand and peat deposits that filled basins enclosed by end moraines of Walker Lake age along the north flank of the Brooks Range are between 10,910 and 4760 yr B.P. in age, with dates concordant in each individual valley. Deeply kettled and highly dissected basin-filling deposits in Okokmilaga Valley began forming shortly before 10,900 yr B.P. The numerous kettles indicate that alluviation took place while stagnant masses of glacier ice still were present on the valley floor. Two dated exposures within the Killik Valley, although of about the same height, are composed largely of eolian sand rather than waterlaid sediments; they also are lower than and distinct from ice-contact deposits that formed during deglaciation. Alluviation at exposures KI-1, KI-2, and KI-3, which took place between at least 8000 and 5650 yr B.P., was both preceded and followed by incision of the Killik River to levels near that of today. Filling of the Kurupa Lake basin began before 4760 yr B.P. and continues to the present.

Alluviation farther up the mountain valleys of Okokmilaga and Killik Rivers may have been controlled primarily by episodic growth of alluvial fans at the mouths of cirque-headed tributary streams. Higher sediment yields during times of glacier expansion and rock-glacier activity in the cirques caused enlargement of the fans and alluviation along main valleys upstream from them. Conversely, retreat of glaciers and stablization of rock glaciers would likely result in dissection of the fans and downcutting along adjoining segments of main valleys. Dated terrace deposits at exposure OK-4 suggest a long-lasting interval of alluviation that began before 3000 yr B.P. and continued long enough for development of large ice wedges within the sediment. The records from terraces of comparable height at exposure KI-4 and KI-5 in the Killik Valley suggest that alluviation may have ceased, at least locally, about 2400 yr B.P. but that it continued in some localities until sometime after 1970 years ago. Dated stream terraces elsewhere in the central Brooks Range (Hamilton, 1981) record widespread alluviation around 3800-2000 yr B.P., which suggests that any pauses or reversals in alluviation during this interval may have been local rather than regional.

Near-surface buried peat layers at exposures NI-1 and EA-2 show closely similar ages of 1155 and 1055 yr B.P. The peat layers are interpreted as indicating an interval of stability at each site that was followed by renewed frost churning and by reactivation of solifluction on slopes. Similar dates ranging between 1590 and 800 yr B.P. have been reported previously for buried soils and peat layers in the central Brooks Range (Hamilton, 1979b, 1979c, 1980b), therefore, the two dated peats could reflect a widespread interval of milder climate between episodes of more intensive frost action.

Buried organic horizons confined above permafrost tables at localities AW-1 and KI-6 date 4210 and 2310 yr B.P. Although these horizons could represent in situ paleosols, burial of structureless organic matter may also take place from the surface downward as a continuous rather than episodic process that has no paleoclimatic significance (Tedrow, 1964; 1977, p. 157-163; Mackay, 1981). The buried charcoal at site EA-3, which is associated with artifacts and clearly of human origin, also is unlikely to indicate any environmental fluctuation.

With the completion of this report, 75 radiocarbon dates have been described from test pits and natural exposures in northern valleys of the central Brooks Range (see also Hamilton, 1979b and 1980b). The age distribution of these dates and three additional unpublished dates from the Howard Pass quadrangle shows a remarkably heavy concentration between 13,200 and 10,500 yr B.P. (fig. 15). No finite dates fall within the time range of 13,500 to 30,000 yr B.P., and datable organic matter also is less abundant for about 4000 years after 10,500 yr B.P. The absence of older radiocarbon dates contrasts sharply with the radiocarbon record from valley systems of the southern Brooks Range, where 16 dates have been reported from between 30,000 and 13,200 yr B.P. (Schweger, 1976; Hamilton, 1982). These relationships indicate unfavorable environments for growth of woody shrubs or formation of peat beds during much of late Pleistocene time in northern Alaska, probably owing to extreme dryness (Carter, 1981; Carter and Hopkins, 1982; Hamilton, 1982). The interval after 10,500 yr B.P. may also have included one or more episodes during which climate became less favorable for woody shrubs and peat-forming plants. Valleys of the southern Brooks Range were largely deglaciated by this time (Hamilton, 1982), but significant glacial readvances after this date could have taken place in upper reaches of northern valleys.

