Quaternary Stratigraphic Nomenclature in Unglaciated Central Alaska

By TROY L. PEWE

GEOLOGICAL SURVEY PROFESSIONAL PAPER 862

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1975

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress Cataloging in Publication Data

Péwé, Troy Lewis, **1918–**

Quaternary stratigraphic nomenclature in unglaciated central Alaska.

(Geological Survey Professional Paper 862)

Bibliography: p. 22-24.

Supt. of Docs. No.: I **19.16:862**

1. Geology, stratigraphic—Quaternary. 2. Geology, stratigraphic—nomenclature—Alaska. I. Title. II. Series: United States Geological Survey Professipnal Paper 862.

QE696.P44 557.3'08s **[551.7'9'014]** 74–26639

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 – Price $1.25 (paper cover)

Stock Number 2401-02574

CONTENTS

ILLUSTRATIONS

TABLES

QUATERNARY STRATIGRAPHIC NOMENCLATURE IN UNGLACIATED CENTRAL ALASKA

By Troy L. Péwé

ABSTRACT

Fifteen long-recognized stratigraphic units of Quaternary age in unglaciated central Alaska are here defined and given formal names. A systematic classification is proposed under which the Quaternary sand, gravel, volcanic ash, loess, retransported loess, and organic deposits can be readily identified. The loess deposits and retransported loess stratigraphic units can be correlated widely in central Alaska and recognized from the Canadian border to the Bering Sea; however, the stratigraphy of underlying creek gravel deposits can be correlated only locally. All sediments perhaps originated in a periglacial climate and are in large part perennially frozen today. The stratigraphic sequence reveals both glacial and interglacial times. More than 150 radiocarbon dates that are applicable to the late Quaternary stratigraphy are presented and arranged by geological formation and locality.

INTRODUCTION

Detailed geologic mapping, floral and faunal studies, sedimentation analyses, and landform studies in central Alaska, mainly in the mining exposures near Fairbanks, since 1940[1] provide the bases for establishing a Quaternary stratigraphic sequence in unglaciated central Alaska. Three geologic names have previously been formalized, but 15 names have been only used informally by the writer, some for as long as 25 years. The long recognized units are here formally defined.

The Quaternary rocks consist entirely of unconsolidated (except most of them are perennially frozen) sand, gravel, volcanic ash, loess, retransported loess, and organic deposits. This report introduces new stratigraphic units, describes their geologic relations, and formulates a systematic classification under which they can be readily identified. Like all classification systems, the one presented here should be modified and expanded as the need develops. The typical lithology and location of the units are described briefly here. Detailed descriptions are found in published reports.

[1]Taber (1943); Péwé (1948, 1952, 1954, 1955a, 1958a, b, 1965a, b, c, 1966, 1968, 1970, 1975); Pewe and Rivard (1961); Péwé and others (1966); Péwé and Sellmann (1971); Williams and others (1959); Sellmann (1967, 1968); Guthrie (1968a, b); Matthews (1968, 1970). (In 1940 J. B. Metcalfe and Ralph Tuck compiled an extensive unpublished report entitled "The Fairbanks Placer Gold Deposits." It is in the files of the U.S. Smelting, Refining, and Mining Co. in New York City. It is referred to in this paper as J. B. Metcalfe and Ralph Tuck, unpub. rept., 1940 and is not listed in "References Cited.")

PHYSICAL SETTING

The area of central Alaska that has not been glaciated is mainly confined to the Yukon-Tanana Upland, a region of rolling hills lying between the Yukon River on the north and the Tanana River on the south, but also includes the foothills of the eastern Alaska Range to the south (fig. 1). Lying south of the Brooks Range and north of the towering Alaska Range, the area was encircled by glaciers on the north, south, and east in Pleistocene time. Small glaciers existed on high peaks in the Yukon-Tanana Upland at this time.

The Quaternary sediments are mainly limited to low hills, lower slopes, and valley bottoms and consist of loess, some of it retransported, and alluvial deposits **(fig. 2).** Deposits of coarse angular creek gravel of local origin underlie the eolian sediments in valley bottoms, and solifluction debris underlies the eolian deposits on the lower and middle slopes. Some outwash gravel is present in major valleys. All the sediments perhaps originated in a periglacial climate and are in large part perennially frozen today. The stratigraphic sequence reveals both glacial and interglacial times.

The loess and retransported loess formations can be correlated widely in central Alaska, but not the underlying creek gravel deposits, whose stratigraphy is well established only in the Fairbanks area.

RADIOCARBON DATING

Unglaciated central Alaska is an excellent locality for radiocarbon dating because of the wonderful preservation of organic specimens. The stratigraphic sequence consists mainly of valley-bottom sediments, sediments that have been washed slowly from the hillsides to accumulate with a great deal of organic material in the form of forest beds, fine particles, and even carcasses of extinct animals. Much of the organic material has been frozen for thousands of years and is well preserved.

The writer began radiocarbon dating samples from central Alaska in 1949, and over the last 26 years many samples have been dated directly or indirectly in connection with his projects. A total of 155 dates are avail-

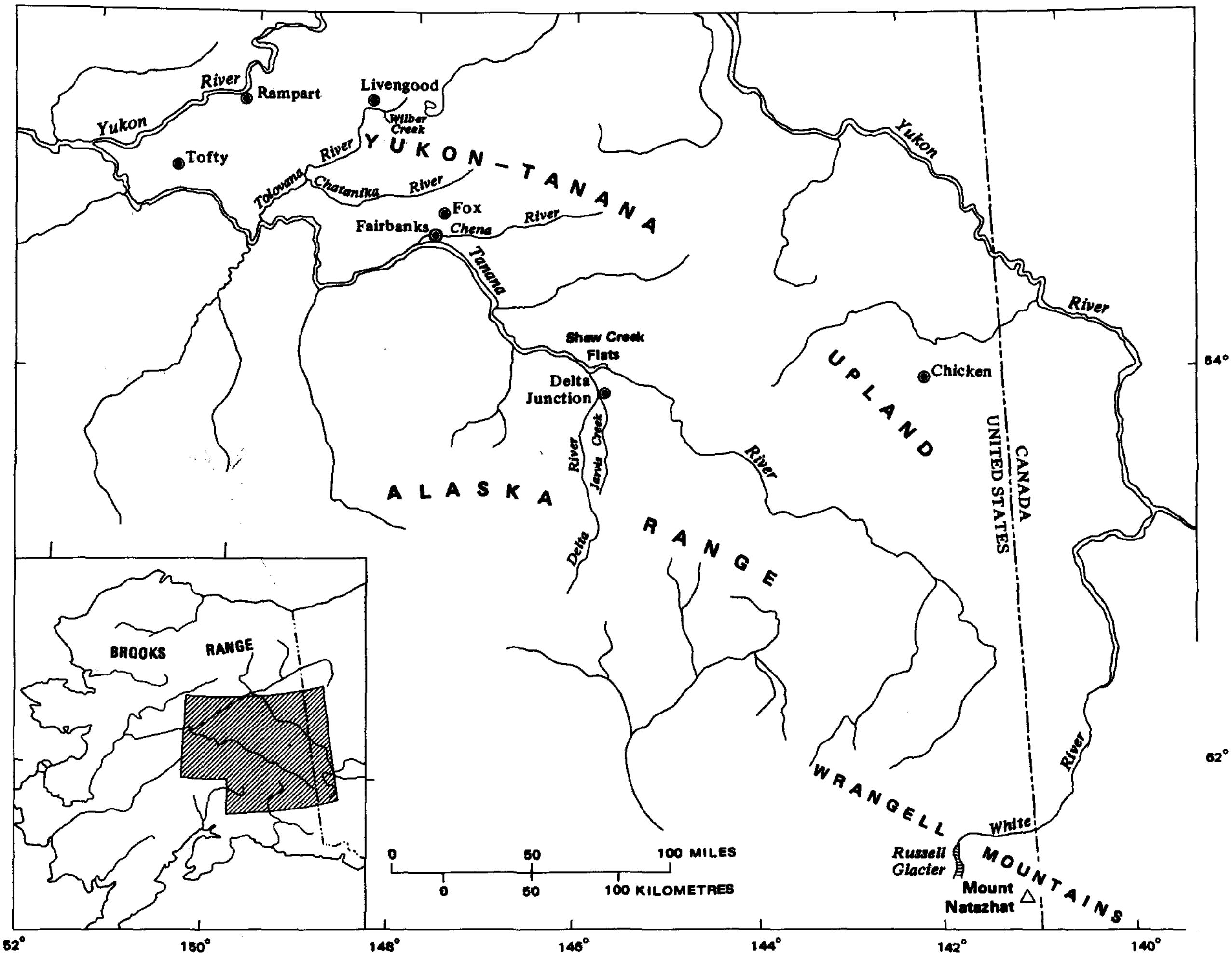

FIGURE 1.—Index map of east-central Alaska.

able that are applicable to the stratigraphic sequence described here, all but a few from the Fairbanks region. They are given in table 4, arranged first by geologic formation and then by locality.

ACKNOWLEDGMENTS

The author is indebted to David M. Hopkins, Helen L. Foster, and Lawrence R. Mayo of the Geological Survey and to Robert K. Merrill for a careful review of the manuscript. Mr. Merrill aided in determining details of the volcanic ash and preparation of some of the illustrations. Randall G. Updike also aided in examining some of the volcanic ash samples, and Deborah G. Robinson carefully handled the many details of bibliography compilation. Both Mrs. Robinson and John W. Bell deserve many thanks for their aid in the compilation of the table involving radiocarbon dates. Deep appreciation is expressed to members of the staff of the U.S. Smelting, Refining, and Mining Co., especially to James D. Crawford and the late John B. Metcalfe, for continued cooperation over the many years of association in Alaska.

STRATIGRAPHY

CRIPPLE GRAVEL

At least two placer gold-bearing gravel formations are exposed by large-scale gold-dredging operations in the Fairbanks area. Although studied, mapped, and mined for 75 years or more, these formations have never been formally named. The older is here named the Cripple Gravel (table 1) from exposures on Cripple Creek 15 km west of Fairbanks (fig. 3).

The Cripple Gravel is everywhere buried by younger formations except where exposed by mining operations or, rarely, by a river. It occurs only in discontinuous stretches on buried bedrock benches 25–50 m above the younger valley-bottom gravel (Pewe, 1965a, fig. 1–9), especially in the many creek valleys draining Ester, Pedro, and Gilmore Domes near Fairbanks. Its spatial relations are shown diagrammatically in figure 4.

The type locality is designated the mining excavation in the valley of Cripple Creek adjacent to "Ester Island" (fig. 3), a hillock of loess that lies between Ester and

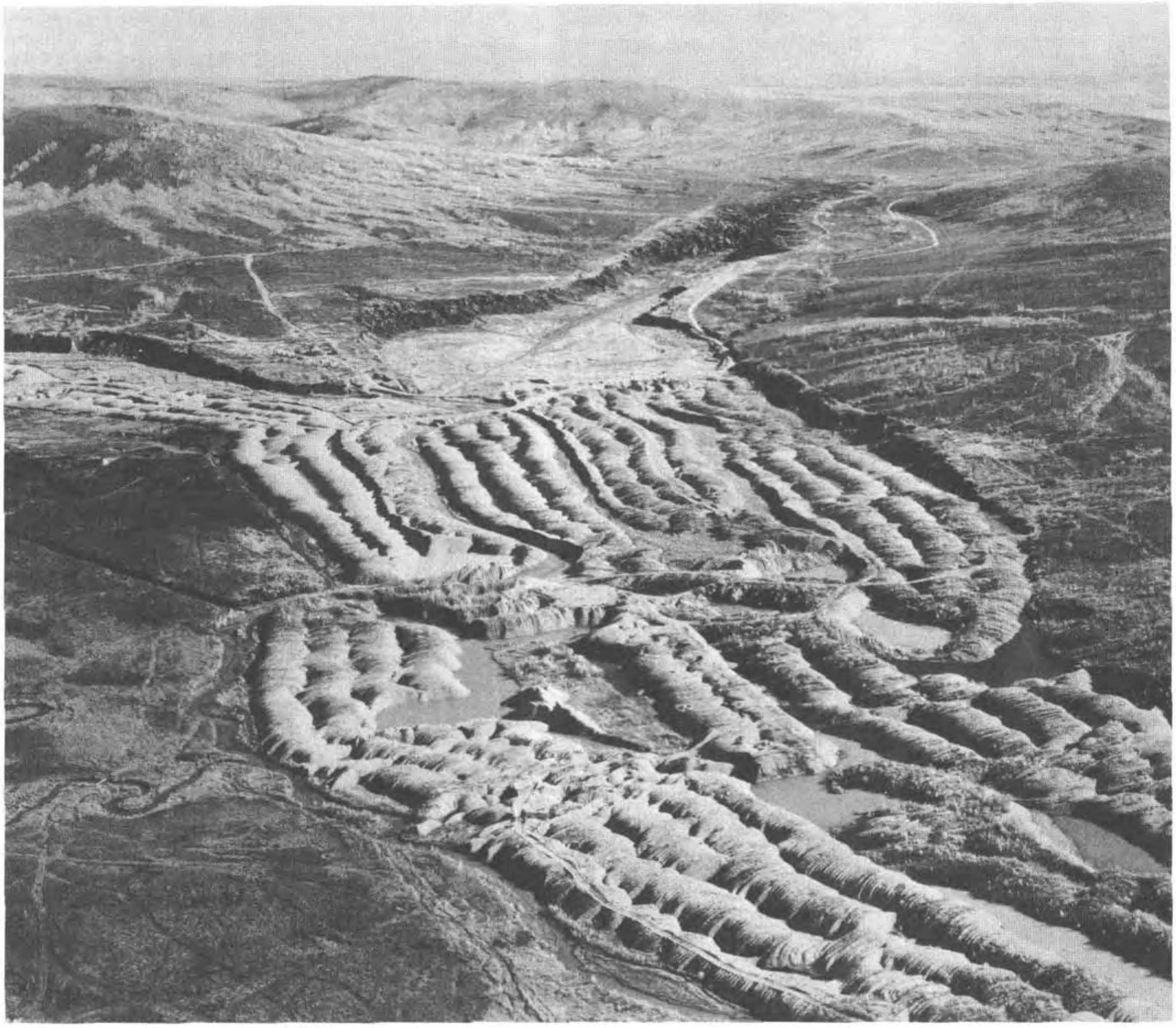

FIGURE 2.—Low oblique air view looking southeast near junction of Engineer and Goldstream Creeks, Fairbanks. Gravel dredge tailings in foreground and to left are on Goldstream Creek. Frozen silt removed from creek-valley bottom by hydraulic stripping is exhibited on Engineer Creek in middle ground. (Photograph 2414 by Bradford Washburn, September 1936.)

Cripple Creeks in the SW¼ sec. 8, T. 1 S., R. 2 W., Fairbanks D-3 quadrangle. At this locality the unit is 25 m thick.

The Cripple Gravel consists of poorly to well-stratified coarse angular sandy gravel with lenses of silt and sand as much as 1 m thick and 2 m long. The gravel clasts are imbricate in some places and consist almost entirely of quartz-mica shist, chlorite schist, phyllite, slate, gneiss, quartz, quartzite, and igneous rocks. The gravel has been transported only short distances, and the composition varies depending on the bedrock source. The gravel fragments are generally 2–15 cm in diameter; cobbles 25 cm or larger are not uncommon in certain areas. Mechanical analyses of much of the gravel from two 15-cm-diameter wells at the type locality reveal that the sediment is poorly sorted and consists of as much as 50 percent sand (Péwé, 1952, p. 36). The composition of the auriferous gravel was described in detail many years ago (Prindle, 1906, 1908a, 1908b, 1913; Mertie, 1937).

In mine tailings, iron oxide stain on the pebbles, cobbles, and boulders imparts a brown color to the formation, in contrast to the tan color of the younger, auriferous Fox Gravel (Péwé, 1965a, p. 16–18). In mining

TABLE 1.—*Quaternary* stratigraphic nomenclature of *unglaciated* central Alaska

Name	Age[1] (B.P. × before present)	Lithologic description	Source of name	Type section (TS) or type locality[2] (TL)
Chena Alluvium	Pleistocene and Holocene (Illinoian(?) to Holocene).	Fluvial sand and gravel, some outwash.	Chena River	TS: Well B, U.S. Smelting, Refining, and Mining Co., SE¼ sec. 3, T. 1 S., R. 1 W., Fairbanks D–2 quad.
Engineer Loess	Holocene (<10,500 yr B.P. ±500).	Loess	Engineer Creek.	TL: Dawson mining cut, mouth of Engineer Creek, SW¼ sec. 6, T. 1 N., R. 1 E., Fairbanks D–2 quad.
White River Ash Bed	Holocene (1,400 yr B.P.).	Ash	White River	TS: North side of White River 13 km downstream from its source, McCarthy D–2 quad.
Jarvis Ash Bed	Holocene (<4,600 yr B.P., >2,000 yr B.P.).	do	Jarvis Creek	TS: Right bank of Delta River 40 km south of Delta Junction, SW¼ sec. 19, T. 14 S., R. 10 E., Mt. Hayes C–4 quad.
Wilber Ash Bed	Holocene (<4,260 yr B.P.).	do	Wilber Creek	TS: West wall of Wilber Creek mining cut, 10 km south of Livengood, Livengood B–3 quad.
Ready Bullion Formation	Holocene (<10,000 yr B. P.).	Colluvial retransported loess and forest beds.	Ready Bullion Creek.	TS: East wall of Ready Bullion bench mining cut, SW% sec. 6, T. 1 S., R. 2 W., Fairbanks D-3 quad.
Goldstream Formation	Pleistocene (Wisconsinan, >10,000 yr B. P., >39,000 yr B.P.).	Colluvial retransported loess.	Goldstream Creek.	TL: Goldstream Creek mining cut, NW% sec. 32, T. 2 N., R. 1 E., Fairbanks D-2 quad.
Chatanika Ash Bed	Pleistocene (Wisconsinan, <14,860 yr B. P. ±840).	Ash	Chatanika River.	TS: Right limit of Chatanika River, NW% sec. 15, T. 3 N., R. 1 W., Livengood A–2 quad.
Eva Formation	Pleistocene (Sangamon, >56,900 yr B. P.).	Organic silt and forest beds.	Eva Creek	TS: North wall of Eva Creek mining cut, SW¼ sec. 5, T. 1 S., R. 2 W., Fairbanks D–3 quad.
Gold Hill Loess	Pleistocene (Illinoian)	Loess	Gold Hill	TS: North wall of Gold Hill mining cut, SW¼ sec. 3, T. 1 S., R. 2 W., Fairbanks D–2 quad.
Dome Ash Bed	Pleistocene (Illinoian)	Ash	Dome Creek	TL: Dome Creek mining cut, NW¼ sec. 5, T. 2 N., R. 1 E., Livengood A–2 quad.
Ester Ash Bed	Pleistocene (Illinoian)	do	Ester Creek	TS: "Ester Island" mining cut, SW% sec. 8, T. 1 S., R. 2 W., Fairbanks D–3 quad.
Fairbanks Loess	Pleistocene and Holocene (Illinoian through Holocene).	Loess	City of Fairbanks.	TS: "Ester Island" mining cut, SW% sec. 8, T. 1 S., R. 2 W., Fairbanks D–3 quad.
Dawson Cut Formation	Pleistocene (Yarmouth?)	Organic silt and forest beds.	Dawson mining cut.	T S Dawson mining cut, SW% sec. 6, T. 1 N., R. 1 W., Fairbanks D–2 quad.
Tanana Formation	Early or middle Pleistocene.	Solifluction deposits.	Yukon-Tanana Upland.	TL: South valley wall of Pedro Creek at junction with Twin Creek, SE% sec. 11, T. 2 N., R. 1 E., Livengood D–3 quad.
Fox Gravel	Early or middle Pleistocene.	Tan auriferous gravel.	Village of Fox	TL: Mining cut near Fox in Goldstream valley, SE¼ sec. 31, T. 2 N., R. 1 E., Fairbanks D-2 quad.
Cripple Gravel	Late Pliocene and (or) early Pleistocene.	Brown auriferous gravel and solifluction deposits.	Cripple Creek	TL: Mining cut at Cripple Creek near "Ester Island," SW¼ sec. 8, T. 1 S., R. 2 W., Fairbanks D-3 quad.

[1]Radiocarbon dating.
[2]Quadrangle (quad.) is U.S. Geological Survey topographic quadrangle map.

shafts in the perennially frozen ground, the older bench gravel appears red (**Prindle, 1908b**, p. 45). In great contrast to the common brownish gravel dominantly composed of metamorphic rocks is a white gravel facies of the Cripple Gravel exposed only on bench workings at the mouth of Engineer Creek. The gravel is composed of fairly well rounded quartz and quartzite boulders in a gray sandy matrix with mica flakes.

The Cripple Gravel appears to be a valley-bottom accumulation of solifluction material that was carried downslope on hillsides during a time of periglacial conditions. This would account for the angularity, poor sorting, and poor stratification. Stream action has carried the debris short distances and winnowed out some of the fine fraction.

A characteristic feature of the Cripple Gravel is the presence of placer gold at and near the base of the formation. The gold in the Fairbanks area occurs in the formation from the upper part of small valleys, near the bedrock source, downstream generally 4 to 6 km, al-

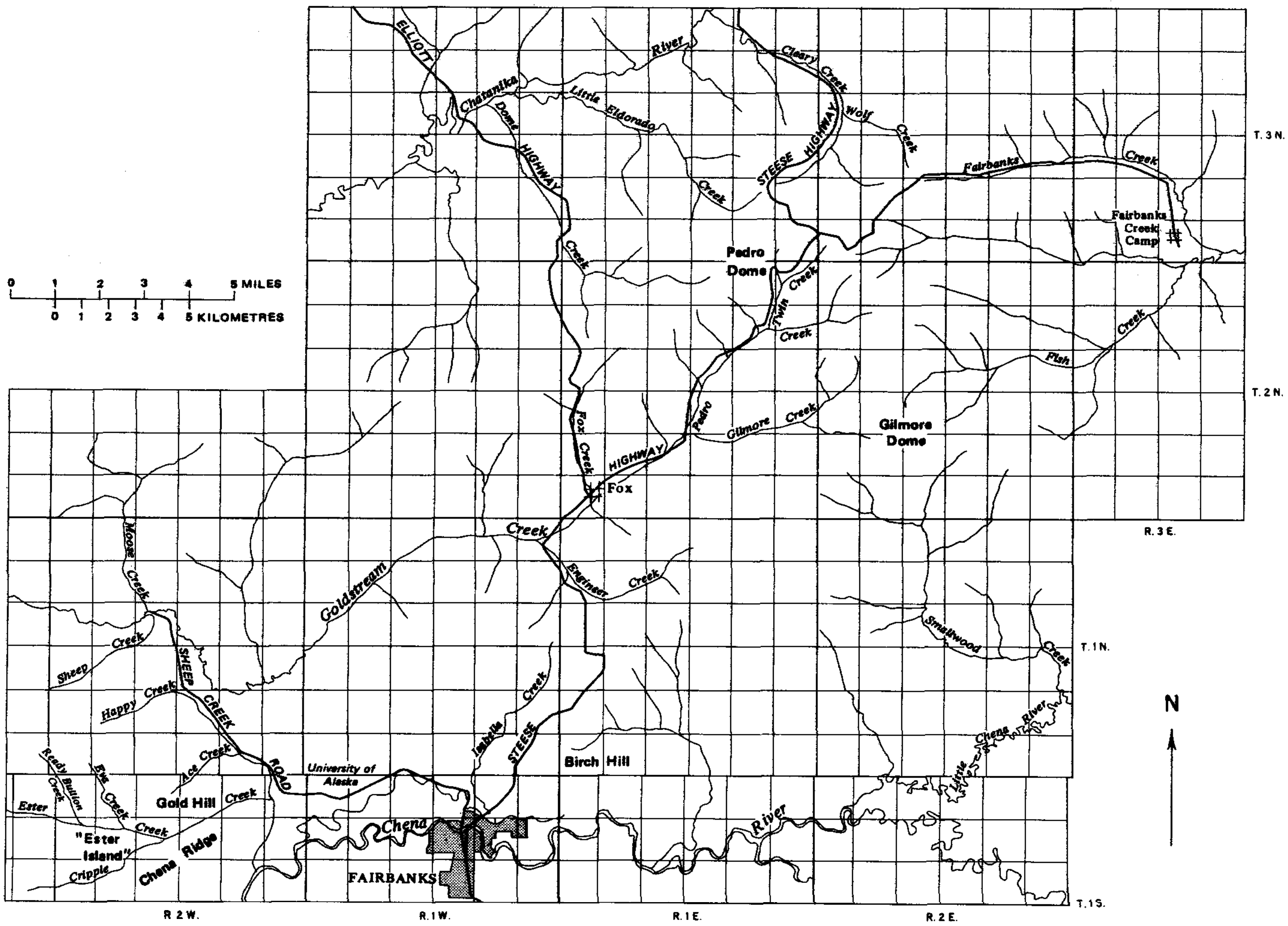

FIGURE 3.—The Fairbanks area.

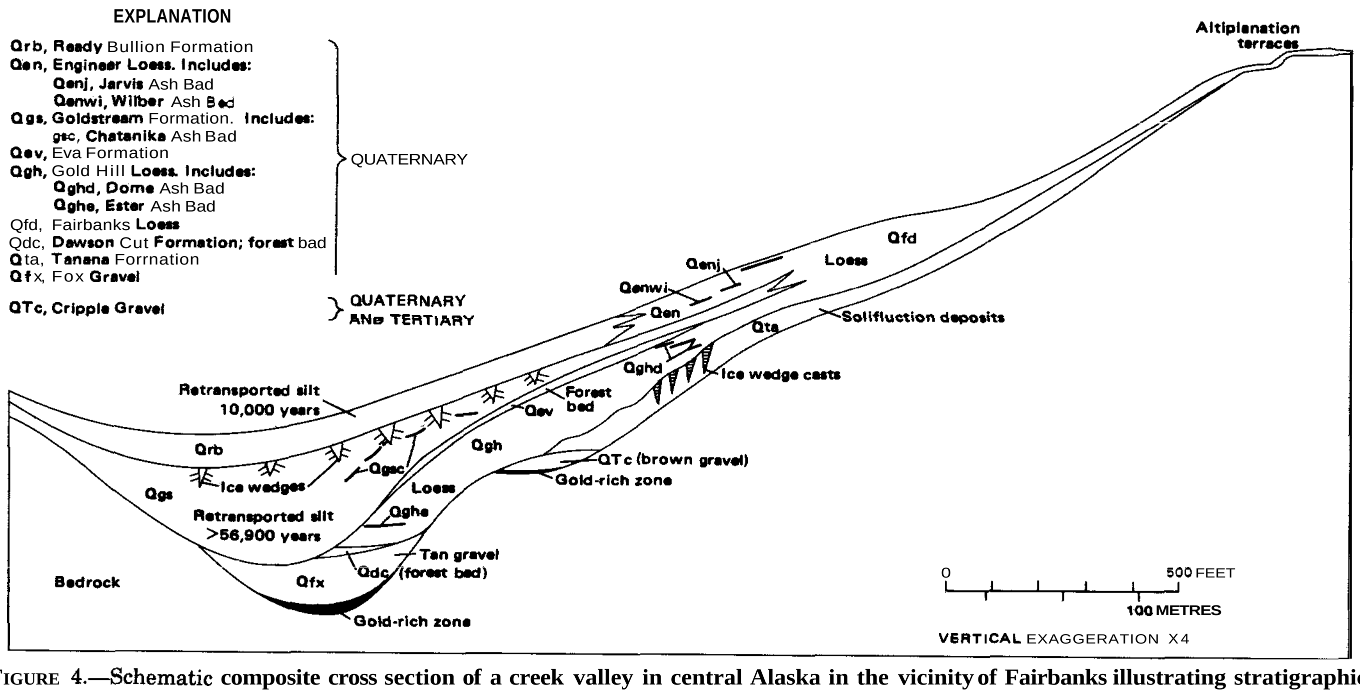

FIGURE 4.—Schematic composite cross section of a creek valley in central Alaska in the vicinity of Fairbanks illustrating stratigraphic relations of the Quaternary deposits.

though a distance of 15 km is not uncommon (Prindle and Katz, 1913, pl. 11). The placer gold in the Fairbanks area is fine to medium; if all the small flakes are considered, the average size of all grains is between 0.4 and 0.58 mm in diameter. Pieces larger than 1 cm are rare. Particle size decreases downstream.

The fineness of placer gold in the gravel formations in the Fairbanks area ranges from a high of 950 to a low of 800, depending on the fineness of the source lode and subsequent weathering and erosion. Smith's (1913, 1941) careful work in the Fairbanks area supports the long-held idea that placer gold increases in fineness the farther it is removed from the parent vein (Devereux, 1882; Browne, 1895; McConnell, 1907; Lindgren, 1911; Gardner and Johnson, 1934; Tuck, 1968). Mertie (1940) disagreed with this idea on the basis of his Alaskan work. Smith (1913) believed that the fineness of placer gold in the Fairbanks area increases with age by weathering processes, but was unable to prove it. Now, with a better understanding of age and distribution of the gravel formations in the Fairbanks area, it can be demonstrated that the gold of the older channels (Cripple Gravel) is usually finer than gold of the younger Fox Gravel. This explains the anomalous fineness records cited by Smith (1941, p. 195).

The Cripple Gravel ranges in thickness from 1 m on benches in the upper reaches of small creeks to at least 25 m in the lower reaches.

The Cripple Gravel overlies bedrock and is overlain by the Fox Gravel and Tanana Formation. In some localities it is overlain by the Dawson Cut, Fairbanks, Gold Hill, or Goldstream Formations (fig. 4). In most creeks in the Fairbanks area, the Cripple lies on an auriferous clay layer, ½–2 m thick, that is thought to be the result of decomposition of the underlying bedrock. The clay could have resulted from pre-Pleistocene weathering or formed during Pleistocene interglacial times by percolation of ground water.

Although fragments of wood and bones of Pleistocene animals occur in the auriferous gravel in the Fairbanks area (Prindle, 1906, p. 114; 1908b, p. 32; Prindle and Katz, 1913, p. 94), no fossils have been reported in the Cripple Gravel, and the writer has seen none.

The Cripple Gravel was deposited in erosional valleys that cut through basalt deposits at Fourth of July Hill on Fairbanks Creek and elsewhere near Fairbanks. Mertie (1937, p. 228) considered the basalts to be late Tertiary. In the basalt on Birch Hill and Lakloey Hill at Fairbanks (Péwé, 1952, 1955b, 1958b; Furst, 1968), the writer discovered petrified coniferous wood "related to Metasequoia, Sequoia, or *Taxodium*" (R. W. Brown, written commun., 1958). This indicates that the basalt is early or middle Tertiary in age. MacNeil, Wolfe, Miller, and Hopkins listed (1961) the basalt as early Tertiary.

The Cripple Gravel seems to consist mostly of reworked solifluction debris; thus, it may have been deposited after a frost climate had begun to affect central Alaska. Although glaciers were present in Alaska as much as 10 million years ago (Péwé, 1975, table 1), the climate in late Tertiary time is believed to have been relatively equable and not intensely cold. Glacial ice did push into the interior from the Wrangell and St. Elias Mountains (Denton and Armstrong, 1969), and ice reached the sea to the south (Gulf of Alaska) at least 10 million years ago. In the Arctic Basin evidence of glaciation and cooling 4–6 million years ago, at least in the adjacent highlands, is indicated by ice-rafted pebbles on the ocean floor (Herman, 1970; Herman and others 1971). Until at least 5.7 million years ago, forest vegetation on the Seward Peninsula was similar to that in southeastern Alaska, rather than to that which grows in the Arctic climate of today (Hopkins and others, 1971). The tundra cover and associated cooler climate of the north and cooler climate of the interior probably were well established no earlier than late Pliocene time.

The Cripple Gravel is definitely older than Illinoian because it underlies the Gold Hill Loess (discussed later). It is probably much older because it is stratigraphically under the Dawson Cut Formation, the Tanana Formation, and the Fox Gravel, all of which are pre-Illinoian but otherwise undated. It is therefore believed the Cripple Gravel represents deposits formed during a period of rigorous climate at the end of the Pliocene and beginning of the Pleistocene.

FOX GRAVEL

The Fox Gravel, a placer gold-bearing gravel deposit in the Fairbanks area, is here named for exposures near the village of Fox in Goldstream valley (fig. 3). It is exposed only by mining excavations or, rarely, by a river, but occurs in valley bottoms of most modern creeks. Its spatial relations are shown diagrammatically in figure 4. It does not include the modern angular creek gravel in the high-altitude areas above the thick loess deposits.

The type locality is designated the mining excavations in Goldstream valley in the SE¼ sec. 31, T. 2 N., R. 1 E., Fairbanks D–2 quadrangle near the village of Fox. Here, the Fox Gravel, about 15 m thick, unconformably overlies Precambrian bedrock and underlies the Goldstream Formation.

The Fox Gravel consists of poorly to fairly well stratified coarse angular sandy gravel with lenses of silt and sand as much as 1 m thick and 2 m long. The gravel clasts are imbricate in some places and consist almost entirely of quartz mica schist, chlorite schist, phyllite, slate, gneiss, quartz, quartzite and igneous rocks. The composition varies depending upon the composition of the bedrock source. The angular slightly transported gravel fragments are 2–15 cm in diameter, with cobbles 25 cm or larger not uncommon in certain areas. The composition of the auriferous gravel has been described in detail (Prindle, 1906, 1908a, 1908b, 1913; Mertie, 1937). The tan color of the formation in mine tailings and walls of pits is caused by iron oxide stain on the clasts.

The Fox Gravel is a valley-bottom accumulation of solifluction material that was carried downslope on hillsides in a periglacial environment. It grades upslope into stabilized solifluction deposits—the Tanana Formation. The solifluction deposit was reworked by stream action, and most of the fine fraction removed to leave a poorly sorted angular local gravel. The origin of the deposit was probably first recognized by J. B. Metcalfe and Ralph Tuck (unpub. rept., 1940), although they concluded that it formed during a "preglacial" period.

The Fox Gravel contains placer gold at and near its base and has yielded most of the placer gold in the Yukon-Tanana Upland. It is unusually rich in gold where it crosses high-level older auriferous deposits—the Cripple Gravel (Prindle and Katz, 1913, p. 104; Péwé, 1965a, p. 19). Most of the gold is in the upper parts of the valleys, but the gold-rich zone may extend downstream 6–15 km (Prindle and Katz, 1913, pl. 11). The gold varies in fineness, but generally is less pure than the gold of the Cripple Gravel (J. B. Metcalfe and Ralph Tuck, unpub. rept., 1940).

The Fox Gravel ranges in thickness from 1 m or less in the upper reaches of small creeks to at least 30 m in the lower reaches. The formation lies unconformably on bedrock and is conformably overlain by the Dawson Cut Formation, Fairbanks Loess, Gold Hill Loess, or Goldstream Formations (fig. 4). In most creeks the gravel lies on an auriferous yellowish to bluish clay layer, ½–2 m thick, that is thought to be the result of decomposition of the underlying bedrock during interglacial times (Bell, 1974).

The writer has collected bones of Pleistocene mammoth and bison from the Fox Gravel in the Fairbanks district. The bones of other Pleistocene animals reported by earlier workers from underground gold workings (Prindle, 1906, p. 114, 1908b, p. 32; Prindle and Katz, 1913, p. 94) may have also been from the Fox Gravel.

The Fox Gravel may be distinguished from the older Cripple Gravel in several ways. Topographically the Cripple always lies on bedrock benches above the modern valley bottoms which contain the Fox Gravel (fig. 4). On the average, gold in the Cripple is finer than that in the Fox (if samples are taken in the same creek and the same distance from the lode). The most common difference between the angular sandy gravel of the Fox and the older Cripple is that the cobbles, pebbles, and sand of the Cripple are stained by iron oxide a dark brown to "red but those of the Fox are less stained and tan. Fieldwork in the Fairbanks area reveals that a few bones of Pleistocene animals (bison and mammoth) occur in the Fox, but no bones have ever been reported from the Cripple Gravel.

The Fox Gravel formed during glacial times in a rigorous climate that produced solifluction deposits on hillsides and an accumulation of stream-washed solifluction debris in the valley bottoms. It is assigned an early or middle Pleistocene age as it is significantly younger than the Cripple Gravel. The Fox occupies new bedrock channels cut below the level of the older Cripple Gravel. It contains a sparse fauna of Pleistocene taxa. Mammoth are known in North America only from early Pleistocene time. However, the bison finds in central and western Alaska in pre-Illinoian sediments are perhaps the earliest record in North America (Péwé, 1975; Péwé and Hopkins, 1967). These finds are consistent with the idea that Asian immigrants established themselves in Alaska much earlier than in the southern part of the United States and with Flerow's (1967) idea that ***Bison priscus crassicornis*** migrated from Asia to America before the Riss Glaciation.

It is older than Illinoian because it underlies the Dawson Cut Formation, which is pre-Illinoian but otherwise undated. It considerably predates Illinoian sediments, which at one locality contain the primitive musk-ox, ***Praovibos,*** known from central and eastern Siberia in deposits of pre-Illinoian age (Vangengeim and Sher, 1970; Sher, 1969, 1971).

TANANA FORMATION

The Tanana Formation is here named for a widespread inactive solifluction layer in the Yukon-Tanana Upland of central Alaska (fig. 1). The deposit occurs on almost all lower slopes in unglaciated central Alaska from the valley margins to elevations of 500 m or more and has been referred to as slide rock by the placer gold miners (Prindle, 1908b, p. 181; J. B. Metcalfe and Ralph Tuck, unpub. rept., 1940) and well drillers. It is overlain by 1–30 m of Fairbanks or Gold Hill Loess.

The formation crops out in roadcuts and gravel pits on slopes, but does not crop out on the surface. Its spatial relations are shown diagrammatically in figure 4.

The type locality is designated the borrow pit on the south valley wall of Pedro Creek at its junction with Twin Creek in the SE¼ sec. 11, T. 2 N., R. 1 E., Livengood D-3 quadrangle. At this locality the Tanana Formation is 1 m thick, grades laterally into the Fox Gravel in the valley bottom, and is overlain by the Fairbanks Loess.

The Tanana Formation is poorly stratified and consists of unsorted and angular fractured and weathered bedrock fragments in a silty-sandy matrix. Elongate or platy fragments are oriented parallel to the surface and give evidence of transportation short distances downslope.

The composition of the Tanana varies depending on the local bedrock and may range from grus to greasy clay to the most common type, platy rock fragments in a silty matrix. Special rock types may, in many places, be traced upslope to their bedrock source. Minor amounts of gold are locally present.

The formation is 1–25 m thick; the greatest thicknesses occur at the base of slopes. A thickness of 25 m was measured at the west side of the mouth of Engineer Creek valley (J. B. Metcalfe and Ralph Tuck, unpub. rept., 1940), and the surface of the deposit is reported to have a wavelike configuration.

In multiple exposures on the lower campus of the University of Alaska (Péwé, 1965a, fig. 1–5) (fig. 5) and near Shaw Creek Flats (Péwé, 1965b, fig. 4–22), excellent ice-wedge casts of eolian sand occur in the Tanana Formation. Exposures at the University of Alaska show two solifluction layers of early or middle Pleistocene age; both are lumped into the Tanana Formation. Future work may show need to separate them.