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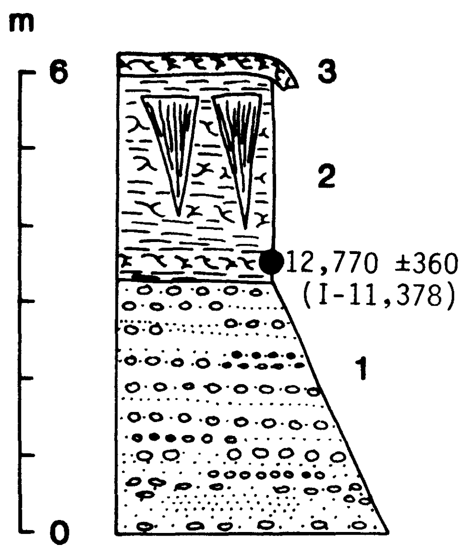
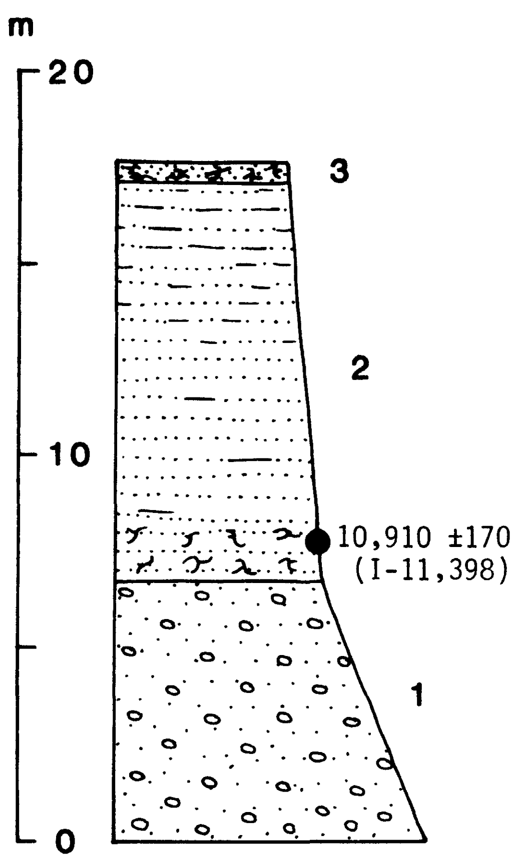


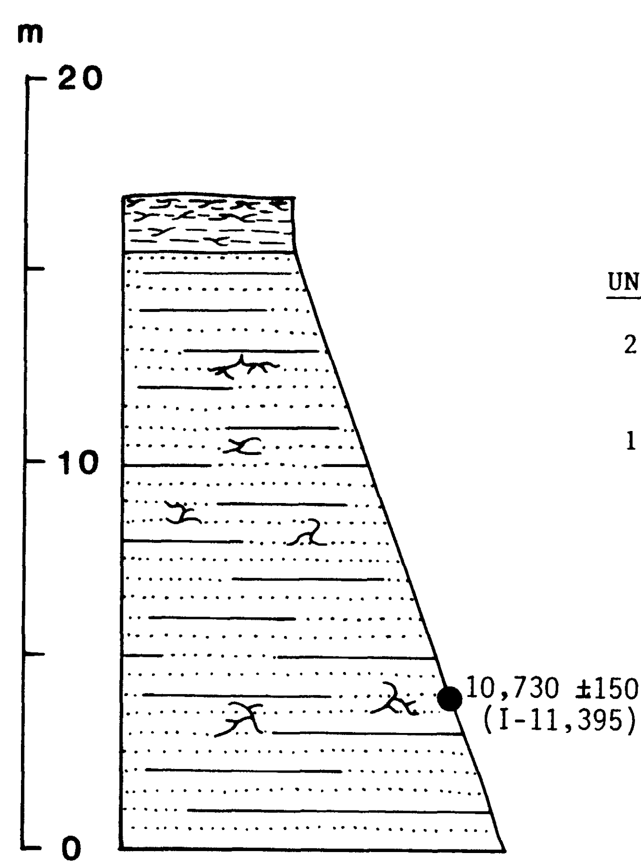
UNIT	THICKNESS (m)	DESCRIPTION
3	0.3	SOD CAP.
2	2.7	SILT AND PEAT. Upper 0.3 m (active layer) is dark grayish brown (2.5Y 4/2) silt with some black (N2) peat lenses. Underlying 2 m is dark olive gray (5Y 3/2) silt and clayey silt with hightly deformed black (N2) peat lenses; cut by ice wedges. Basal 0.4 m locally consists of horizontally bedded silt, peaty silt, and peat with twigs.
1	3.2	SANDY GRAVEL. Rounded pebbles and cobbles up to 20-25 cm diameter in matrix of medium to coarse sand with shale chips. Well bedded; contains lenses and thin layers of coarse to medium sand and pebble-granule gravel.

Figure 1. Exposure OK-1. West bank Okokmilaga River 2.5 km above its mouth. Section measured from river level.