No flora or fauna are known from the Tanana Formation. The solifluction deposits originated in large part from cutting of altiplanation terraces (fig. 4) (Péwé, 1970) before Illinoian loess was deposited. Because the Tanana Formation underlies Illinoian and pre-Illinoian deposits and, elsewhere, grades into the early or middle Pleistocene Fox Formation in valley bottoms, it is also thought to be early or middle Pleistocene in age.

The Tanana Formation overlies bedrock and underlies loess and retransported loess of Illinoian and pre-Illinoian ages; it is iron stained in most places. It is not to be confused with pods of angular rock fragments and sand that occur locally at creek junctions in the Goldstream Formation, nor with younger solifluction deposits at high altitudes in the Yukon-Tanana Upland that were formed during later cold periods or may be forming today and are not overlain by loess of Illinoian age or older.

DAWSON CUT FORMATION

A 1–3-m-thick silt rich in plant material is here named the Dawson Cut Formation for its exposure in the Dawson Cut placer mine 10 km north of Fairbanks. The writer has informally used the term Dawson muck for this mappable unit since the late forties; the term Dawson Formation is preempted, and so it here is formally named the Dawson Cut Formation.

The formation crops out at the base of mining exposures in valley bottoms on Eva Creek (fig. 6) (Péwé, 1952, fig. 40), Engineer Creek, Dawson Cut, Sheep Creek, and Ready Bullion bench cut and is perennially frozen. It also has been tentatively identified from mining exposures near Livengood. It does not crop out on the surface; its spatial relations are shown diagrammatically in figure 4.

The type section is designated the northeast wall of the Dawson Cut placer mine, SW ¼ sec. 6, T. 1 N., R. 1 W., Fairbanks D–2 quadrangle, on the right limit of Engineer Creek near its junction with Goldstream Creek 10 km north of Fairbanks. At this locality the Dawson Cut Formation is 1 m thick and is underlain by the Cripple Gravel and overlain by the Gold Hill Loess.

The Dawson Cut Formation consists of peat lenses, logs, and forest beds in a dark gray to black (when frozen) silt, rich in minute carbonized plant fragments. When dried, the silt is light gray to tan. The silt is well sorted and probably is in part reworked loess and soil. Some fine angular gravel derived from the underlying Fox Formation occurs in thin layers and lenses a few centimetres thick. The gravel and some basal silt are cemented by an iron oxide compound.

The Dawson Cut Formation overlies the Fox Gravel in valley bottoms. It is overlain in most localities by the Gold Hill Loess; however, on the east wall of Eva Creek the loess has been removed and the Goldstream Forma-

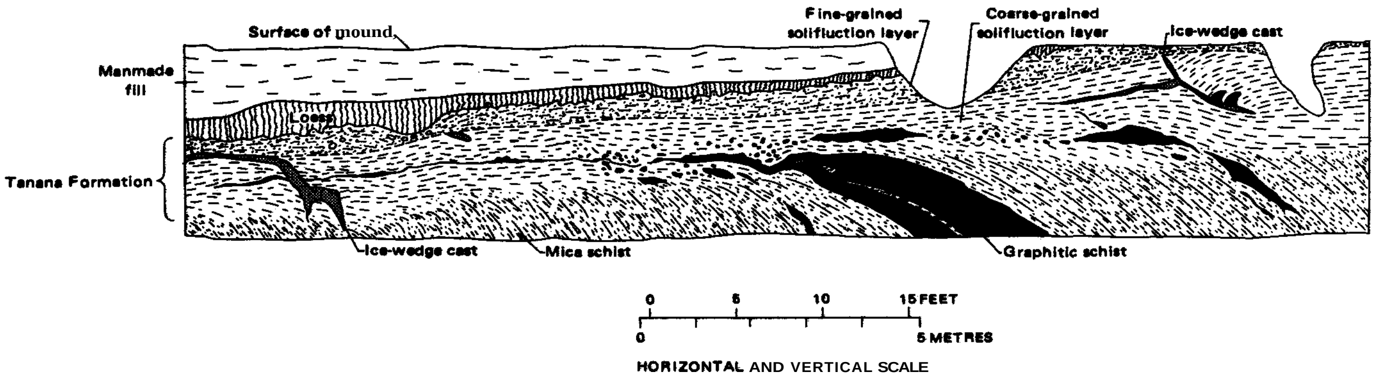

FIGURE 5.—Tanana Formation, a solifluction deposit, and ice-wedge casts of sand exposed in excavation for Duckering Building, University of Alaska, Fairbanks (drawn by L. Burbank and R. D. Reger).

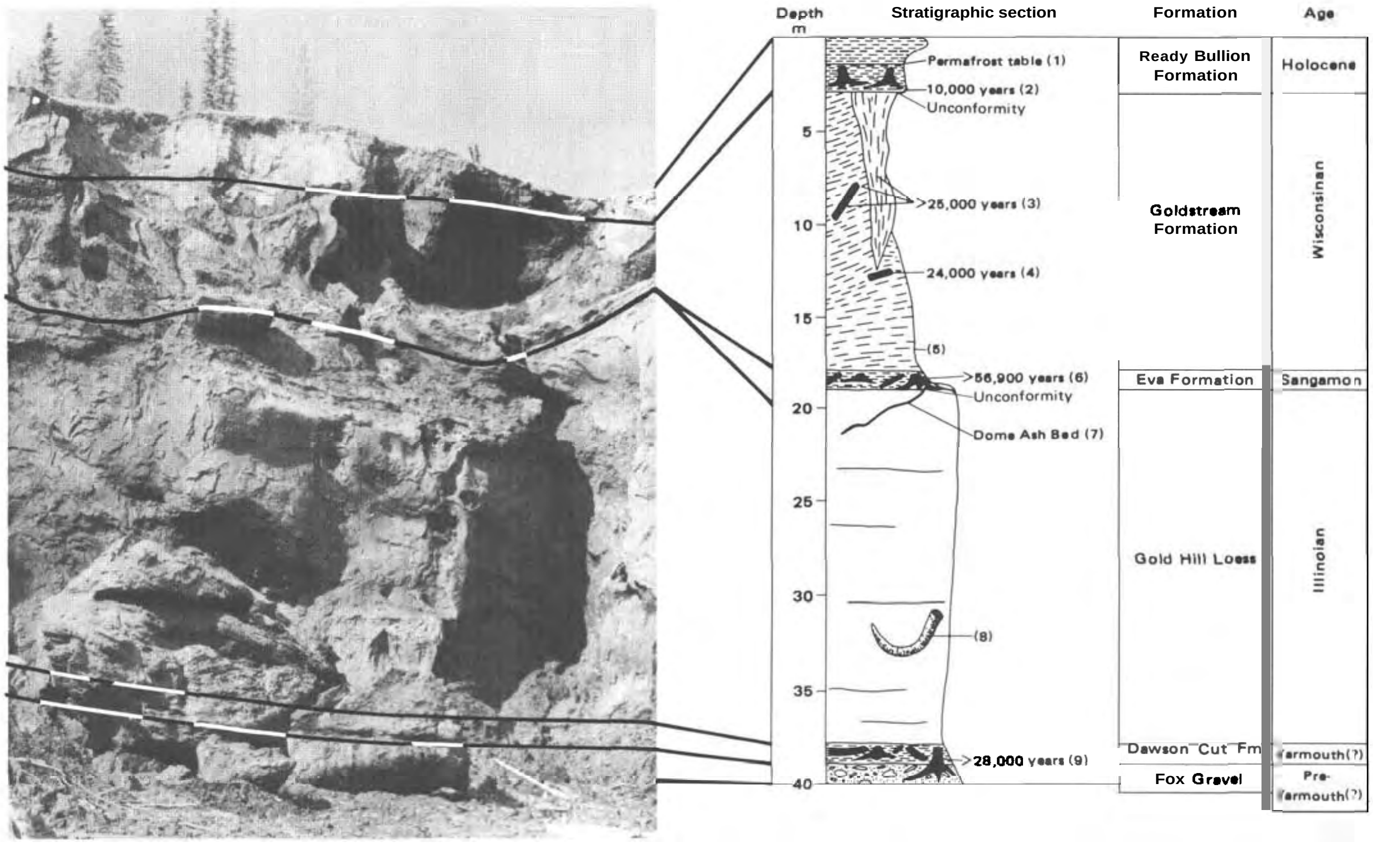

FIGURE 6.—Late Quaternary perennially frozen sediments with radiocarbon dates and vertebrate occurrences. Eva Creek mining cut 16 km west of Fairbanks. (Photograph 2540 by T. L. Péwé, July 2, 1967.)

[1]The permafrost table was lowered throughout central Alaska 1–5 m about 10.000 years ago and has since risen to its present position. All sediments in the deep thaw layer were unfrozen for hundreds if not thousands of years. Flat-top ice wedges and collapse of sediments over ice wedges remain as evidence of this thawing episode.

[2]The age of the Ready Bullion Formation in the Fairbanks area is well documented (Péwé, 1952, 1958b, 1965a, 1975). More than a dozen samples have been dated from this formation and the Engineer Loess in many different mining exposures; the dates range from about 3,000 to 10,000 years, with most of them in the neighborhood of 5,0067,000 years. A date of 3,750±200 years (L–117H) was obtained on a sample of wood collected 2 m below the surface by the writer in 1951 fmm the Ready Bullion Formation on Eva Creek. A data of 10,000±500 years (L–137S) was obtained on a sample of wood collected by the writer in 1951 from the base of the Engineer Loess on Eva Bench mining exposure 3 m below the surface.

[3]In 1967 the writer collected for dating samples of ice, wood, and carbonaceous silt that were adjacent. All were dated by the radiocarbon laboratory at the University of Arizona as more than 25,000 years old. More detailed dating probably would have indicated an age between 25,000 and 30,000 years. A wood sample collected in 1954 by the writer 2.5 m below the top of the Goldstream Formation on Eva Creek was dated at 23,300±1,000 years (W–435). Wood samples collected by the writer in 1952 at the base of the Goldstream Formation and near the middle were dated as greater than 23,000 years old (L–157A) and greater than 30,000 years (L–163J).

[4]A radiocarbon date of 24,400±650 years (I–2116) was obtained on wood collected at the base of the ice wedges (Matthews, 1968, p. 207).

[5]Matthews (1968) examined fossil beetles from the Goldstream Formation. Beetles, plus a pollen study by Matthews and by the writer, indicate a treeless tundra environment during the Wisconsman. In 1949 Pewe also collected bones of mammoth and *Citellus* undulatus from the Goldstream Formation here. Guthrie (1968b) recovered Microtw gregalis, *Lemmus sibericus,* Dicrostonyx *torquatus*, and *Citellus* undulatus from both the Goldstream Formation and the Gold Hill Loess.

[6]Péwé (1952) has reported a forest bed at this stratigraphic horizon fmm many exposures in the Fairbanks area. The oldest date obtained on the Eva Formation was reported by Matthews (1968) as more than 56,900 years (Hv–1328). This carbonaceous silt layer with tree stumps and logs unconformably overlies the deformed loess.

[7]In innumerable exposures of the contact between the Goldstream Formation and Gold Hill Loess in the Fairbanks area, a 1-em-thick white vitric volcanic ash bed occurs at the top of the Illinoian loess and is truncated by an unconformity. This ash bed, the Dome Ash Bed, is deformed by faulting and solifluction.

[8]The writer collected (1949–67) mammoth tusks and various bones of bison from the Gold Hill Loess on Eva Creek.

[9]At Dawson mining cut and others a well-developed organic silt crops out (Péwé, 1952). This unit contains large stumps and logs that are partly flattened and deformed; it is thought to represent an interstadial or interglacial forest bed. One particularly fine white spruce stump fmm the Dawson Cut Formation of the Eva Creek section, with roots in the underlying gravel, is more than 28,000 years old (L–137X).

tion lies directly on the Dawson Cut Formation (Péwé, 1952, p. 108).

The flora of the Dawson Cut Formation is characterized by peat layers, sticks, horizontal logs as much as 3 m long and 30 cm in diameter (but mostly smaller), and white spruce stumps as much as 20 cm in diameter rooted in peaty soil (Péwé, 1975, fig. 40). The wood is more weathered, smashed, flattened, and iron stained than similar specimens in the Wisconsinan and Holocene deposits near Fairbanks. Bones of bison (probably *Bison priscus)* are relatively common, compared with the overlying loess and gravel. Guthrie (1968b) reported microtines present.

The Dawson Cut Formation is a pre-Illinoian interglacial deposit possibly Yarmouth in age because of its close relation to the overlying Illinoian Gold Hill Loess. Some of the silt in the formation mav be the result of reworking and penetration of the earliest loess of the Gold Hill Formation, which represents a more rigorous glacial climate.

FAIRBANKS LOESS

The Fairbanks Loess, named by Péwé (1958b) for the city of Fairbanks, is the most widespread deposit of Quaternary age in central Alaska. The loess blankets the hills of central Alaska, especially below the elevation of 600 m. The term Fairbanks Loess was defined to include all loess on hilltops and upper hillslopes (fig. 4) (generally not perennially frozen). When traced laterally to lower slopes and valley bottoms, the loess can be divided into the Gold Hill Loess (Illinoian), the retransported silt of the Goldstream Formation (Wisconsinan), and the Engineer Loess (Holocene). Their spatial relations are shown diagrammatically in figure 4. Good exposures are numerous in roadcuts, mining cuts, and quarries in central Alaska, especially near Fairbanks (Péwé, 1958b).

No type locality has previously been designated for the Fairbanks Loess, although it was mentioned (Péwé, 1958b) that excellent exposures occur in the placer excavations near Fairbanks, especially on Gold Hill and "Ester Island" (fig. 3). The type section is here established as the section on the east side of the "Ester Island" mining cut in the SW¼ sec. 8, T. 1 S., R. 2 W., Fairbanks D-3 quadrangle, where loess 60 m thick overlies the Cripple Gravel (Péwé, 1952, fig. 33). This section has been described in detail (Péwé, 1952, p. 49-52), and although there are slight color variations, the texture of this sediment is the same throughout. Lindholm, Thomas, Davidson, Handy, and Roy (1957) have examined in detail the engineering properties of the silt of this section.

The Fairbanks Loess is thickest near major rivers draining glaciated areas. It is thin or absent on the highest hilltops, but thickens downslope to almost 30 m. The valley-bottom loess and retransported silt deposits, which are equivalent to the Fairbanks Loess (fig. 4), reach thicknesses of as much as 150 m. Near Fairbanks a thickness of 68 m of Fairbanks Loess caps Gold Hill (fig. 3).

The Fairbanks Loess is generally tan to grayish tan. The silt is well sorted: 75–85 per cent of the particles are between 0.005 mm and 0.05 mm in diameter. (For cumulative frequency curves of loess from various parts of central Alaska, see Péwé, 1955a.) The loess is massive, showing little jointing or stratification, although in many localities thin dark carbonaceous layers and iron oxide-stained bands are present. Except in a few isolated localities, the loess is noncalcareous. At least two pronounced white vitric ash beds occur in the Fairbanks Loess; the lower, the Ester Ash Bed, occurs near its base.

The loess overlies the auriferous Cripple Gravel and various types of pre-Quaternary bedrock with a sharp contact. It is bounded on the top by modern soil.

One of the most widespread topographic characteristics of the loess on upper slopes is the old slightly subdued parallel gullies 10-15 m deep and 100-200 m long. (See Péwé, 1955a, pl. 3, fig. 1.) Since the loess is not undergoing active gullying today, except where human activity weakens the vegetation cover or concentrates runoff, the rounded gullys must be relicts of a past period with different precipitation or vegetation cover, or different distribution of permafrost. Although mammal remains are abundant in the valley-bottom silt formations, they are rare in the Fairbanks Loess because most remains have been concentrated in valley bottoms by slope wash and mass movement of the mantle, and also, good exposures are not as common in the Fairbanks Loess as in the valley bottoms. Undiagnostic bones of mammoth, horse, and bison occur in the Fairbanks Loess. Guthrie (1968b) reported remains of ***Citellus undulatus*** and ***Dicrostonyx torquatus*** from the Fairbanks Loess along Chena Ridge Road 10 km west of Fairbanks.

The Fairbanks Loess is thought to span the Illinoian, Wisconsinan, and Holocene because when traced laterally to valley bottoms it grades into the Engineer Loess, the Goldstream Formation, and the Gold Hill Loess.

GOLD HILL LOESS

The Gold Hill Loess is here named for Gold Hill, 10 km west of Fairbanks, where it is well exposed in a placer gold mining cut. The name was used informally in the late forties and early fifties for Holocene loess in the Fairbanks area (Péwé, 1952). Since about the middle fifties, the term has been informally used for an Illinoian formation in valley bottoms equivalent to the Fairbanks Loess, and it is here so used and formally adopted.

The term Gold Hill Loess is applied to the oldest and thickest loess on lower slopes and in valley bottoms. This perennially frozen material is exposed in vertical cuts and does not crop out on the surface. Its spatial relations are shown diagrammatically in figure 4.

The type section is designated the north wall of Gold Hill mining cut on Gold Hill in the SW¼ sec. 3, T. 1 S., R. 2 W., 10 km west of Fairbanks, Fairbanks D–2 quadrangle (Péwé, 1965a, fig. 1–8). At this locality approximately 55 m of the unit is exposed. Its thickness ranges from 55 m in valley bottoms to a few centimetres upslope. The formation consists of massive loess that has the same texture as the Fairbanks Loess. Thin iron oxide-stained and carbonaceous beds are common. The base of the unit locally contains marcasite concretions, many with vertebrate bones or fragments of frost-shattered bedrock as nuclei.

Conspicuous structural features of the Gold Hill Loess are folds and contortions 2–35 m across. Because of the uniformity in texture and composition of the silt, structural features are seen only when ash or carbonaceous beds are present (fig. 7) (Péwé, 1952, figs. 38, 39, 40, 41, 42).