UNIT	THICKNESS (m)	DESCRIPTION
3	0.5	SAND CAP. Peaty silty sand, weakly bedded, with abundant rootlets.
2	10.4	SAND AND SILT. Very dark gray (5YR 3/1) to yellowish red (5YR 5/6) slightly clayey silty fine sand. Grades downward into dark brown (7.5YR 3/2) fine sand, with abundant rootlets in basal 1.5 m.
1	6.7	GRAVEL. Subrounded to rounded pebbles, cobbles, and some small boulders (up to 42 cm diameter) in matrix of coarse sand and granules. Some stones near upper contact are fractured and carbonate-encrusted.

Figure 2. Exposure OK-2. North end of kettle lake on valley floor east of Okokmilaga River 4.5 km north of Tikmiapalik Creek. Section measured from lake level.



UNIT	THICKNESS (m)	DESCRIPTION
2	1.5	PEAT AND SILT. Brown to gray silty peat, grading downward into peaty silt.
1	15.5	SAND. Very dark gray (10YR 3/1) fine to medium sand with shale chips, horizontally bedded in well to weakly defined beds 1-4 cm thick. Contains willow roots and rootlets.

Figure 3. Exposure OK-3. East bank Okokmilaga River 2 km north of Tikmiakpalik Creek. Section measured from water level.

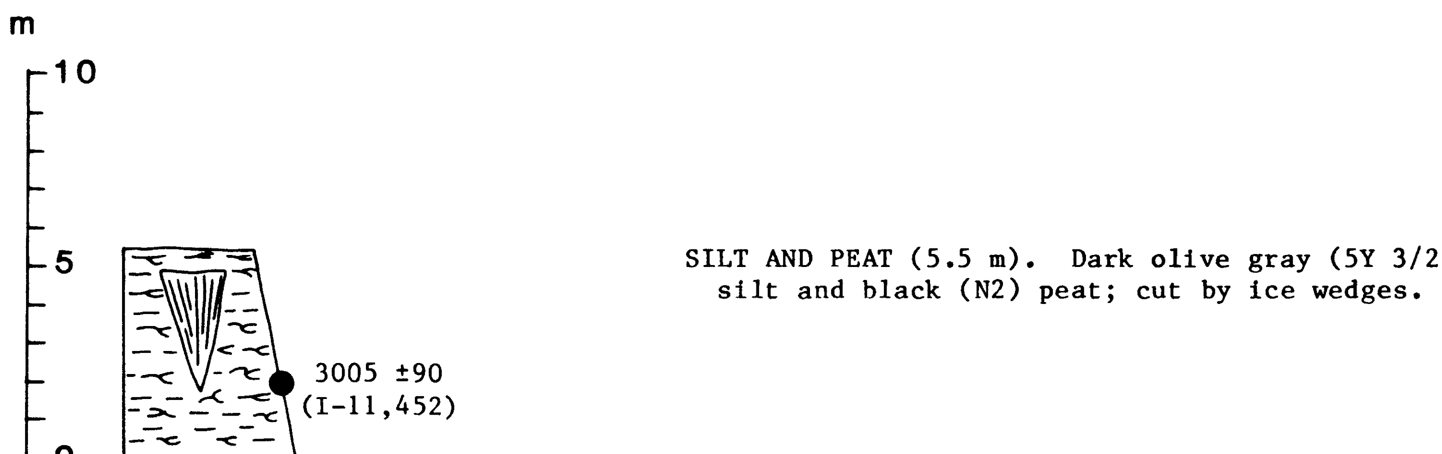
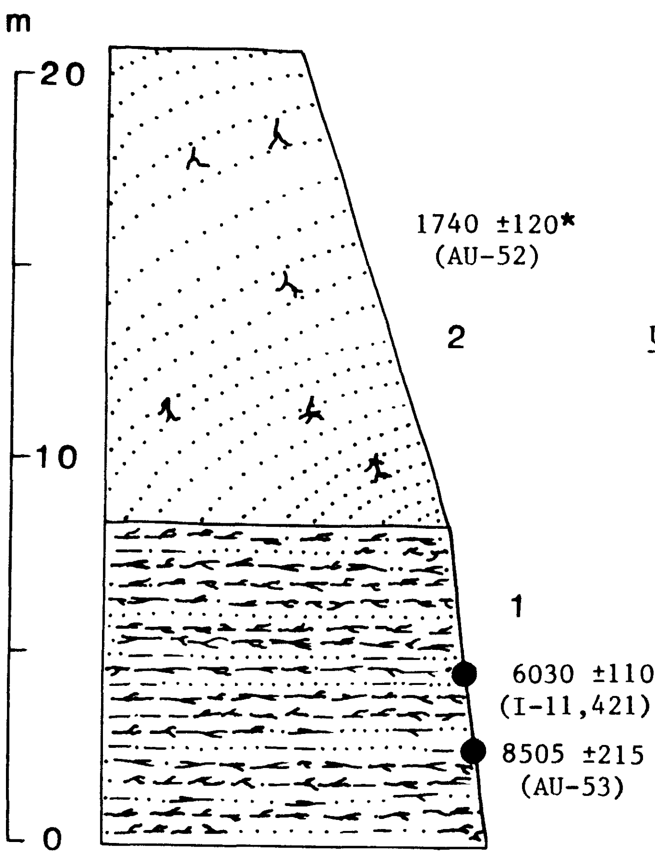


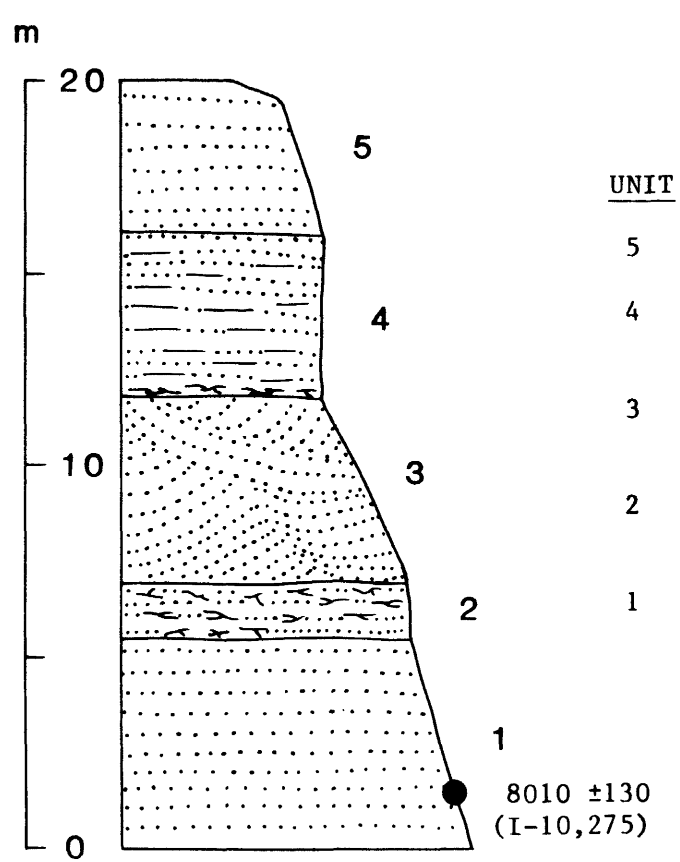
Figure 4. Exposure OK-4. East side Okokmilaga River near mouth of Takuak Creek. Section measured from river level.



UNIT	THICKNESS (m)	DESCRIPTION
2	12.4	DUNE SAND. Cross-bedded medium sand containing shale chips. Contains abundant roots and root hairs, especially through basal 3 m.
1	8.3	SAND AND PEAT. Parallel-bedded sandy peat, with lenses and layers of medium sand to organic silty fine sand. Peat is mainly grasses and sedges, with some rooted twigs of dwarf birch or willow.

*Projected from farther west along bank

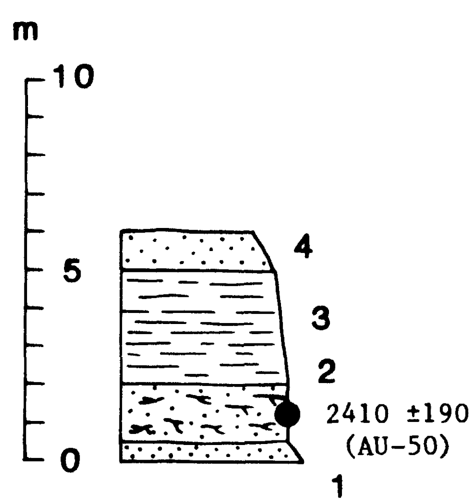
Figure 5. Exposure KI-1. North side Killik River 0.5 km south of Lake Udrivik. Section measured from river level. Stratigraphic position of sample AU-52 is projected from location farther west along exposure face.



UNIT	THICKNESS (m)*	DESCRIPTION*
5	4	EOLIAN SAND. Subhorizontal bedding.
4	4.3	GLEYED SAND. Organic-rich marsh deposit; peaty layer at base.
3	4.8	FLUVIAL SAND. Cross-bedded; fills channel in unit 2.
2	1.4	PEATY SAND. Locally interbedded with eolian sand
1	5.5	SAND. Parallel-bedded basin-fill deposit, contains rooted willows.