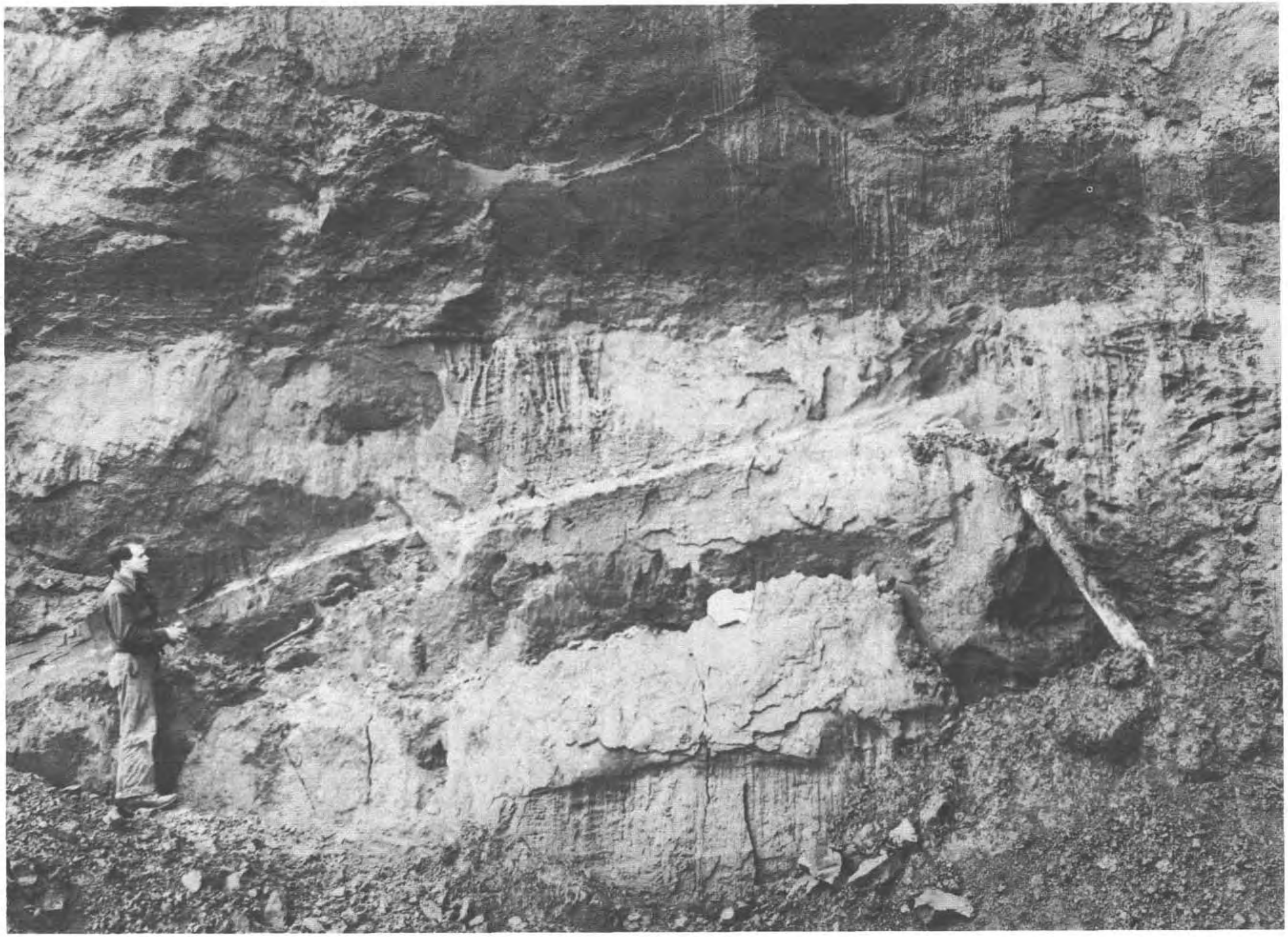

FIGURE 7.—Horizontally bedded gray to black silt of the Goldstream Formation overlying with an angular unconformity tilted blocks of the Gold Hill Loess with enclosing minutely faulted Dome Ash Bed. West wall of Eva Creek mining excavation 14 km west of Fairbanks. Log propped against wall is modern wood. (Photograph 370 by T. L. Péwé, June 28, 1949).

A white rather gritty highly vitric ash, the Ester Ash Bed, is exposed near the base of the Gold Hill Loess in many exposures. The Dome Ash Bed is a ubiquitous thin white ash bed that crops out near the top of the Gold Hill Loess (fig. 4) and is folded or faulted wherever exposed (figs. 6, 7).

The perennially frozen freshly exposed Gold Hill Loess is either brown or green. The upper part of the formation that directly underlies the Eva or Goldstream Formations is green because of reduction of the ferric iron to ferrous iron. The green facies is thickest in valley bottoms and ranges from 1 to 20 m in thickness. Weathering and thawing turn the loess tan. The Gold Hill Loess lies unconformably over the pre-Quaternary bedrock, Cripple Formation, Fox Formation, Tanana Formation, and, elsewhere, the Dawson Cut Formation. It is unconformably overlain by the Eva and Goldstream Formations of Sangamon and Wisconsinan age, respectively (fig. 6).

The flora of the loess was reported by Péwé (1952; 1975). Megafossils are rare or absent, and two small pollen studies (Pdwe, 1975) indicate a greatly reduced tree cover and 450–600 m of drop in tree line. Mammal remains are common, mainly of horse, mammoth, and bison. Vertebrate fossils in the Gold Hill Loess support the idea that many taxa were present in North America earlier than previously recognized. Guthrie (1968b) reported on the small mammals in this unit. The remains of all known mammals in the Gold Hill Loess were summarized by Péwé and Hopkins (1967) and Pdwe (1975).

The Gold Hill Loess lies between two forest beds formed during interglaciations. The loess records an intervening long period of rigorous glacial climate with restricted forest cover. The upper forest bed has been dated as older than 57,000 years old (Matthews, 1968), and therefore the Gold Hill Loess is thought to be Illinoian in age.

ESTER ASH BED

The Ester Ash Bed occurs within the base of the Fairbanks Loess and is the oldest and thickest ash layer recognized in central Alaska. It was first described by Pdwe (1952, p. 49–52, 55) and informally termed the Ester ash layer from nearby Ester Creek. Later the name was formalized to the Ester Ash Bed, and the unit was described in more detail (Péwé, 1955a, p. 713).

The type sectionis here established near the base of the 60-m-thick section of Fairbanks Loess on the east side of "Ester Island" mining cut in the SW¼ sec. 8, T. 1 S., R. 2 W., Fairbanks D–3 quadrangle. Here, 4 m above the base of the Fairbanks Loess, is exposed a 15-cm-thick layer of white vitric unconsolidated ash (Péwé, 1955a, pl. 1, fig. 1)(fig. 8). The basal 1-cm-thick layer of the ash bed is iron oxide stained, and the 2.5-cm-thick layer immediately above the basal layer is bright pink.

The ash bed is composed mainly of glass; it also contains andesine (An37) and other minerals (R. K. Merrill, written commun., 1971). The index of the glass is 1.517 (R. G. Updike, written commun., 1971). A chemical analysis (table 2) reveals the ash could be termed a rhyodacite if the water content is added to the silica content.

The upper and lower contacts of the bed are sharp. Thickness ranges from 5 to 15 cm. Near the type section a "pocket" of ash 1 m in diameter is present. The ash is exposed just above the base of the Gold Hill Loess in Gold Hill, Dawson, Engineer, and Cripple Sump mining cuts near Fairbanks (fig. 3) and near the base of the Fairbanks Loess in its type section.

TABLE 2.—*Chemical analysis of volcanic ash from the Ester Ash Bed, 16 km west of Fairbanks*

[Sample 155; analysis by W. J. Blake, U.S. Geological Survey, 1950]

SiO_2	65.39
Al_2O_3	13.96
Fe_2O_3	1.75
FeO	2.71
MgO	.63
CaO	2.19
Na_2O	4.19
K_2O	2.54
H_2O-	.52
H_2O+	4.85
TiO_2	.56
CO_2	.01
P_2O_5	.15
Cl	.15
MnO	.15
BaO	.09
	99.84
Less O for Cl	.03
Total	99.81

The Ester Ash Bed occurs near the base of the Fairbanks Loess and its valley-bottom equivalent, the Gold Hill Loess, and therefore is thought to be early Illinoian in age (fig. 4).

DOME ASH BED

The most persistent ash layer of Pleistocene age in central Alaska is the Dome Ash Bed, a thin white ash layer exposed within and near the top of the Gold Hill Loess in mining cuts and in natural exposures. In addition to the many exposures in the Fairbanks area, the writer has recognized the ash in the Tofty, Livengood, and Circle mining areas. It was first mapped in the late forties and recorded by Péwé (1952, p. 86, figs. 34, 38, 39, 41, 42) in numerous sections informally as the Eva ash. Because the term Eva is used elsewhere in the stratigraphic terminology, the ash layer is here named

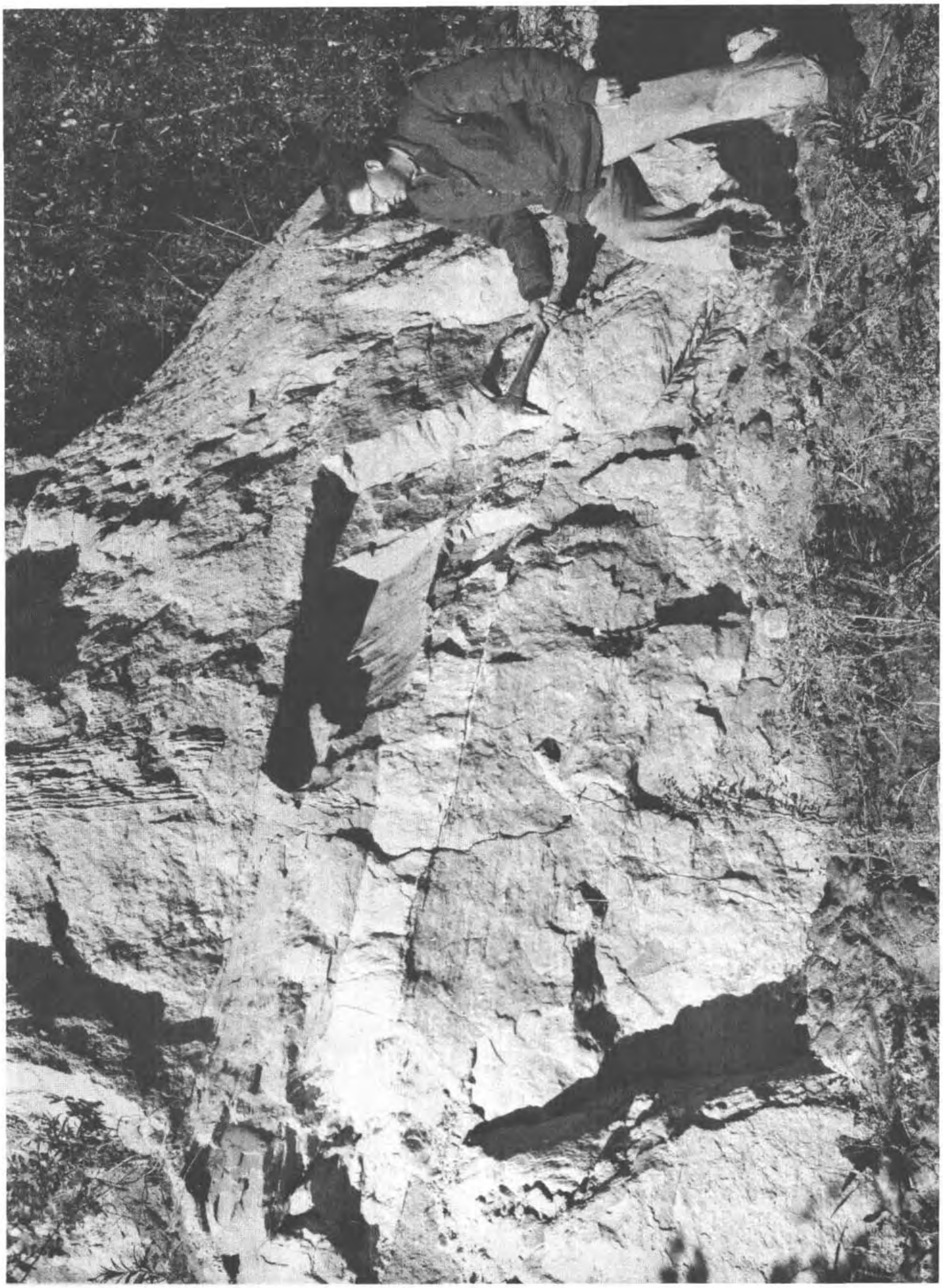

FIGURE 8.—Type section of Ester Ash Bed, here within the base of the Fairbanks Loess (Illinoian), exposed near base of "Ester Island" mining cut between Ester and Cripple Creeks, 16 km east of Fairbanks. (Photograph 354 by T. L. Péwé, August 23, 1948.)

the Dome Ash Bed from exposures in Dome Creek mining cut. The type locality is in Dome Creek mining cut in the NW¼ sec. 5, T. 2 N., R. 1 E., Livengood A–2 quadrangle, where the ash is 1 cm thick.

All mining cuts in the Fairbanks area display good exposures of the ash on fresh faces, and in all exposures the ash layer is deformed and locally overlain unconformably by either the Eva or Goldstream Formations (figs. 4, 6). The Gold Hill Loess and the ash bed have characteristically been disturbed by block slumping (fig. 7) or solifluction (Péwé, 1952, figs. 40, 41) in all exposures.

The Dome Ash Bed is a white vitric ash, and the refractive index of the glass is 1.517 (R. G. Updike, written commun., 1971). It ranges from 1 to 10 cm in thickness and is present in all exposures of the upper part of the Gold Hill Loess. In one locality (Eva Creek mining cut) the ash bed accumulated in a "pocket" 1 m in diameter. The Dome is restricted to the top of the Gold Hill Loess and is therefore thought to be late Illinoian in age.

It is almost impossible to tell the difference in the field between the different ash beds of central Alaska, except by stratigraphic position. The Ester and Dome Ash Beds are both in loess, but the Ester Ash Bed is thicker and not as deformed as the Dome Ash Bed. The Chatanika Ash Bed is not in loess but in bedded organic silt. The Holocene ash beds are all in loess and near the present surface. The ashes have been studied considerably, but ordinary chemical analysis does not separate them nor does a study of bubble curvature. Indices of refraction differ slightly for all but the Dome and Ester Ash Beds. Detailed studies are now underway to investigate the chemical composition of the glass by microprobe analyses.

EVA FORMATION

The Eva Formation is here named from Eva Creek, 16 km west of Fairbanks, where it is exposed in a placer mining cut (Péwé, 1952; 1975) (fig. 6). In all the mining-cut exposures in the Fairbanks area, the Gold Hill Loess is separated from the Goldstream Formation by a poorly to well formed topographic bench. At Eva Creek, Dawson Cut, Gold Hill, and elsewhere, the bench is prominent because of the presence of a forest layer with rooted and unrooted stumps (Matthews, 1968, fig. 2, 1970, fig. 5; Guthrie, 1968b, fig. 2; Péwé, 1975, fig. 30) that represents the Eva Formation (fig. 6). The Eva Formation crops out only in vertical cuts and does not appear on the surface. Its spatial relations are shown diagrammatically in figures 4 and 6.

The type section is designated as the north wall of Eva Creek mining cut in the NW¼ sec. 5, T. 1 S., R. 2 W., 16 km west of Fairbanks (fig. 4) (Pewe, 1952, fig. 37; 1975, fig. 29), Fairbanks D–3 quadrangle. The formation is 1 m thick at this locality. It consists of peat lenses, sticks, logs, and rooted stumps in loesslike silt rich in minute carbonized plant fragments. The silt is reworked loess and soil. The perennially frozen soil, silt, and organic clasts are tightly matted into a relatively resistant layer about 1 m thick. The Eva Formation unconformably overlies the Gold Hill Loess and is conformably overlain with a gradational contact by the Goldstream Formation.

The megaflora in the Eva Formation consists mainly of sticks and fragments of well-preserved wood, as well as many rooted stumps and prostrate logs of birch and white spruce as much as 25 cm in diameter and 3 m long. This concentration of large trees may represent the return of the forest to the area after the period when the Gold Hill Loess was deposited, a time of rigorous glacial climate with restricted forest cover. Matthews (1968, 1970) discussed the vegetation and insects in this unit, and Guthrie (1968b) reported on the microtines from the Eva Formation at its type locality. They showed that the loess immediately above the forest bed and some that has collected perhaps around the stumps contain pollen, insects, and microtines indicative of a tundra environment. I believe this indicates the return of the lower tree line and colder conditions after the forest of Eva time. This would explain why spruce macrofossils are found associated with tundra type pollen, beetles, and microtines in the silt, as Matthews (1970, p. 249) reported.

A radiocarbon date of more than 59,600 years on wood from this formation was reported by Matthews (1968) from Eva Creek, and the writer reports a date of more than 24,000 years from a rooted stump in this formation from Dawson Cut. The formation consists of vegetation material (and soil?) of presumed Sangamon age locally engulfed by interspersed silt probably of very earliest Wisconsinan age. Péwé and Sellmann (1971, 1973) showed that geochemically the Eva Formation has a relatively low conductivity which may reflect thawing or slow deposition conditions during an interglacial period. The Eva Formation is thus thought to represent an interglacial time, the Sangamon Interglaciation.

GOLDSTREAM FORMATION

The Goldstream Formation, one of the most widespread formations in central Alaska, is perhaps also the most interesting. The deposit, long informally known as the Goldstream muck (Péwé, 1952; Rubin and Alexander, 1958, p. 1479), is here named for Goldstream Creek 10 km north of Fairbanks, where it has been exposed by mining operations since the early 1900's.

The type locality is the left limit of Goldstream Creek in the SW¼ sec. 32, T. 2 N., R. 1 E., about one-half mile east of the village of Fox, Fairbanks D–2 quadrangle.

The Goldstream Formation is 15 m thick here. Exposures of the frozen, ice-rich silt with abundant vegetation have been common here for many years. Taber (1943) illustrated several exposures of the muck as it appeared in 1935 in Goldstream Creek valley. Despite slumping of the mining cut walls, the formation is still freshly exposed in the U.S. Army tunnel in permafrost on the left limit of Goldstream Creek near Fox (Sellmann, 1967, 1968, 1972).

The Goldstream Formation is a valley-bottom accumulation of loess in almost all creek and small river valleys in central Alaska. It is exposed in river cuts and most commonly in placer mining cuts. The writer has examined it in hundreds of exposures in central Alaska from the Canadian border to the Seward Peninsula. It rarely crops out on the surface; however, just north of Fairbanks it crops out over an area of about 6 km^2 where younger fans do not cover it. It also crops out in small areas in Goldstream Creek valley. These deposits were mapped in the Fairbanks D-2 quadrangle as perennially frozen organic silt (Péwé, 1958b). (See also Péwé, 1952, fig. 1; Péwé and others, 1975a, 1975b.) The spatial relations of the Goldstream Formation are shown diagrammatically in figure 4.

The Goldstream Formation, described in detail by Péwé (1952), consists of perennially frozen retransported bedded loess that contains abundant minute carbonized organic fragments and some peat lenses, sticks, and twigs. Vertebrate remains are common, and pond deposits with aquatic mollusks are known. The silt is poorly to fairly well stratified. The stratification is emphasized by ice seams and lenses (Taber ice) (Taber, 1943; Péwé, 1966). Larger masses of foliated ice (ice wedges) are abundant, especially near the upper part of the formation (figs. 6, 9). Large masses of pingo ice are present locally (Holmes and others, 1968, fig. 10). A thin white vitric volcanic ash layer, the Chatanika Ash Bed, occurs near the upper middle of the formation. In rare localities, especially near the base of the formation on lower hill slopes, or near junctions of tributary creeks, thin layers of sand and (or) angular local alluvial gravel ½–2 m thick occur. The formation is gray to black to greenish black when frozen and is 10–35 m thick. It unconformably overlies the Fox Gravel in valley bottoms and the Tanana Formation on lower valley slopes. In many lower slopes it lies unconformably on the Gold Hill Loess. It is overlain unconformably by the Engineer Loess on middle slopes and by the Ready Bullion Formation on lower slopes and in valley bottoms (fig. 4).

Silt of the Goldstream Formation has been washed to valley bottoms and is bedded, black to gray, rich in organic matter, and perennially frozen with large masses of ice. All this serves to distinguish the formation from the Fairbanks, Engineer, and Gold Hill Loesses. Although the Goldstream and Ready Bullion Formations are both bedded, black, and perennially frozen, the overlying Ready Bullion Formation (fig. 4) does not contain large ice masses or remains of extinct Pleistocene vertebrates, and the organic matter it contains is 10,000 years old or younger.

The Goldstream Formation grades upslope into unbedded loess of Wisconsinan age; however, inasmuch as there is no break between such loess and the underlying Illinoian loess and overlying Holocene loess on upper slopes and hilltops, all the loess in such localities is mapped as the Fairbanks Loess.

The flora of the Goldstream Formation is well preserved because the sediments and accumulated organic remains froze soon after deposition. Abundant layers, lenses, and pods of plant remains, mainly peat, sticks, twigs, ground squirrel seed caches, and isolated tree limbs, are present (Wilkerson, 1932; Chaney and Mason, 1936; Mertie, 1937; Péwé, 1952, 1975). Wood is not nearly as abundant, however, as in the underlying Eva Formation or the overlying Ready Bullion Formation. Pollen collected by the writer indicates that trees were scarce and the tree line was lower (E. G. Barghoorn, written commun., 1954). See also Matthews, 1970.) Recent work by Matthews (1974) suggests that trees returned briefly around middle Wisconsinan time.