*Approximate

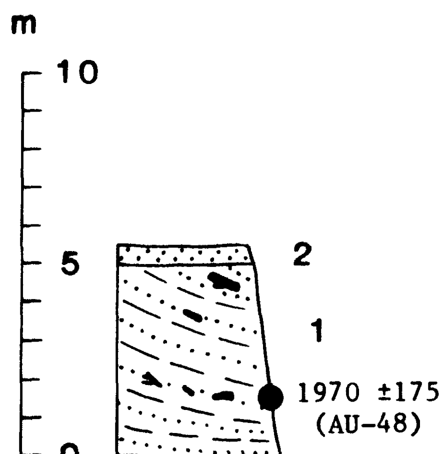
Figure 6. Exposure KI-2. North side Akmalik Creek 0.8 km west of confluence with Killik River. Section measured from level of modern floodplain.



UNIT	THICKNESS (m)*	DESCRIPTION
4	1	EOLIAN SAND. Fine sand, structureless; thickens downvalley into 10-m dunal deposit above modern point-bar gravel.
3	3	SILTY CLAY. Gray, nonbedded; desiccated at upper surface
2	1.5	PEAT. Sedge or grass peat with thin interbeds of silty fine sand.
1	0.5	SAND. Medium to fine sand, parallel bedded to cross-bedded; contains abundant detrital wood

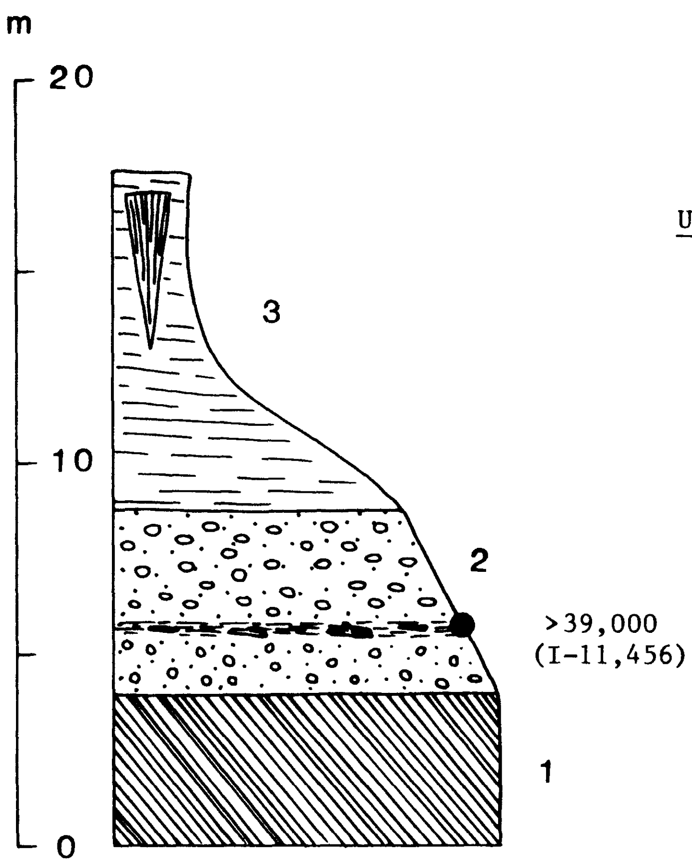
*Approximate

Figure 7. Exposure KI-4. West bank Killik River 1 km south of Togoyuk Creek. Section measured from river level.



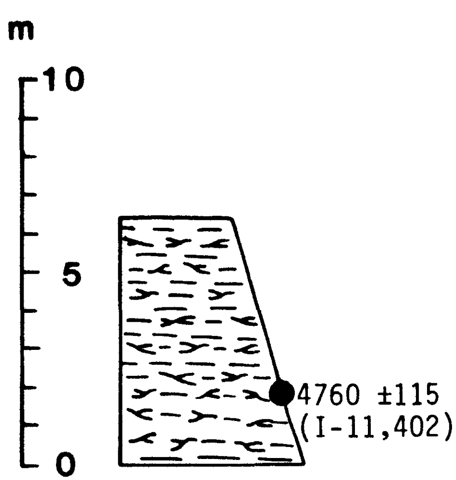
UNIT	THICKNESS (m)	DESCRIPTION
2	0.5	EOLIAN SAND. Structureless; very well sorted.
1	5.0	SILT AND FINE SAND. Cross-bedded, with foreset beds dipping downvalley; oxidized throughout; contains abundant detrital wood. Clayey near base, with frost structures present.

Figure 8. Exposure KI-5. West bank Killik River 1 km south of Lake Kaniksrak. Section measured from river level.