The Goldstream Formation is the greatest repository of remains of Pleistocene vertebrates in Alaska, if not in North America. Various conditions favored the accumulation of vertebrate remains of Wisconsinan age in this deposit: (1) The Goldstream Formation is a valley-bottom deposit, and most bones of the vertebrates are gradually transported downslope to valley bottoms; (2) the older valley-bottom deposits of Illinoian age have been mostly removed; and (3) sediments of the Goldstream Formation froze soon after deposition. The most abundant remains are those of bison; remains of mammoth and horse are next in abundance. The extensive vertebrate fauna of the formation has been discussed by Frick (1930), Wilkerson (1932), Mertie (1937), Taber (1943), Geist (1940, 1953), Skarland (1949), Skinner and Kaisen (1947), Pew6 (1952, 1958b, 1965a, 1966, 1975), Repenning, Hopkins, and Rubin (1964), and Guthrie (1968b). The famous partial carcasses of Pleistocene mammals were found in this formation (Geist, 1940; Pewe, 1952, p. 123–126; 1966; 1975, table 13).

Freshwater mollusks occur locally in the formation and have been reported by Dorsh (1934), Mertie (1937), Taber (1943), and Péwé (1952, 1975). Insect remains have been studied by Matthews (1968).

The Goldstream Formation is overlain by the Ready Bullion Formation and (or) the Engineer Loess, whose bases are dated at about 10,000 years. More than 60 radiocarbon dates (table 4) from the Goldstream Forma-

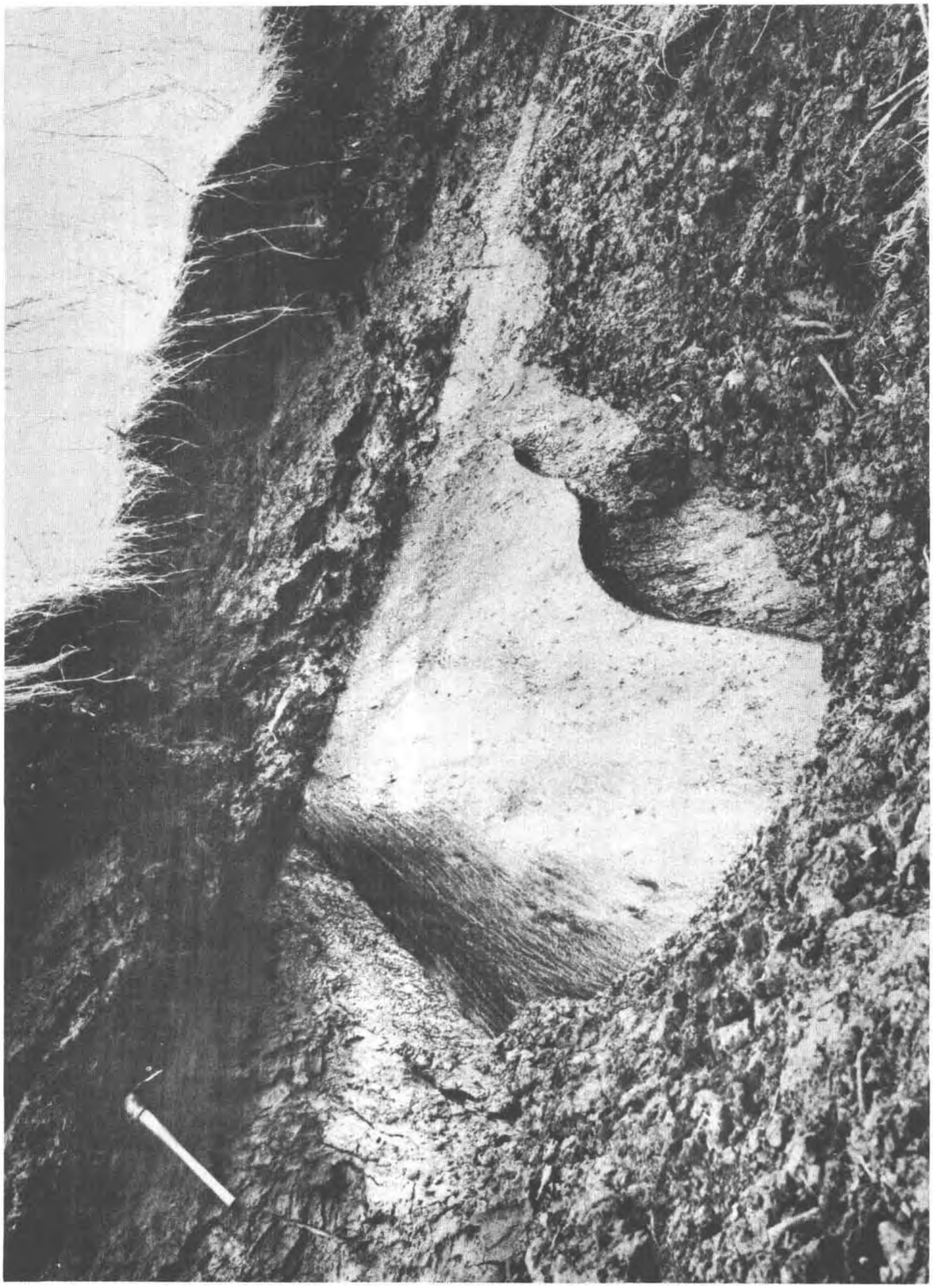

FIGURE 9.—Ice wedge in retransported silt of the Goldstream Formation overlain unconformably by retransported silt of the Ready Bullion Formation, the left limit of lower Engineer Creek near Fairbanks. (Photograph 479 by T. L. Péwé, September 23, 1949.)

tion record material older than 10,000 years, and many dates are older than 30,000 years. Wood in the underlying Eva Formation is older than 59,600 years; the Goldstream Formation is thus considered to be Wisconsinan in age.

CHATANIKA ASH BED

A distinctive ash bed is here named the Chatanika Ash Bed from exposures along the Chatanika River 40 km north of Fairbanks. It occurs within and near the top of the Goldstream Formation and is exhibited in natural and mining exposures in the Fairbanks area. It was first mapped in the late forties and recorded by Péwé (1952, fig. 58) near Fairbanks.

The type section is designated the 15-m-high cutbank of the Chatanika River 2 km downstream from the Elliott Highway bridge over the Chatanika River 40 km north of Fairbanks in the NW¼ sec. 15, T. 3 N., R. 1 W., Livengood A–2 quadrangle. Here the Goldstream Formation is overlain by a thick deposit of retransported silt and buried forest beds, the Ready Bullion Formation. The Chatanika Ash Bed, a volcanic ash layer about 1 cm thick, occurs about 4 m below the top of the Goldstream Formation (fig. 10). The section was described by Péwé (1965a).

The Chatanika Ash Bed is a white vitric ash. The refractive index of the glass is 1.503 (R. K. Merrill, written commun., 1971). The ash ranges in thickness from 1 to 10 mm and is quite persistent in the area. One of its most outstanding characteristics is that it is greatly contorted by massive ice-wedge growth; in many places adjacent to the ice wedges, the ash bed is almost vertical (fig. 10).

At the type section a radiocarbon date of 14,760±850 (GX–0250) years was obtained on a *Citellus* nest 4 m below the ash layer. A date of 14,510±450 (W–2703) years was obtained on *Citellus* coprolites from silt 1 m above the ash layer (Meyer Rubin, oral commun., 1972). The ash is thus considered to be about 14,000 years old (Wisconsinan).

ENGINEER LOESS

The names "Engineer muck" and "Engineer formation" were used informally by the writer in the late forties and fifties (Péwé, 1952; Rubin and Alexander, 1958, p. 1479) for Holocene retransported silt in valley bottoms. Since the fifties the term has been used informally for a Holocene equivalent of the Fairbanks Loess on middle slopes, and it is here so used and formally named the Engineer Loess.

The Engineer Loess is here named for exposures on Engineer Creek 10 km north of Fairbanks. The type locality is designated the loess exposed in Dawson Cut, a gold placer mining excavation in the SW% sec. 6, T. 1 N., R. 1 E., Fairbanks D–2 quadrangle on the right limit of Engineer Creek near its confluence with Goldstream Creek. (See Péwé, 1952, fig. 34C.) At this locality approximately 1–1% m of Engineer Loess disconformably overlies a thick section of silt of the Goldstream Formation. The Engineer consists of some masses of unbedded loess and some weakly bedded slightly retransported loess with thin iron oxide-stained and carbonaceous beds. It is similar to the Fairbanks Loess in texture and mineralogy and is locally calcareous. In the immediate Fairbanks area, the formation is 1–7 m thick, but near glaciated regions, such as in the middle and upper Tanana valleys, the loess may reach thicknesses of 12 m

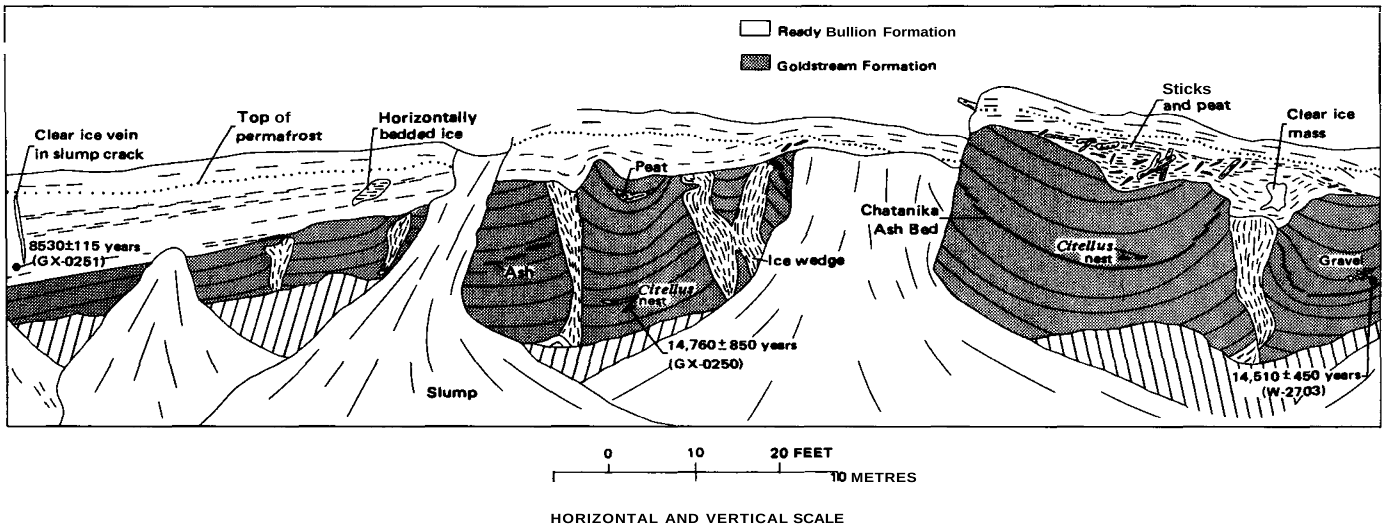

FIGURE 10.—Bank of the Chatanika River 2 km downstream from Elliot Highway bridge, 40 km north of Fairbanks. Goldstream Formation, with ice wedges and Chatanika Ash Bed, is overlain by the Ready Bullion Formation. Number with date is lab. number from table 4.

near braided glacial streams (Péwé and Holmes, 1964). In such areas the rapid loess accumulation over Wisconsinan till and outwash enabled many Holocene forest layers to be preserved (Péwé, 1965c, p. 53; Reger and others, 1964).

The term Engineer Loess is used for the younger and thinner of two loesses on middle slopes. The lower part of the formation is perennially frozen. The loess is exposed in vertical walls such as Eva bench cut and Gold Hill (Péwé, 1965a, fig. 1–8) and Wilber Creek cuts and is the formation upon which the modern soil is developed on middle slopes. Downslope it grades into the Holocene Ready Bullion Formation. Its spatial relations are shown diagrammatically in figure 4.

This loess is widespread in central Alaska and contains three thin white volcanic ash beds: the Wilber Ash Bed in the Fairbanks area and to the north, the Jarvis Ash Bed near the junction of the Delta and Tanana Rivers, and the White River Ash Bed in east-central Alaska.

The Engineer Loess lies disconformably over the Goldstream Formation, till, and outwash of Wisconsinan age and is bounded on the top by the modern soil. Beyond the limit of the till, outwash, or Goldstream Formation, it is equivalent to the upper part of the Fairbanks Loess. (See Péwé, 1965a, fig. 1–8.) (See fig. 4).

No plant fossils occur at most localities near Fairbanks, but forest layers of white spruce stumps (table 4) are well preserved in the upper part of the Engineer Loess along the Delta River (Péwé and Holmes, 1964, sections R and S; Reger and others, 1964). No vertebrate fossils have been found. Land snails, however, have been found 70 km west of Fairbanks along the Tanana River, and the writer has collected three species—*Succinea* avara Say, Discus chronkhitei (Newcomb), and Euconulus *fulvus* alaskensis Pilsbry[2]—along the Delta River.

Only a few radiocarbon dates are available on wood from the Engineer Loess, but several are available from its valley-bottom equivalent, the Ready Bullion Formation. Most dates from the Engineer Loess are between 3,500 and 8,500 years (table 4). A critical date of 10,500±500 (L–137S) years (Broecker and others, 1956, p. 137) was obtained on a 0.5 m-thick peat and forest bed of logs of spruce and birch at the base of a 3-m-thick section of massive Engineer Loess in Eva bench cut, where it unconformably overlies the Goldstream Formation (Péwé, 1952, fig. 58). The radiocarbon date of 10,500±500 years (L–137S) by the Lamont Laboratory is a black carbon date, but the writer believes the date is valid. Regarding this date, W. S. Broecker of the Lamont-Doherty Geological Observatory stated, "I suspect that the date is quite good***. Most of the early black carbon dates have stood the test of time." (written commun., 1973). All radiocarbon dates support a Holocene age for the Engineer Loess.

[2]Identified by T.C. Yen, U.S. Natl. Mus., 1953 (Péwé, 1955a, p. 714).

WILBER ASH BED

A thin bed of white ash exposed in mining cuts in the Engineer Loess in the Fairbanks area and northward to Livengood was informally termed the Wilber ash by Péwé (1952, p. 156). It is here named the Wilber Ash Bed for exposures in the Wilber Creek mining cut 10 km southeast of Livengood (fig. 1), Livengood B–3 quadrangle. The type section is the west wall of the gold placer mining cut.

The ash is mainly glass and is exposed as a thin layer 5–25 mm thick. It occurs ½–1 m beneath the modern soil. The outstanding distribution characteristic is that the essentially horizontal ash bed is disrupted, deformed, or absent over ice wedges in the underlying Goldstream Formation.

The age of the Wilber Ash Bed is not exactly known because closely bracketed radiocarbon dates are not yet available. It is thought to be less than 4,200 years old because a date of 4,200±200 (L–117G) was obtained on wood 2 m below the surface in the Engineer Loess on the west side of Wilber Creek mining cut. The Wilber Ash Bed was not present in the loess at this exact locality, but was present a few metres away.

The Wilber and Jarvis Ash Beds may be the same ashfall. Until more detailed petrologic and chemical work underway on the ash is reported and more radiocarbon work is done, this question is unanswered. However, stratigraphic relations and deformations of the ash bed suggest that they are different.

JARVIS ASH BED

The Jarvis Ash Bed occurs in the Engineer Loess near the junction of the Delta and Tanana Rivers. It is found north of the glaciated area and also occurs in loess overlying outwash and glacial till. The writer first sampled and studied the ash in the late forties. It was first mentioned by Lindholm, Thomas, Davidson, Handy, and Roy (1957, p. 11, 13) and later listed by Péwé and Holmes (1964, sections R and S) on the Delta River and Jarvis Creek. The name Jarvis Ash Bed first appeared in print in 1964 (Reger and others, 1964, p. 95) in reference to exposures at an archaeological site along the Delta River 13 km south of Delta Junction.

The type section is here established as the 6-mm-thick ash in a loess overlying Donnelly till on the right bank of the Delta River in the SW¼ sec. 19, T. 14 S., R. 10 E., 40 km south of Delta Junction, Mount Hayes G 4 quadrangle. This ash underlies 2 m of loess. The section is described by Péwé (1965c, p. 63) and is the spot where bracketing radiocarbon dates were obtained.

The Jarvis Ash Bed is a white vitric ash 2–10 mm thick. The glass has an index of refraction of 1.555 (R. G. Updike, written commun., 1971). The source of the ash is unknown, but may be from the Wrangell Mountains 260 km to the south.

At the type section a radiocarbon date of 4,650±250 (L–137Q) years was obtained on wood 27 cm below the Jarvis Ash Bed. A date of 1,950±150 (L–163K) years was obtained on wood a few millimetres above the ash bed (Péwé, 1968). These date the Jarvis Ash Bed as Holocene.

WHITE RIVER ASH BED

The White River Ash Bed lies within and near the top of the Engineer Loess. It occurs in east-central Alaska and is widespread in the adjacent Yukon Territory of Canada. It has been known for many years, and the first published mention of the ash was by Schwatka (1885), who observed it along the banks of the Lewis River in 1883. Except for the ash of the 1912 eruption of Mount Katmai, this ash is probably studied in more detail than any other Quaternary ash in Alaska. Capps (1916b) made an early summary of its extent, thickness, composition, and age, but the most detailed work has been done by Lerbekmo, Hanson, and Campbell (1968) and Lerbekmo and Campbell (1969).

Although Capps (1916b) never used the term White River ash, it is apparent that he was referring to this ash because he refers to the White River volcano (p. 62) and the White River eruption (p. 64) as its source. It thus appears that the term White River Ash was first published by Lerbekmo, Hanson, and Campbell (1968). The ash is here renamed the White River Ash Bed and considered a formal stratigraphic unit.

Since no type locality nor type section has been established, it seems best to establish one at the exposures where Capps made his study for the estimate of its age. The type section is on the north side of the White River about 13 km downstream from the source of the river in Russell Glacier and about 50 km west of the Alaska-Canada border (McCarthy D–2 quadrangle). Here the ash is 0.75 m thick and underlies 2 m of peat (Capps, 1916b). Capps published photographs of the type section (1916a, fig. 2; 1916b, pl. VI–C). A similar photograph has been published by Denton (1974, fig. 5) from near the type section.

The ash is composed mainly of glass, but it also contains plagioclase, hornblende, hypersthene, and magnetite in decreasing order of abundance and is termed a rhyodacite (Lerbekmo and Campbell, 1969). The glass is pumiceous, with a refractive index of 1.502±0.002. The ash bed is several tens of metres thick near its source near Mount Natazhat in Alaska, near the Canadian border, but rapidly thins to 1 metre and then to a few millimetres to the north and to the east. One of the common characteristics of its distribution is that it lies only a few centimetres below the surface in most areas; in fact it generally lies directly under the vegetation or turf mat. The ash is limited to east-central Alaska and western Yukon Territory (fig. 11).

The White River Ash Bed, especially in Alaska, was estimated by an ingenious method to be 1,400 years old (Capps, 1916b, p. 64). Capps established the rate of peat accumulation in the area by tree-ring study and thus determined the age of the ash, which is buried under peat.

The date has subsequently been supported by radiocarbon dating. Fernald (1962) gave radiocarbon dates of 1,750±110 (I–275) and 1,520±100 (I–276) years on peat samples taken just below and above the ash, respectively, in eastern Alaska (Tanana valley). In western Canada the age of the ash is indicated by radiocarbon dates obtained by Stuiver, Borns, and Denton (1964) on peat samples taken immediately above (1,390±70 years; Y–1364) and below (1,460±70 years; Y–1363) the ash. The date of approximately 1,400 years estimated by Capps (1916a) is the date here used for the age of the White River Ash Bed. It is probably as accurate as the radiocarbon dates or perhaps even more accurate. Recent work (Lerbekmo and others, 1973) suggest the ash fall may be more complex than previously realized. There may be three layers closely spaced in time, with the youngest about 1000 years old.

READY BULLION FORMATION

The Ready Bullion Formation is here named for Ready Bullion Creek, 17 km west of Fairbanks, where it is well exposed in a mining cut at the top of a thick silt. This deposit of Holocene retransported windblown silt in valley bottoms has been informally called "Engineer muck" since the forties (Péwé, 1952; Rubin and Alexander, 1958, p. 1479).

The type section is the east wall of the Ready Bullion bench mining cut on Ready Bullion Creek 17 km west of Fairbanks in the SW¼ sec. 6, T. 1 S., R. 2 W., Fairbanks D–3 quadrangle. At this locality the Ready Bullion Formation, approximately 2 m thick, unconformably overlies the Goldstream Formation and is overlain by modern soil (fig. 12).

The formation, a thin widespread deposit of silt rich in organic material, occurs in creek valley bottoms and lower slopes in central Alaska. It is excellently exposed in vertical banks on Ready Bullion, Eva, Engineer, Sheep, Fairbanks, and Dome Creeks, and Dawson cut; in river exposures in the Fairbanks area; on Wilber, Amy, Lillian, and other creeks in the Livengood area; and in mining cuts in the Tofty, Circle, and Chicken areas as well as near Dawson, Yukon Territory. It is the formation upon which the modern soil is developed in

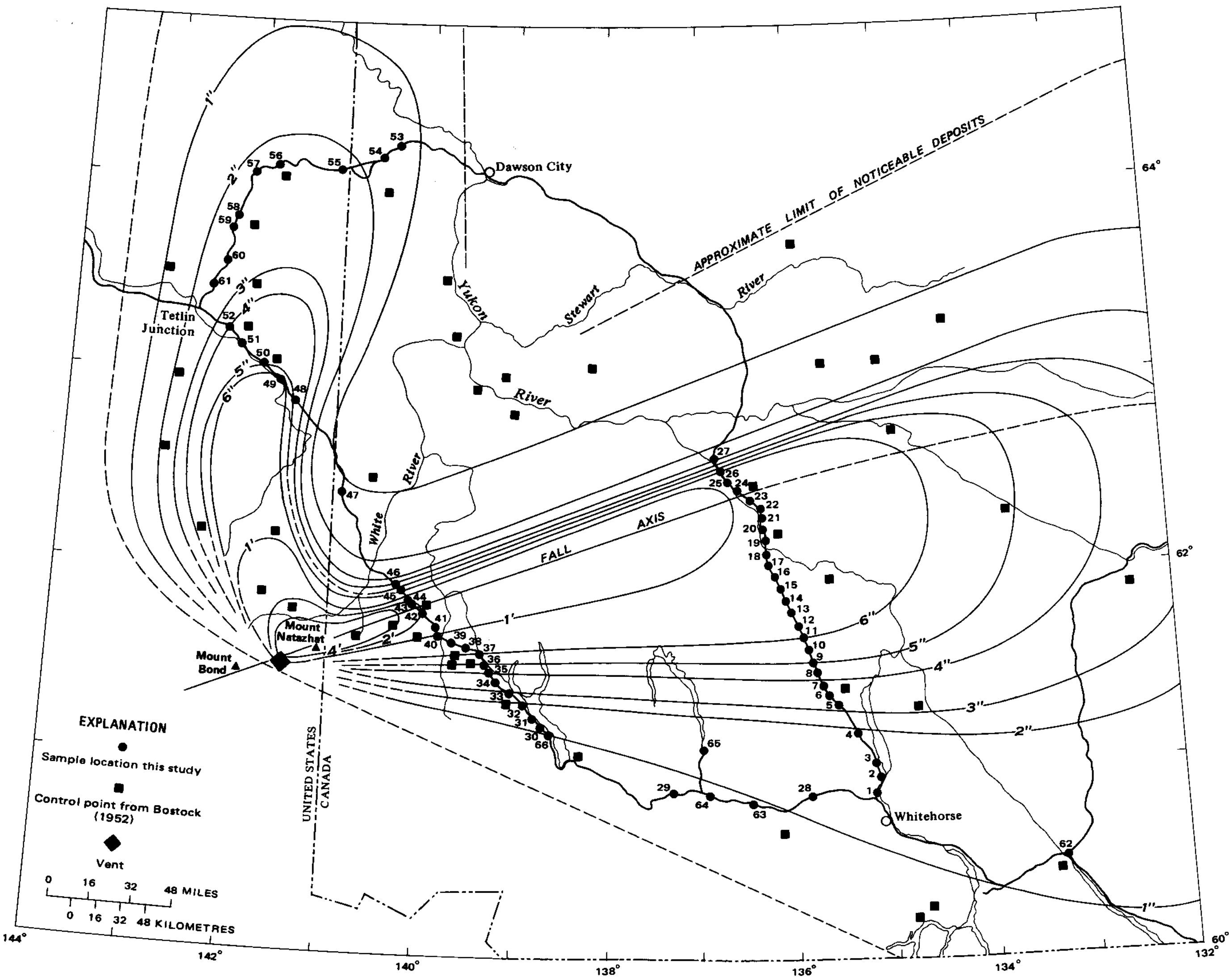

FIGURE 11.—Isopach map of White River Ash Bed (from Lerbekmo and others, 1968, fig. 2).

valley bottoms and lower slopes. Upslope, the Ready Bullion Formation grades into the Engineer Loess. Its spatial relations are shown diagrammatically in figure 4.

The Ready Bullion Formation consists of perennially frozen retransported loess that has accumulated minute carbonized plant fragments, peat lenses, sticks, and abundant logs and rooted stumps. The silt is poorly to well stratified and below a depth of about 1 m is perennially frozen. No large foliated ice masses occur; only ice seams and lenses less than 1 cm thick are present. Rare clear-ice masses of recent origin may be present (fig. 6). (See Péwé, 1952, fig. 55.) The silt is gray to black when frozen and tan when thawed. Locally, especially near junctions with tributary drainage lines, layers and lenses of sandy angular gravel ½–2 m thick occur.

The formation is 1–10 m thick in the center of the valleys (Péwé, 1952, p. 148; Taber, 1943, p. 1494) and thins upslope on either side. It unconformably overlies the Goldstream Formation. The underlying formation and ice wedges appear to have been truncated in valley bottoms (fig. 9) (Péwé, 1952, figs. 53, 54, 55) before the Ready Bullion Formation was deposited. Taber (1943, p. 1538) recognized this unconformity when visiting the Fairbanks area in 1935; however, he attributed it to erosion during the Yarmouth Interglaciation. The Ready Bullion is overlain by modern soil.

Plant remains are abundant and exceedingly well preserved; green leaves dated radiometrically at 3,000–4,000 years old occur. Abundant layers, lenses, and pods of peat, twigs, and forest beds with rooted stumps of birch and spruce occur (Taber, 1943, pl. 10, fig. 1). Giddings (1938) described as many as three spruce forest layers with stumps superposed on one

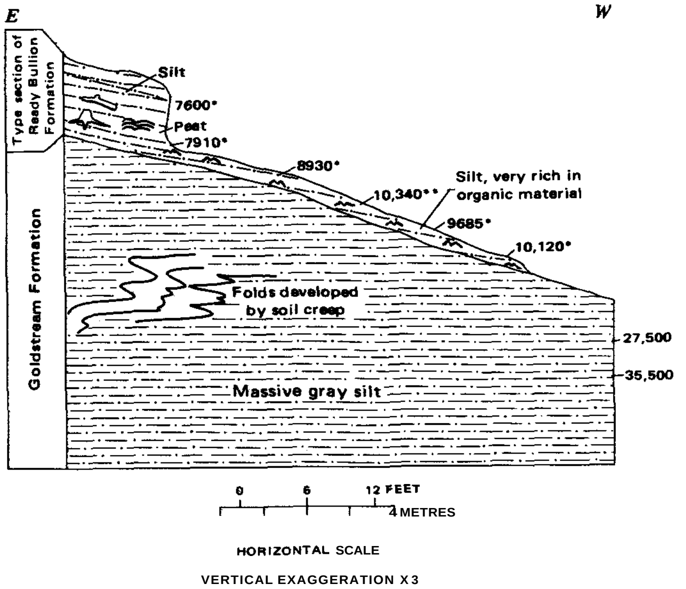

FIGURE 12.—Upper part of east wall of Ready Bullion bench placer mining cut on Ready Bullion Creek, 17 km west of Fairbanks. Numbers are radiocarbon years (see table 3 for details); those with an asterisk (*) are average of two or more runs by different laboratories. Radiocarbon years given in the type section for Ready Bullion Formation have been run twice or more, and in all cases the date has averaged younger. (See table 3.) Two asterisks (**) indicate date of sample is probably a few years too old, inasmuch as it was not run by other laboratories.

another. Trees are much more common than in the underlying Goldstream Formation and mark the return of the forest.

The Ready Bullion Formation contains few vertebrate remains, unlike the underlying Goldstream Formation, which is also a lower slope and valley-bottom perennially frozen retransported silt deposit. It contains none of the many extinct Pleistocene forms such as bison, horse, and mammoth present in the underlying Goldstream Formation (Péwé, 1952, 1965a; 1975). Also, animals common to the treeless areas today and present in the Goldstream Formation, such as Dicrostonyx, Citeltus undulatus, and *Ovis,* are not found in the Ready Bullion Formation (Péwé, 1952). Guthrie (1968b) reported Microtus *gregalis* and *Lemmus* sibericus in older formations, but they are not found in the Ready Bullion Formation. The only vertebrate remains the writer collected from this formation are well-preserved perennially frozen moose coprolites.

Because the base of the Ready Bullion Formation probably represents (1) the time of extinction of many vertebrates, (2) the return of the forest, (3) warming of the climate, and (4) the beginning of Holocene time, the age of the formation, especially the basal boundary, is important. Several radiocarbon dates on wood from the Ready Bullion Formation are available from different mining exposures and are from 3,500 to 10,000 years (fig. 12). Basal dates are available from the Ready Bullion Formation and its upvalley equivalent, the Engineer Loess. The base of the Engineer Loess is dated as 10,500±500 (L-137S) years on Eva bench cut.

A series of thirteen radiocarbon dates from the lower part of the type Ready Bullion Formation is illustrated in figure 12 and table 3. The dates demonstrate that deposition of the formation began at 10,120±175 years,[3] or approximately 10,000 years ago (beginning of Holocene).

CHENA ALLUVIUM

The Chena Alluvium is here named for the Chena River at Fairbanks, which is on the flood plain of the river. The formation consists of deposits in the flood plain and channels of modern rivers and is widespread in central Alaska. Chena Alluvium replaces the long-used term "Recent alluvium" (Prindle and Katz, 1913; Péwé and others, 1966) because (1) the alluvium is a distinctive lithologic unit, (2) the term Recent has been replaced by Holocene, and (3) in many valleys only the upper part of the alluvium is of Holocene age.

The type section is a 15-cm-diameter water well (U.S. Smelting, Refining, and Mining Co. Well B) at 510 Illinois Street in Fairbanks drilled in 1927 (SE¼ sec. 3, T. 1 S., R. 1 W.; Fairbanks D-2 quadrangle) (Boring 162, Péwé, 1958b). It is 120 m deep, one of the deepest water wells on record in central Alaska and is entirely in unconsolidated silt, sand, and gravel. Mechanical analyses were made on all sediments in 115-cm increments of depth. (These analyses are on file at the Fairbanks office of the U.S. Smelting, Refining, and Mining Co. and the U.S. Geological Survey.)

The alluvium consists of alternating lenses and layers of well-sorted river silt, sand, and gravel, including glacial outwash deposits, and has been described by Péwé (1952; 1958b), Williams, Péwé, and Paige (1959), Pew6 and Rivard (1961), Péwé, Wahrhaftig, and Weber (1966), and Péwé, Bell, Forbes, and Weber (1975a). In this report the alluvial terraces of the major rivers are included in the formation. In the future they may be listed as different formations or members of the Chena Alluvium. The terrace alluvium is generally covered with loess, and the modern flood plain is not. Such terraces along the Tanana River upstream from Fairbanks have been delineated by Blackwell (1965). The Chena Alluvium is perennially frozen from 1 to 80 m deep, with many unfrozen zones (Péwé, 1954, fig. 72; Williams, 1970).

The Chena Alluvium ranges in thickness from a few metres on smaller streams to more than 100 m in major rivers, such as the Tanana and Yukon. It generally lies unconformably on bedrock or locally on the Cripple or

[3]Average of two dates on same sample (table 3).

TABLE 3—Radiocarbondatesfrom typesection of the Ready Bullion Formation, Ready Bullion benchplacer mining cut, Fairbanks (see fig. 12)

Formation	Field ^	Collector	Date collected	Lab No.	C-14 age (years before present)	Material
Ready Bullion Formation	P. 158	T.L. Péwé and R. Becker.	June 10,1964	PIC–11	7,530'265	9-cm-diameter spruce stem.
				(2d run)[1]	7,6652220	
	63AMo6	L.R. Mayo[2] ----	July 11, 1963	PIC–5,	8,080±165	Stick.
				TX–157[3]	7,740±170	
	63AMo3	------do------	------do------	PIC–3,	8,900±200	Peat.
				TX–159	8,970'150	
	63AMo5	------do------	------do------	PIC–6	10,450' 150	Tree root.
				TX–158a	9,500±200	
				TX–158b	9,320±160	
				IVIC–151[4]	9,470±180	
	63AMo4	------do------	------do------	PIC–4	10,3402475	Peat.
	63AMo2	------do------	------do------	PIC–2	11,000'350	Stick.
				TX–160	9,2402400	
Unconformity						
Goldstream Formation	P. 162	T.L. Péwé and R. Becker.	June 10,1964	PIC–12	27,5802 950	Minute carbonized plant fragments dispersed in soil.
	P. 162x	------do------	------do------	PIC–14	35,47523250	Do.

[1]Packard Instrument Company (see Kowalski, 1965, p. 202203; Kowalski and Schrodt, 1966, p. 388)
[2]Assistant to T. L. Péwé, 1965-65.
[3]University of Texas (see Pearson and others, 1965, p. 296).
[4]Instituto Venezolano de InvestigacionesCientificas (see Tamers, 1966, p. 211).

Tanana Formations, such as at the mouth of Dome Creek on the Chatanika River (Péwé, 1965a, p. 33), where 46 m of river gravel overlies older auriferous gravel (Prindle and Katz, 1913, pl. 15).

Except for shallow gravel pits, information about the Chena Alluvium is derived from wells, and little is known of the flora and fauna of the formation. Well records indicate isolated "logs" at various depths. No remains of extinct vertebrates have been found in the deposits. It is important to note, however, that ***Bison (Bison) bison*** has been found on the flood-plain deposits of Holocene age of large streams. O. W. Geist stated that such finds, reported in Skinner and Kaisen (1947), were from such sediments and further mentioned (oral commun.) that a bone of ***Bison (Bison) bison*** was found in the Chena Alluvium during construction of the new railroad freight terminal at Fairbanks.

The Chena Alluvium is in the process of formation and is Illinoian(?) to Holocene (Pleistocene and Holocene) in age.

REFERENCES CITED

Ager, T. A., 1972, Surficial geology and Quaternary history of the Healy Lake area, Alaska: Univ. Alaska, unpub. M.S. thesis, 127 p.

Arnold, J. R., and Libby, W. F., 1951, Radiocarbon dates: Science, v. 113, p. 111–120.

Bell, E. K., 1974, Origin of the auriferous clays in the Fairbanks area, Alaska: Ariz. State Univ., unpub. M.S. thesis, 63 p.

Blackwell, M. F., 1965, Surficial geology and geomorphology of the Harding Lake area, Big Delta quadrangle, Alaska: Univ. Alaska, unpub. M.S. thesis, 91 p.

Bostock, H. S., 1952, Geology of northwest Shakwak Valley, Yukon Territory: Canada Geol. Survey Mem. 267, 54 p.

Broecker, W. S., Kulp, J. L., and Tucek, C. S., 1956, Lamont natural radiocarbon measurements III: Science, v. 124, p. 154–165.

Brown, Jerry, Gray, Sheldon, and Allan, R. J., 1969, Late Quaternary evolution of a valley-fill, Fairbanks, Alaska; Part I, Geochemistry and stratigraphy of the permafrost: U.S. Army Cold Regions Research and Eng. Lab. Tech. Note, 18 p.

Brown, Jerry, Gray, Sheldon, and Webster, William, 1967, Chemical and related properties of a permafrost section from Fairbanks, Alaska: U.S. Army Cold Regions Research and Eng. Lab. Tech. Note, 18 p.

Browne, R. E., 1895, California placer gold: Eng. and Mining Jour., v. 59, p. 101–102.

Buckley, J. D., Trautman, M. A., and Willis, E. H., 1968, Isotopes radiocarbon measurements VI: Radiocarbon, v. 10, no. 2, p. 246–294.

Capps, S. R., 1916a, An ancient volcanic eruption in the upper Yukon basin: U.S. Geol. Survey Prof. Paper 95–D, p. 59–64.

——— 1916b, The Chisana–White River district, Alaska: U.S. Geol. Survey Bull. 630, 130 p.

Chaney, R. W., and Mason, H. L., 1936, A Pleistocene flora from Fairbanks, Alaska: Am. Mus. Novitates, v. 887, 17 p.

Crane, H. R., 1956, University of Michigan radiocarbon dates I: Science, v. 124, p. 664–672.

Denton, G. H., 1974, Quaternary glaciations of the White River Valley, Alaska, with a regional synthesis for the northern St. Elias Mountains, Alaska and Yukon Territory: Geol. Soc. America Bull., v. 85, p. 871–892.

Denton, G. H., and Armstrong, R. L., 1969, Miocene-Pliocene glaciations in southern Alaska: Am. Jour. Sci., v. 267, p. 1121–1142.

Devereux, W. B., 1882, The occurrence of gold in the Black Hills: Am. Inst. Mining Engineers Trans., v. 10, p. 465–475.

Dorsh, J. B., 1934, Notes on the Pleistocene and Recent geology of the Fairbanks district, Alaska: Univ. Alaska, unpub. Bachelor's thesis, 31 p.

Farrand, W. R., 1961, Frozen mammoths and modern geology: Science, v. 133, p. 729–735.

Fernald, A. T., 1962, Radiocarbon dates relating to a widespread volcanic ash deposit, eastern Alaska, in Short papers in geology, hydrology, and topography: U.S. Geol. Survey Prof. Paper 450–B, p. B29–B30.

Flerow, C. C., 1967, On the origin of the mammalian fauna of Canada, in Hopkins, D. M., ed., The Bering Land Bridge: Stanford, Stanford Univ. Press, p. 271–280.

Frick, Childs, 1930, Alaska's frozen fauna: Nat. History, v. 30, p. 71–80.

Furst, G. A., 1968, Geology and petrology of the Fairbanks basalts, Fairbanks, Alaska: Univ. Alaska, unpub. M.S. thesis, 53 p.

Gardner, E. D., and Johnson, C. H., 1934, Placer mining in the western United States; Part I, General information, hand-shoveling, and ground sluicing: U.S. Bur. Mines Inf. Circ. 6786, 73 p.

Geist, O. W., 1940, Mammoth's foot found: Univ. Alaska, Farthest-North Collegian, 1 p.

——— 1953, Collecting Pleistocene fossils in Alaska: Alaskan Sci. Conf., 2d, Mt. McKinley Natl. Park 1951, Proc., p. 171–172.