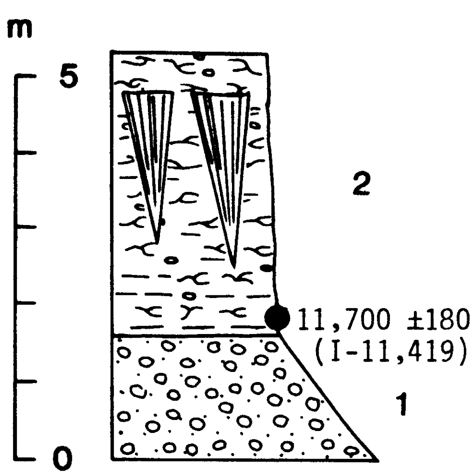
UNIT	THICKNESS (m)	DESCRIPTION
3	8.8	SILT. Dark gray, ice-rich, with large lenses or wedges of ice. Outer face retreating by thaw to form cirque-like hollow.
2	4.8	GRAVEL. Rounded oxidized stones up to cobble size, with some small boulders, in oxidized matrix of coarse sand and granules with secondary silt. Wood occurs in bed of organic clayey silt 50-60 cm thick
1	4.0	BEDROCK. Dark fissile shale.

Figure 9. Exposure KU-1. East side Nogak Creek 10.5 km above its mouth. Section measured from river level.



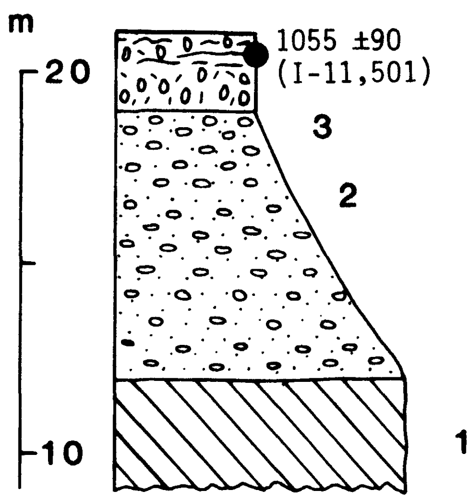
PEAT (6.4 m). Peat and silty peat, containing Sphagnum, sedges, and abundant rootlets.

Figure 10. Exposure KU-2. West side Kurupa Lake inlet stream 3 km above Kurupa Lake. Section measured from water level.



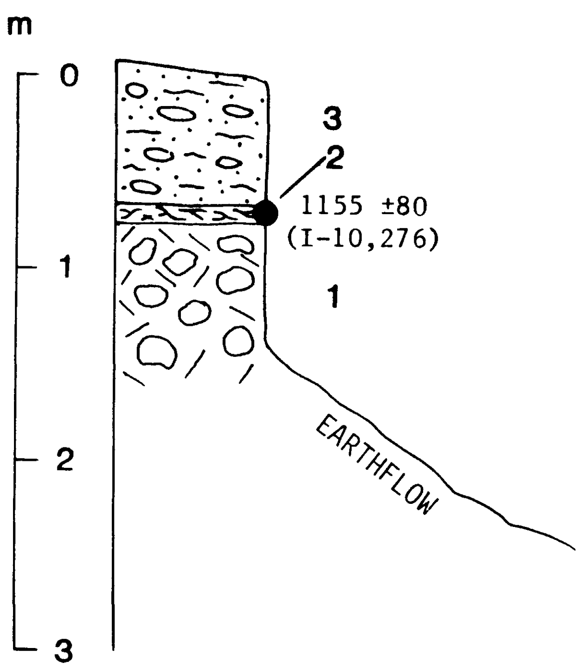
UNIT	THICKNESS (m)	DESCRIPTION
2	3.7	PEAT. Black peat containing scattered pebbles and some small cobbles. Forms lenses and pockets in very dark gray (N3) silt near base. Cut by ice wedges.
1	1.6	GRAVEL. Rounded pebbles and small cobbles in sand matrix. Largest stones are 14-18 cm long.

Figure 11. Exposure EA-1. West bank East Fork Etivluk River 11.5 km below mouth of Iteriak Creek. Section measured from river level.



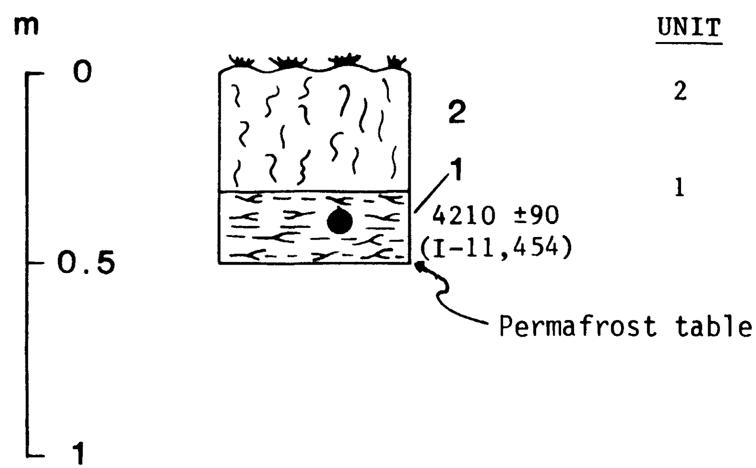
UNIT	THICKNESS (m)	DESCRIPTION
3	2	FROST-MIXED ZONE. Dark yellowish brown (10YR 3/4) stony silt with sparse dark reddish brown (5YR 3/3) peat lenses in upper 0.5 m; grading downward into silty gravel. Stones weathered and discolored by oxides; many stand vertically.
2	7	GRAVEL. Pebble-small cobble gravel at base, with rounded stones up to 10-12 cm diameter (rarely to 20 cm) in matrix of coarse sand and platy shale granules. Coarsens upwards into cobble gravel with rounded to occasional subrounded stones up to 25 cm (very rarely up to 35 cm) length in matrix of coarse sand and granules.
1	12	BEDROCK. Siltstone.

Figure 12. Exposure EA-2. West bank of East Fork Etivluk River 5 km below mouth of Iteriak Creek. Section measured from river level.



UNIT	THICKNESS (m)	DESCRIPTION
3	0.68	COLLUVIUM. Sparse stones in matrix of silty sand. Stone fabric parallels slope.
2	0.07	PEAT. Overlies slightly oxidized silty sand in places.
1	2+	TILL. Subangular to subrounded stones up to boulder size in matrix of ice-rich stony silty sand.

Figure 13. Exposure NI-1. East bank Nigu River 5 km east of Etivluk Lake. Section measured from top of earthflow head wall.



UNIT	THICKNESS (m)	DESCRIPTION
2	0.31	SILT. Dark yellowish brown; slightly clayey. Highly deformed by frost churning.
1	0.19	PEAT AND SILT. Very dark gray (N3) silty humic peat to slightly clayey humic silt.

Figure 14. Soil pit in upland surface, south side Awuna Valley 21 km west of Awuna River mouth. Located within Ikpikpuk River quadrangle 1 km north of Killik River quadrangle boundary. Section measured from top of pit.

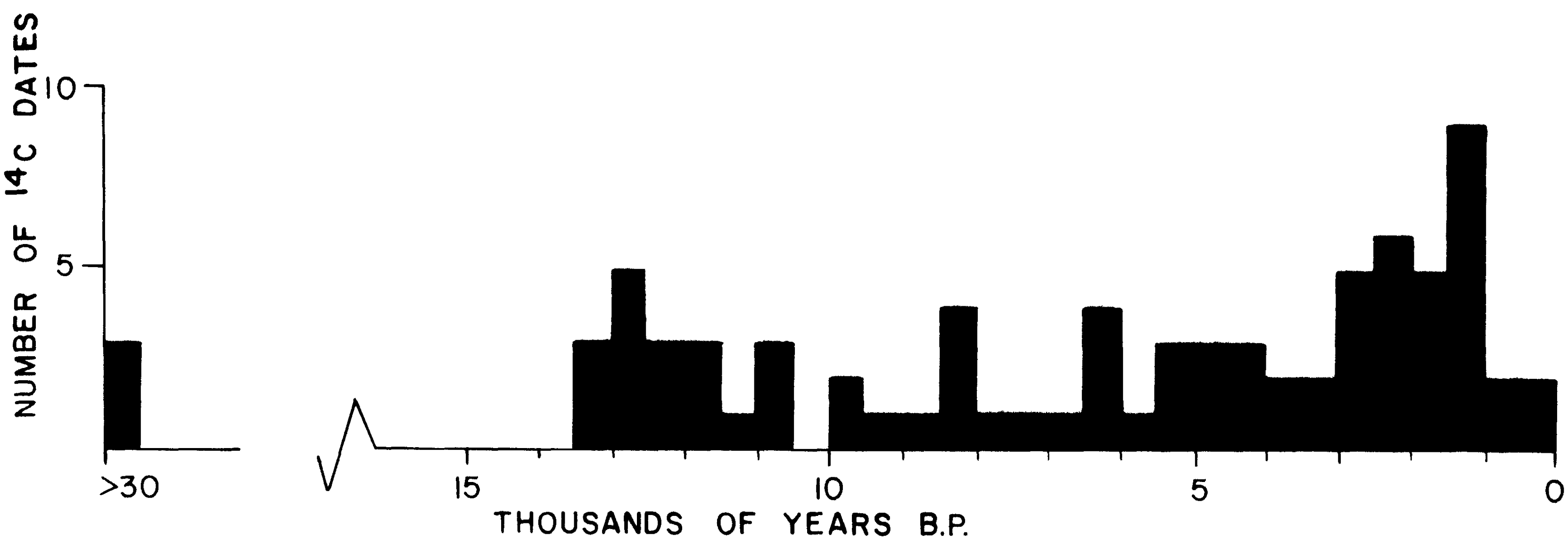


Figure 15. Histogram showing age distribution of radiocarbon dates (N = 78) from north-central Brooks Range. Plotted in 500-year increments. Archeologic dates not included.