Giddings, J. L., Jr., 1938, Buried wood from Fairbanks, Alaska: Tree-ring Bull., v. 4, p. 3–6.

Guthrie, R. D., 1968a, Paleoecology of the large-mammal community in interior Alaska during the Late Pleistocene: Am. Midland Naturalist, v. 79, no. 2, p. 346–363.

——— 1968b, Paleoecology of a late Pleistocene small-mammal community from interior Alaska: Arctic, v. 21, no. 4, p. 223–244.

Herman, Yvonne, 1970, Arctic paleo-oceanography in late Cenozoic time: Science, v. 169, p. 474–477.

Herman, Yvonne, Grazzini, C. V., and Hooper, C., 1971, Arctic palaeotemperatures in late Cenozoic time: Nature, v. 232, p. 466–469.

Holmes, G. W., Hopkins, D. M., and Foster, H. L., 1968, Pingos in central Alaska: U.S. Geol. Survey Bull. 1241–H, 40 p.

Hopkins, D. M., Matthews, J. V., Wolfe, J. A., and Silberman, M. L., 1971, A Pliocene flora and insect fauna from the Bering Strait region: Palaeogeography, Paleoclimatology, Palaeoecology, v. 9, p. 211–231.

Ives, P. C., Levin, Betsy, Robinson, R. D., and Rubin, Meyer, 1964, U.S. Geological Survey radiocarbon dates VII: Radiocarbon, v. 6, p. 37–76

Kjøller, Annelise, and Ødom, Søren, 1971, Evidence for longevity of seeds and microorganisms in permafrost: Arctic, v. 24, no. 3, p. 230-233.

Kowalski, S. J., 1965, Packard Instrument Company radiocarbon dates I: Radiocarbon, v. 7, p. 200-204.

Kowalski, S. J., and Schrodt, A. G., 1966, Packard Instrument Company radiocarbon dates II: Radiocarbon, v. 8, p. 386–389.

Krueger, H. W., and Weeks, C. F., 1966, Geochron Laboratories, Inc. radiocarbon measurements II: Radiocarbon, v. 8, p. 142–160.

Kulp, J. L., Tryon, L. E., Eckelman, W. R., and Snell, W. A., 1952, Lamont natural radiocarbon measurements, II: Science, v. 116, no. 3016, p. 409-414.

Lerbekmo, J. F., and Campbell, F. A., 1969, Distribution, composition, and the source of the White River Ash, Yukon Territory: Canadian Jour. Earth Sci., v. 6, p. 109-116.

Lerbekmo, J. F., Hanson, L. W., and Campbell, F. A., 1968, Application of particle size distribution to determination of source of a volcanic ash deposit: Internat. Geol. Cong., 23d, Prague 1968, Proc., v. 2, p. 283–295.

Lerbekmo, J. F., Westgate, J. A. Smith, D. G. W., and Denton, G. H., 1973, New data on the eruptive history of the White River vent, Alaska: Internat. Assoc. Quaternary Research, 9th Cong., New Zealand, 1973: Christchurch, NZ, Abst. Vol., p. 208.

Libby, W. F., 1951, Radiocarbon dates II: Science, v. 114, p. 291–296.

Lindgren, W., 1911, Tertiary gravels of the Sierra Nevada of California: U.S. Geol. Survey Prof. Paper 73,226 p.

Lindholm, G. F., Thomas, L. A., Davidson, D. T., Handy, R. L., and Roy, C. J., 1957, Geologic and engineering properties of silts near Big Delta and Fairbanks, Alaska: Iowa State Coll. Eng. Expt. Sta., Iowa Univ. Sci. and Technology, Proj. 320–S, Final Rept. 1, 113 p.

Long, Austin, and Mielke, J. E., 1967, Smithsonian Institution radiocarbon measurements IV: Radiocarbon, v. 9, p. 368–381.

McConnell, R. G., 1907, Report on gold values in the Klondike high level gravels: Canada Geol. Survey Rept. 979, Ottawa, 34 p.

MacNeil, F. S., Wolfe, J. A., Miller, D. J., and Hopkins, D. M., 1961, Correlation of Tertiary formations of Alaska: Am. Assoc. Petroleum Geologists Bull., v. 45, no. 11, p. 1801–1809.

Matthews, J. V., Jr., 1968, A paleoenvironmental analysis of three late Pleistocene Coleopterous assemblages from Fairbanks, Alaska: Quaestiones entmologicae, v. 4, p. 241–251.

——— 1970, Quaternary environmental history of interior Alaska; pollen samples from organic colluviurn and peats: Arctic and Alpine Research, v. 2, no. 4, p. 241–251.

——— 1974, Wisconsin environment of interior Alaska; pollen and macrofossil analysis of a 27-meter core from the Isabella Basin (Fairbanks, Alaska): Canadian Jour. Earth Sci., v. 11, no. 6, p. 828–841.

Mertie, J. B., Jr., 1937, The Yukon-Tanana region, Alaska: U.S. Geol. Survey Bull. 872, 276 p.

——— 1940, Placer gold in Alaska: Washington Acad. Sci. Jour., v. 30, no. 3, p. 93–124.

Mielke, J. E., and Long, Austin, 1969, Smithsonian Institution radiocarbon measurements V: Radiocarbon, v. 11, no. 1, p. 163–182.

Olson, E. A., and Broecker, W. S., 1961, Lamont natural radiocarbon measurements VII: Radiocarbon, v. 3, p. 141–175.

Pearson, F. J., Jr., Davis, E. M., Tamers, M. A., and Johnstone, R. W., 1965, University of Texas radiocarbon dates III: Radiocarbon, v. 7, p. 296–314.

Péwé, T. L., 1948, Terrain and permafrost of the Galena Air Base, Galena, Alaska: U.S. Geol. Survey Permafrost Program Prog. Rept. 7, 52 p.

——— 1952, Geomorphology of the Fairbanks area: Stanford Univ., unpub. Ph.D. thesis, 220 p.

——— 1954, Effect of permafrost on cultivated fields, Fairbanks area, Alaska: U.S. Geol. Survey Bull. 989–F, p. 315–351.

——— 1955a, Origin of the upland silt near Fairbanks, Alaska: Geol. Soc. America Bull., v. 66, p. 699–724.

——— 1955b, Basalt near Fairbanks, Alaska (abs.): Geol. Soc. America Bull., v. 66, p. 1708.

——— 1958a, Permafrost and its effect on life in the north, in Arctic Biology: Oregon State Coll., Ann. Biology Colloquium, 18th, Corvallis 1957, p. 12–25.

——— 1958b, Geology of the Fairbanks (D–2) quadrangle, Alaska: U.S. Geol. Survey Geol. Quad. Map GQ–110.

——— 1965a, Fairbanks area, *in* Péwé, T. L., Ferrians, O. J., Jr., Nichols, D. R., and Karlstrom, T. N. V., Guidebook for Field Conf. F, central and southcentral Alaska — Internat. Assoc. Quaternary Research, 7th Cong., USA 1965: Lincoln, Nebr., Nebraska Acad. Sci., p. 6–36.

——— 1965b, Middle Tanana River valley, *in* Péwé, T. L., Ferrians, O. J., Jr., Nichols, D. R., and Karlstrom, T. N. V., Guidebook for Field Conf. F, central and south-central Alaska — Internat. Assoc. Quaternary Research, 7th Cong., USA 1965: Lincoln, Nebr., Nebraska Acad. Sci., p. 36–54.

——— 1965c, Delta River area, Alaska Range, *in* Péwé, T. L., Ferrians, O. J., Jr., Nichols, D. R., and Karlstrom, T. N. V., Guidebook for Field Conf. F, central and south-central Alaska — Internat. Assoc. Quaternary Research, 7th Cong., USA 1965: Lincoln, Nebr., Nebraska Acad. Sci., p. 55–93.

——— 1966, Permafrost and its effect on life in the north: Corvallis, Oregon State Univ. Press, 40 p.

——— 1968, Loess deposits of Alaska: Internat. Geol. Cong., 23d, Prague 1968, Proc., v. 8, p. 297–309.

——— 1970, Altiplanation terraces of early Quaternary age near Fairbanks, Alaska: Acta Geographica Lodziensia, no. 24, p. 357–363.

———1975, Quaternary geology of Alaska: U.S. Geol. Survey Prof. Paper 835 (in press).

Péwé, T. L., Bell, J. W., Forbes, R. B., Weber, F. R., 1975a, Geologic map of the Fairbanks D-2 SW quadrangle, Alaska: U.S. Geol. Survey Misc. Map I-829A (in press).

———1975b, Geologic map of the Fairbanks D-2 NW quadrangle, Alaska: U.S. Geol. Survey Mi. Map Series (in press).

Péwe, T. L., and Holmes, G. W., 1964, Geology of the Mt. Hayes D-4 quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-394.

Péwé, T. L., and Hopkins, D. M., 1967, Mammal remains of pre-Wisconsinan age in Alaska, in Hopkins, D. M., ed., The Bering Land Bridge: Stanford, Stanford Univ. Press, p. 266-270.

Péwe, T. L., and Rivard, N. R., 1961, Geologic map and section of the Fairbanks D-3 quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-340.

Péwé, T. L., and Sellmann, P. V., 1971, Geochemistry of permafrost and Quaternary stratigraphy: Geol. Soc. America Ann. Mtg., Abs. with Programs, v. 3, no. 7, p. 669.

Péwé, T. L., and Sellmann, P. V., 1973, Geochemistry of permafrost and Quaternary stratigraphy: Internat. Permafrost Conf., 2d, Yakutsk, Proc. U.S. Natl. Acad. Sci. Pub., p. 166-170.

Péwé, T. L., Wahrhaftig, Clyde, and Weber, F. R., 1966, Geology of the Fairbanks quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-455.

Prindle, L. M., 1906, Yukon placer fields: U.S. Geol. Survey Bull. 284, p. 109-131.

———1908a, The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: U.S. Geol. Survey Bull., 337, p. 9-63.

———1908b, Occurrence of gold in the Yukon-Tanana region, in Brooks, A. H., and others, 1908, Mineral resources of Alaska: U.S. Geol. Survey Bull. 345, p. 179-186.

———1913, A geologic reconnaissance of the Fairbanks quadrangle, Alaska, in Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U.S. Geol. Survey Bull. 525, p. 1-58.

Prindle, L. M., and Katz, F. J., 1913, Detailed description of the Fairbanks district, in Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U.S. Geol. Survey Bull. 525, p. 59-152.

Reger, R. D., Péwé, T. L., Hadleigh-West, F., and Skarland, I., 1964, Geology and archeology of the Yardang flint station: Anthropol. Paper, Univ. Alaska, v. 12, p. 92-100.

Repenning, C. A., Hopkins, D. M., and Rubin, Meyer, 1964, Tundra rodents in a late Pleistocene fauna from the Tofty district, central Alaska: Arctic, v. 17, p. 177-197.

Rubin, Meyer, and Alexander, Corrine, 1958, U.S. Geological Survey radiocarbon dates IV: Science, v. 127, p. 1476-1487.

———1960, U.S. Geological Survey radiocarbon dates V: Radiocarbon Supp., v. 2, p. 129-185.

Rubin, Meyer, and Berthold, S. M., 1961, U.S. Geological Survey radiocarbon dates VI: Radiocarbon, v. 3, p. 86-98.

Rubin, Meyer, and Seuss, H. E., 1955, U.S. Geological Survey radiocarbon dates II: Science, v. 121, p. 481-488.

Schwatka, Frederick, 1885, Along Alaska's great river: New York, Cassell & Co., Ltd., 360 p.

Sellmann, P. V., 1967, Geology of the USA-CRREL permafrost tunnel, Fairbanks, Alaska: U.S. Army Cold Regions Research and Eng. Lab. Tech. Rept. 199, 33 p.

———1968, Geochemistry and ground ice structures; an aid in interpreting a Pleistocene section, Alaska (abs.): Geol. Soc. America Spec. Paper 101, p. 197-198.

———1972, Additional information on the geology and properties of materials exposed in the USA-CRREL permafrost tunnel: U.S. Army Cold Regions Research and Eng. Lab. Spec. Rept., 16 p.

Sher, A. V., 1969, Early Pleistocene mammals of extreme northeastern Asia and their environment (abs.): Internat. Assoc. Quaternary Research, 8th Cong., Paris 1969, p. 135.

———1971, Mammals and stratigraphy of the Pleistocene of the extreme northeast of the U.S.S.R. and North America: Moscow, Nauka, 310 p.

Skarland, Ivar, 1949, The geography of Alaska in Pleistocene and early post-glacial time; a study of the environment from an anthropological viewpoint: Harvard Univ., unpub. Ph.D. thesis.

Skinner, M. F., and Kaisen, O. C., 1947, The fossil *Bison* of Alaska and preliminary revision of the genus: Am. Mus. Nat. History Bull., v. 89, p. 123-256.

Smith, P. S., 1913, The fineness of gold in the Fairbanks District, Alaska: Econ. Geology, v. 8, p. 449-454.

———1941, Fineness of gold from Alaska placers: U.S. Geol. Survey Bull. 910-C, 272 p.

Stuckenrath, R., Jr., and Mielke, J. E., 1970, Smithsonian Institution radiocarbon measurements VI: Radiocarbon, v. 12, no. 1, p. 193-204.

———1973, Smithsonian Institution radiocarbon measurements VIII: Radiocarbon, v. 15, p. 388-424.

Stuiver, Minze, Borns, H. W., and Denton, G. H., 1964, Age of a widespread layer of volcanic ash in the southwestern Yukon Territory: Arctic, v. 17, p. 259-260.

Taber, Stephen, 1943, Perennially frozen ground in Alaska; its origin and history: Geol. Soc. America Bull., v. 54, p. 1433-1548.

Tamers, M. A., 1966, Instituto Venezolano de investigaciones cientificas natural radiocarbon measurements II: Radiocarbon, v. 8, p. 204-212.

Trautman, M. A., 1963, Isotopes, Inc. radiocarbon measurements III: Radiocarbon, v. 5, p. 62-79.

———1964, Isotopes, Inc. radiocarbon measurements IV: Radiocarbon, v. 6, p. 269-279.

Tuck, Ralph, 1968, Origin of the bedrock values of placer deposits: Econ. Geology, v. 63, p. 191-193.

Vangengeim, E. A., and Sher, A. V., 1970, Siberian equivalents of the Tiraspol faunal complex: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 8, p. 197-207.

Wilkerson, A. S., 1932, Some frozen deposits in the gold fields of interior Alaska: Am. Mus. Novitates 525, 22 p.

Williams, J. R., 1970, Ground water in the permafrost regions of Alaska: U.S. Geol. Survey Prof. Paper 696, 83 p.

Williams, J. R., Péwé, T. L., and Paige, R. A., 1959, Geology of the Fairbanks (D-1) quadrangle, Alaska: U.S. Geol. Survey Geol. Quad. Map GQ-124.

TABLE 4

TABLE 4.—*Radiocarbon dates from central Alaska*

Date (year before present)	Lab No	Stratigraphic location	Material	Collector and date	Location: Site	Location: Quadrangle	Location: Sec T R or lat and long	Reference
Engineer Loess								
2,300±180	I–647	From loess 12 cm above top of gravel fan and 1½ m below surface.	Peat	T. L. Péwé, R. D. Reger, and G. Bond, 6/20/62.	Ruby Creek.	Mt. Hayes C-4.	NW¼ sec. 7, T. 15 S., R. 10 E.	Trautman (1963, p. 64); Péwé (1965c, p. 66).
5,900±250	I–646	From loess 20 cm above underlying gravel fan and 2 m below surface.	Wood	T. L. Péwé, 5/25/60.	do	do	do	Do.
2,565±295	GX–254	In loess; 60 cm below surface.	Charcoal	T. L. Péwé, 8/19/64.	Shaw Creek Road.	Big Delta B–5.	NW¼ sec. 35, T. 7 S., R. 8 E.	Krueger and Weeks (1966, p. 144); Péwé (1965b, fig. 4–22, p. 145).
4,020±200	W–183	Near base of formation; 2 m below the surface.	Stump	T. L. Péwé, 6/5/51.	Gold Hill.	Fairbanks D–2.	SW¼ sec. 3, T. 1 S., R. 2 W.	Rubin and Suess (1955, p. 486); Péwé (1965a, p. 20).
8,040±190	GX–255	Near base of loess over sand dune.	Charcoal	T. L. Péwé, 8/19/64.	Shaw Creek Flats in cut bank of Tanana River.	Big Delta A–4.	NE% sec. 35, T. 8 S., R. 9 E.	Krueger and Weeks (1966, p. 145); Péwé (1965b, p. 53).
10,500±500	L–137S	3 m below surface in loess. Base of of formation.	Birch wood (not dwarf birch).	T. L. Péwé, 6/5/51.	Eva bench mining cut on Eva Creek.	Fairbanks D–3.	SW¼ sec. 5, T. 1 S., R. 2 W.	Broecker, Kulp, and Tucek (1956, p. 157).
7,000±275	Isotopes (no number)	Base of 13 m section of loess overlying outwash gravel.	Spruce mot.	T. L. Péwé, 8/17/55.	Delta River (right limit).	Mt. Hayes D–4.	63°46′N; 145°56′W	Péwé (unpub. data).
455±130	GX–2166	In loess at a depth of 5 cm.	Plant fragments.	T. A. Ager, 1969.	Healy Lake Test Pit T. 20 N. R. 10 E.	Big Delta A–2.	Center sec. 35, T. 26 N., R. 15 E.	Ager (1972, p. 63).
900±455	Gak–1886	Depth of 5 cm	do	do	do	do	do	Do.
1,360±80	Gak–1887	Depth of 10 cm	do	do	do	do	do	Do.
905±906	GX–2160	do	do	do	do	do	do	Do.
1,655±180	GX–2168	do	do	do	do	do	do	Do.
2,875±140	GX–2169	do	do	do	do	do	do	Do.
3,550±140	GX–2165	Depth of 12 cm	do	do	do	do	do	Do.
2,660±100	GX–2176	Depth of 15 cm	do	do	do	do	do	Do.
2,150±180	GX–2161	In loess at a depth of 17 cm.	do	do	do	do	do	Do.
4,010±110	GX–2163	Depth of 20 cm	do	do	do	do	do	Do.
8,960±150	GX–1340	do	do	do	do	do	do	Do.
10,250±380	GX–2173	Depth of 25 cm at base of formation overlying Wisconsinan eolian sand.	do	do	do	do	do	Do.
8,655±280 8,680±240	GX–2171 GX–2170 (split sample)	Depth of 35 cm at base of formation overlying Wisconsinan eolian sand.	do	do	do	do	do	Do.
9,895±210 10,150±210	GX–2174 SI–737 (split sample)	do	do	do	do	do	do	Do.
11,090±170	GX–1391	Depth of 40 cm at base of formation overlying Wisconsinan eolian sand.	do	do	do	do	do	Do.
6,045±280 8,210±155	GX–2159 SI–738 (split sample)	Depth of 55 cm at base of formation overlying Wisconsinan eolian sand.	do	do	do	do	do	Do.
10,500±280	GX–1944	In loess at a depth of 55 cm at base of formation overlying Wisconsinan eolian sand.	do	do	do	do	do	Do.
8,465±360 10,040±210	GX–2175 SI–739 (split sample)	Depth of 60 cm at base of formation overlying Wisconsinan eolian sand.	do	do	do	do	do	Do.
White River Ash Bed								
1,520±100	I–276	Immediately over White River Ash Bed.	Layered peat.	A. T. Fernald, 1959.	Upper Tanana River valley; right cut bank.	Tanacross A–3.	63°10′N; 142°08′W	Fernald (1962, p. B–30).
1,750±110	I-275	Immediately under White River Ash Bed.	do	do	do	do	do	Do.
2,000±250	W-978	7.5 cm under White River Ash Bed.	do	do	Tanana River flood plain.	do	63°08′N; 142°06′W	Ives, Levin, Robinson, and Rubin (1964, p. 69); Fernald (1962, p. B–30).