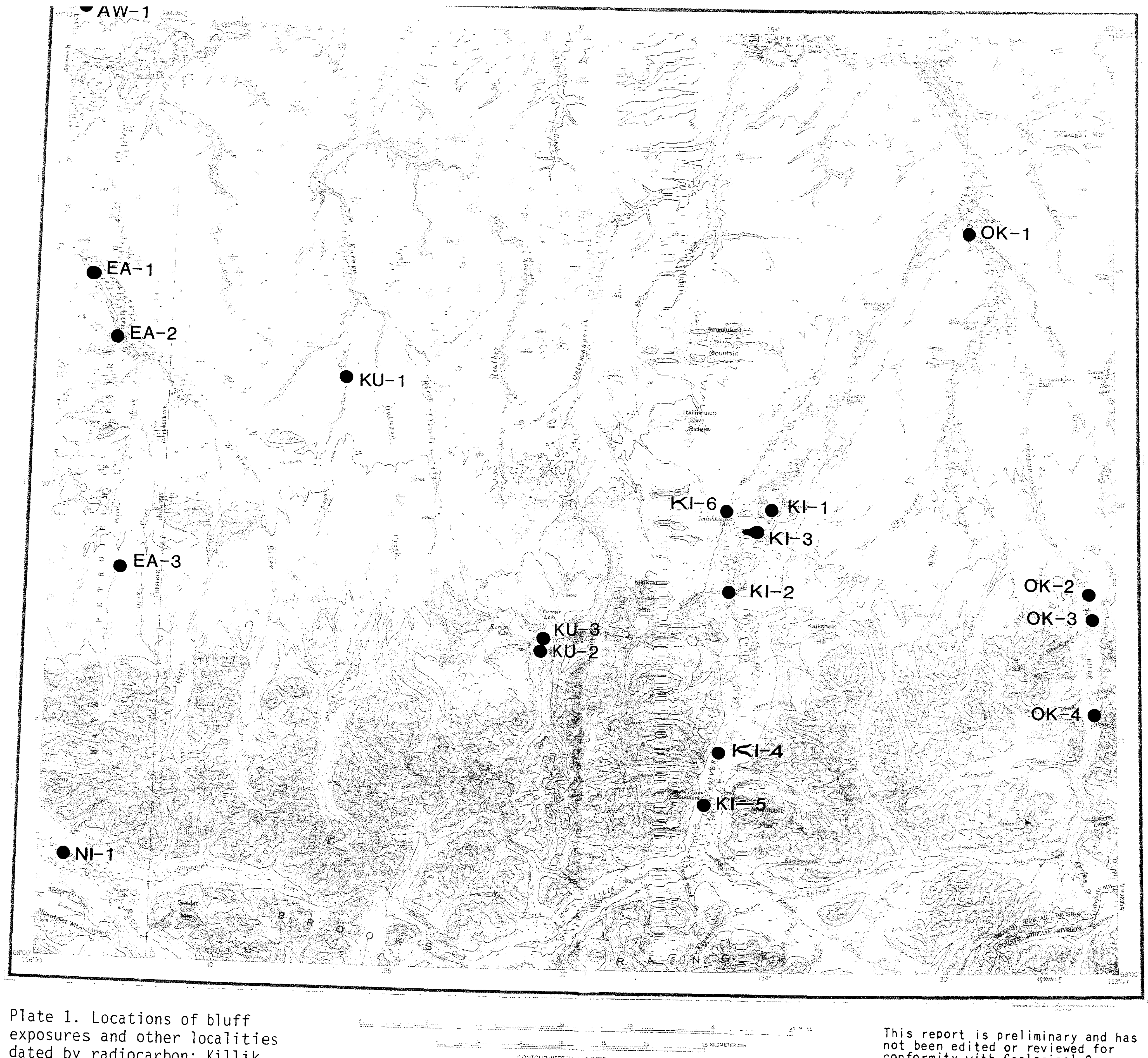


Plate 1. Locations of bluff exposures and other localities dated by radiocarbon; Killik River quadrangle, Alaska.

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.