TABLE 4.—*Radiocarbon dates from central Alaska*—Continued

Date (year before present)	Lab No	Stratigraphic location	Material	Collector and date	Location: Site	Location: Quadrangle	Location: Sec. T R or lat and long	Reference
Jarvis Ash Bed								
1,950±150	L-163K	In loess just above Jarvis Ash Bed.	Wood	T.L. Péwé, 9/18/51.	Delta River Bluff near Donnelly Dome.	Mt. Hayes C-4.	SW¼ sec. 19, T. 14 S., R. 10 E.	Péwé (1968, p. 307).
4,650±250	L-137Q	In loess just below Jarvis Ash Bed.	do	T.L. Péwé, 6/28/51.	do	do	do	Do.
Wilber Ash Bed								
4,200±200	L-117G	2 m below surface in organic layer and about 1 m below Wilber Ash Bed.	Wood	T.L. Pewe, 6/2/51.	Wilber Creek.	Livengood B-3.	65°27′N; 148°22′W.	Kulp, Tryon, Eckelman, and Snell, 1952, p. 412.
Ready Bullion Formation								
7,530±265 7,665±220	PIC-11 2d run	1 m below surface and top of formation.	9-cm-diameter spruce stem.	T.L. Péwé, and R.E. Becker, 6/10/64.	Ready Bullion bench mining cut; Ready Bullion Creek.	Fairbanks D-3.	SW¼ sec. 6, T. 1 S., R. 2 W.	Kowalski and Schrodt (1966, p. 388); Pewe (this report, fig. 12, table 3).
8,080±165	PIG5	2 m below surface and top of formation.	Stick	L.R. Mayo, 7/11/63.	do	do	do	Kowalski (1965, p. 203); Pewe (this report, fig. 12, table 3).
7,740±170	TX-157	Same sample as PIC-5	do	do	do	do	do	Pearson, Davis, Tamers, and Johnstone (1965, p. 296); Péwé (this report, fig. 12, table 3).
8,900±200	PIG3	Within one-half m of base of formation.	Peat	do	do	do	do	Kowalski (1965, p. 202); Péwé (this report, fig. 12, table 3).
8,970±150	TX-159	Same sample as PIC-3	do	do	do	do	do	Pearson, Davis, Tamers, and Johnstone (1965, p. 296); Péwé (this report, fig. 12, table 3).
9,320±160	TX-158b	Within one-half m of base of formation.	Tree mot	do	do	do	do	Do.
9,470±180	IVIC-151	Same sample as TX-158b.	do	do	do	do	do	Tamers (1966, p. 211).
9,500±200	TX-158a	do	do	do	do	do	do	Pearson, Davis, Tamera, and Johnstone (1965, p. 296).
10,450±150	PIG6	do	do	do	do	do	do	Kowalski (1965, p. 203).
10,340±475	PIG4	At base of formation.	Peat	do	do	do	do	Kowalski (1965, p. 202); Péwé (this report, fig. 12, table 3).
9,240±400	TX-160	Within one-half m of base of formation.	Stick	do	do	do	do	F. J. Pearson in Kowalski (1965, p. 202); Péwé (this report, fig. 12, table 3).
11,000±350	PIG2	Same sample as TX-160.	do	do	do	do	do	Kowalski (1965, p. 202); Pew6 (this report, fig. 12, table 3).
5,940±250	W-859	6 m below surface on local gravel fan interbedded in silt. Gravel overlies Goldstream Formation.	Root	T.L. Péwé, 8/14/56.	Sheep Creek.	Fairbanks D-2.	NW¼ sec. 20, T. 1 N., R. 2 W.	Rubin and Alexander (1960, p. 173).
360±95	I-3879	0.2 m below surface in perennially fmzen silt of drill core.	Shreds of organic matter.	Jerry Brown, Sheldon Gray, and William Webster, 1967.	Isabella Creek.	do	SE¼ see. 24, T. 1 N., R. 1 W.	Brown, Gray, and Allan (1969, table 1).
4,510±120	I-3627	1.5 m below surface in perennially frozen silt of drill core.	do	do	do	do	do	Do.
5,600±110	I-3626	2.1 m below surface in perennially frozen silt of drill core.	do	do	do	do	do	Do.
6,910±140	I-3624	2.0 m below surface in perennially fmzen silt of drill core.	do	do	do	do	do	Do.
7,810±160	I-3625	2.8 m below surface in perennially frozen silt of drill core.	do	do	do	do	do	Do.

TABLE 4.—*Radiocarbon dates from central Alaska*—Continued

Date (year before present)	Lab. No.	Stratigraphic location	Material	Collector and date	Location			Reference
					Site	Quadrangle	Sec. T. R. or lat and long	
Ready Bullion Formation—Continued								
9,200±160	I-3006	3.6 m below surface in perennially frozen silt of drill core.	Shreds of organic material and twigs	Jerry Brown, Sheldon Gray, and William Webster, 1967.	Isabella Creek.	Fairbanks D-2.	SEU sec. 24, T. 1 N., R. 1 W.	Brown, Gray, and Webster (1967, p. 6); Brown, Gray and Allan (1969, table 1).
6,040±240	W-434	Near base of formation 2½ m below surface.	Birch stump	T.L. Péwé, 6/10/52.	Fairbanks Creek.	Livengood A-1.	65°03'N; 147°10'W	Rubin and Alexander (1958, p 1479).
7,350±250	L-163I	Near base of formation	12-cm-diameter upright spruce stumps in polygonal pattern 10 m in diameter.	T.L. Péwé, 6/6/52.	do.	do.	do.	T. L. Péwé (unpub. data).
6,970±135	I-2118	2 m below surface in ventilating shaft of mafrost tunnel.	Fine fibrous organic material.	P.V. Sellmann, 1966.	Goldstream Creek. CRREL permafrost tunnel.	Fairbanks D-2.	SE¼ sec. 31, T. 2 N., R. 1 E.	Buckley, Trautman, and Willis (1968, p. 248); Sellmann (1967, p. 17).
8,460±250	I-2119	4 m from surface in ventilating shaft of permafrost tunnel.	do	do	do.	do	do.	Do.
8,530±115	GX-251	6 m below top of formation.	Twigs	T.L. Péwé, 5/11/62.	Chatanika River (right limit).	Livengocd A-2.	NW¼ sec. 15, T. 3 N., R. 1 W.	Krueger and Weeks (1966, p. 145); Péwé (1965a, p. 34; this paper, fig. 10).
3,750±200	L-117H	2 m below surface in organic layer.	wood	T.L. Péwé, 6/4/51.	Eva Creek.	Fairbanks D-3.	SW¼ T. 1 S., R. 2 W.	Kulp, Tryon, Eckelman, and Snell (1952, p. 412); Pew6 (this paper, fig. 6).
3,005±75	GX-277	5.6 m below surface at base of a silt fan and on top of lower terrace gravel.	do	M.F. Blackwell, 1964	Mouth of Canyon Creek.	Big Delta B-5.	SW¼ sec. 24, T. 7 S., R. 6 E.	Krueger and Weeks (1966, p. 146); Blackwell (1965, p. 61).
3,920±75	GX-257	1 m below top of gravel in gravel fan of Banner Creek near Tanana River	Log	do	Banner Creek.	do.	SW¼ sec. 22, T. 7 S., R. 7 E.	Do.
3,750±380	SI-356	From beaver dam near base of formation.	wood	Collected by H.L. Foster; submitted by F.L. Whitmore, 1965.	Canyon Creek.	Eagle A-1	SW¼ sec. 16, T. 27 N., R. 22 E.	Mielke and Long (1969, p. 177).
<200	W-1106	In channel fill of silty sand and gravel. Hopkins believes wood and rodent fossils of Wisconsinan age reworked from old sediments.	Log	D.M. Hopkins.	Sullivan placer pit, Sullivan Creek near Tofty.	Tanana A-2.	NE¼ sec. 18, T. 3 N., R. 16 W.	Repenning, Hopkins and Rubin (1964, p. 182).
<200	W-1111	do.	do.	do.	do	do	do	Do.
200±200	W-937	do	do	do.	do.	do.	do	Do.
2,520±200	W-891	do	do.	do.	do	do	do	Do.
6.730±260	W-1108	In peaty silt about 2 m below surface. Hopkins believes logs reworked from older sediments.	Beaver-gnawed birch log.	D.M. Hopkins and Bond Taber, 1959-61.	do	do.	do	Ives, Levin, Robinson, and Rubin (1964, p. 67); Repenning, Hopkins, and Rubin (1964, p. 182).
6,820±200	W-733	do	do	D.M. Hopkins, 1956.	do	do	do	Rubin and Alexander (1960, p. 174); Repenning, Hopkins, and Rubin (1964, p. 182).
>38,000	W-1113	Wood of Wisconsinan age reworked into overlying post-Wisconsinan sediments (D.M. Hopkins).	Wood	D.M. Hopkins and Bond Taber, 195961.	do	do	do	Ives, Levin, Robinson, and Rubin (1964, p. 67).
7,280±140	I-2240	Near overturned stumps.	Woody, silty peat.	J.V. Mat thews.	McGee Cut; Dalton Gulch near Sullivan Creek.	do	do	Matthews (1970, p. 247).
4,100±200	W-896	In fresh gravel overlain by gravelly peaty silt.	Wood	D.M. Hop. kins.	Omega Creek mining cut.	Tanana A-1.	NW ¼ sec. 14, T. 4 N., R. 14 W.	Rubin and Berthold (1961, p. 93).
515±110	GX-1970	1.2-m depth from surface.	Woody peat.	T.A. Ager, 1969.	Healy Lake TP59.	Mt. Hayes D-2.	NWU sec. 1, T. 25 N., R. 15 E.	Ager (1972, p. 107).
5,530±140	GX-1969	1.8-m depth	Plant fragments.	do.	Healy Lake TP74.	do	do	Do.
760±80	GX-2026	1-m depth	Peat	Anderson, 1969.	do	do	SE¼ sec. 22, T. 25 N, R. 15 E.	Ager (1972, p. 110).
1,685±90	GX-2025	1.8-m depth	do.	do.		do.	do.	Do.
230±120	GX-1971	1-m depth	Wocdy peat.	T.A. Ager, 1969.	Healy Lake TP75.	do	NW¼ sec. 24, T. 25 N., R. 15 E.	Ager (1972, p. 59).
1,160±110	GX-1972	1.3-m depth	do	do	do	do	do.	Do.

TABLE 4.--*Radiocarbon dates from central Alaska—Continued*

Date (year before present)	Lab. No.	Stratigraphic location	Material	Collector and date	Location: Site	Location: Quadrangle	Location: Sec. T. R. or lat and long	Reference
Chatanika Ash Bed								
14,760±850	GX–0250	4 m below top of **Goldstream** Formation and about 2 m below Chatanika **Ash** Bed.	*Citellus* nest.	T.L. **Péwé, 4/14/62.**	**Chatanika River** (right limit).	Livengood A–2.	NW¼ *sec.* 15, **T. 3** N., R. 1 W.	Krueger and Weeks (1966, p. 145); **Péwé (1965a,** p. 34; this report, fig. **10).**
14,510±450	W–2703	3 m below top of **Goldstream** Formation and one-half m above Chatanika Ash Bed.	*Citellus* coprolites.	----do----	----do----	----do----	----do----	Meyer **Rubin** (oral **commun., 1972); Péwé** (this report, fig. **10).**
6,570±300	GX–2555	Immediately **above Chatanika** Ash Bed.	Wood sample probably in slump material from above **(T.L. Péwé).**	L.R. **Mayo,** 11127171.	----do----	----do----	----do----	R. H. **Reesman** (written commun., **2/29/72).**
Goldstream Formation								
>25,000	**A–921A**	3 m below eroded top of formation.	Organic residue in ice wedge.	T.L. Pewe, 6115166.	**Ready Bullion** Creek.	Fairbanks **D–3.**	**SW¼ sec.** 6, T. 1 S., R. 2 W.	**Long (written commun., 1971).**
>25,000	**A–922A**	----------do----------	Organic **material—** minute carbonized **plant fragments** dispersed in soil.	----do----	----do----	----do----	----do----	Do.
>38,000	**GX–0252**	----------do----------	Sticks--------	T.L. **Péwé,** 8111164.	----do----	----do----	----do----	Krueger and Weeks (1966, p. 145).
14,300±1,200	**GX–0253**	Under clear ice mass (river **icing?**) 6 m below **eroded** top of **formation.**	Highly organic mud.	----do----	----do----	----do----	----do----	**Do.**
27,580±950	**PIC–12**	Near top of eroded formation 6 m below surface.	Minute plant fragments.	T.L. Pewe and R.E. Becker, 6110164.	Ready Bullion bench cut; **Ready Bullion Creek.**	----do----	----do----	**Long (written commun., 1971); Péwé (this report, fig. 12, table 3).**
35,475±3,250	**PIC–14**	3 m below eroded top of formation 6 m below surface.	------do------	----do----	----do----	----do----	----do----	**Kowalski** and Schrodt (1966, p. 388); **Péwé** (this report, fig. 12, table 3).
18,250±1,130	**PIC–13**	12 m below surface ------	*Twigs* --------	----do----	----do----	----do----	----do----	**Kowalski and Schrodt (1966, p. 388).**
>35,000	Danish National Museum.	9 m below surface --------	wood --------	**Søren Ødum, 7/17/68.**	**Ready Bullion** bench cut: Ready Bullion Creek (misnamed Ester Creek **in Kjøller and Ødum).**	----do----	----do----	**Kjøller and Ødum (1971, p. 231).**
>35,000	----do----	Base of formation near gravel.	------do------	----do----	----do----	----do----	----do.	**Do**
25,090±1,070	**SI–850**	In frozen muck ----------	Hornsheath *Symbos.*	O.W. Geist, 1939.	Dome Creek.	**Livengood A–2.**	**NW¼** *sec.* 5, T. 2 N., R. 1 E.	Stuckenrath and Mielke (1973).
31,400+2,040 −1,815	**ST–1721**	In frozen silt near contact with underlying gravel. A great concentration of mammal bones of various species occur in this part of the formation.	Hide and hair from carcass of Bison ***(Superbison) crassicornis.***	O.W. **Geist,** 1951; submitted by T.L. **Péwé.**	----do----	----do----	----do----	**Péwé (1965a, p. 33)**
>28,000	**L–127**	----------do----------	Dried **tissue** fmm carcass **of *Bison* (*Superbison*) *crassicornis*** (same carcass as ST–1721).	O.W. Geist, 1951	d o----	----do----	----do----	Kulp, **Tryon,** Eckelman, and Snell (1952, p. 411).
>25,000	**L–157B**	In silt one-half m above stump **(L–158A).**	**Wood** --------	T.L. **Péwé,** 6/8/52.	----do----	----do----	----do----	Broecker, Kulp, and Tucek **(1956,** p. 157).
>30,000	**L–158A**	Stum rooted on gravel surface at base **of** formation. About 2 m below where bison carcass (ST–1721) was said to be collected in 1951.	**Stump approximately** one-half m diameter.	----do----	----do----	----do----	----do----	Do.
>30,000	**L–158B**	Adjacent to stump **(L–158A).**	Silt with many minute **pieces** of organic materials.	----do----	----do----	----do----	----do----	Do.

TABLE 4.--*Radiocarbon dates from central Alaska*—Continued

Date (year before present)	Lab. No.	Stratigraphic location	Material	Collector and date	Location: Site	Location: Quadrangle	Location: Sec. T. R. or lat and long	Reference
Goldstream Formation—Continued								
>30,000	L-163H	Near bison site (ST-1721).	wood	T. L. Péwé, 6/8/52.	Dome Creek.	Livengood A-2.	NW¼ sec. 5, T. 2 N., R. 1 E.	Broecker, Kulp, and Tucek (1956, p. 157).
32,700±980	ST-1632	In frozen silt rich in organic matter.	Hair fmm skull of mammoth.	O.W. Geist (1951); submitted by T.L. Péwé.	do	do	do	Péwé (1965a, p. 33).
23,900±1,000	w-435	2.5 m below top of formation.	Stems and twigs.	T.L. Péwé, 8/15/54.	Eva Creek.	Fairbanks D-3.	SW¼ sec. 5, T. 1 S., R. 2 W.	Rubin and Alexander (1958, p. 1479); Péwé (this report, fig. 6).
24,400±650	I-2116	8 m above base of formation.	wood	J.V. Matthews, 1964.	do	do	do	Matthews (1970, p. 247); Péwè (this report, fig. 6).
>25,000	A-924	8 m below top of formation.	Minute carbonized plant fragments dispersed in silt.	T.L. Péwé, 7/15/66.	do	do	do	Long (written commun., 1971); Péwé (this report, fig. 6).
>25,000	A-923A	do	Minute carbonized plant fragments fmm ice wedges.	do	do	do	do	Do.
>30,000	L-163J	10 m below surface near middle of the formation.	wood	T.L. Péwé, 6/4/52.	do	do	do	Broecker, Kulp, and Tucek (1956, p. 157); Péwé (this report, fig. 6).
>23,000	L-157A	20 m below surface at base of formation.	do	T.L. Péwé, 6/10/52.	do	do	do	Do.
7,840±280	I-4774	7 m below surface in perennially fmzen silt of drill core (date spurious; T.L. Péwé and J.V. Mathews).	Shreds of organic matter.	Jerry Brown, Sheldon Gray, and William Webster, 1967.	Isabella Creek.	Fairbanks D-2.	SE¼ sec. 24, T. 1 N., R. 1 W.	Matthews (1974).
11,500±190	I-3007	9.9 m below surface in perennially frozen silt of drill core.	Shreds of organic material and twigs.	do	do	do	do	Brown, Gray, and Webster (1967, p. 6); Brown, Gray, and Allan (1969, table 1).
>31,900	I-4775	18 m below surface in perennially frozen silt of drill core.	Shreds of organic material.	J.V. Matthews, 1967.	do	do	do	Matthews (1974).
34,900+2,950 −2,220	1-3083	25.1 m below surface in perennially frozen silt of drill core.	Shreds of organic material and twigs.	Jerry Brown, Sheldon Gray, and William Webster, 1967.	do	do	do	Brown, Gray, and Webster (1967, p. 6); Brown, Gray, and Allan (1969, table 1).
11,980±135	ST-1633	In fmzen silt rich in organic matter.	Hide, Bison (*Superbison*) *crassicornis* female.	O.W. Geist, no date; submitted by T.L. Péwé.	Fairbanks Creek.	Livengood A-1.	65°03′N; 147°10′W	Péwé (1965a, p. 33)
12,622±750	Univ. of Chicago, 301	10-20 m below surface	wood	Collected by Schuman, 1948; submitted by Oswalt.	do	do	do	Libby (1951, p. 294).
13,600±600	L-117I	From buried beaver dam	do	T.L. Péwé, 6/6/51	do	do	do	Kulp, Tryon, Eckelman, and Snell (1952, p. 412).
15,380±30	SI-453	Frozen silt 26 m below surface.	Flesh fmm lower leg, *Mammuthus primigenius*.	Osborne, 1940.	do	do	do	Stuckenrath and Mielke (1970).
17,210±500	SI-454	Frozen silt rich in organic material.	Hair fmm hind limb of *Ovibos* sp.	O.W. Geist, 1940.	do	do	do	Do.
17,170±840	SI-838	Frozen silt	Hornsheath Bison.	O.W. Geist, 1952; submitted by R.D. Guthrie.	do	do	do	Stuckenrath and Mielke (1973).
26,445±885	SI-837	do	do	do	do	do	do	Do.
24,140±2,200	SI-455	Frozen silt rich in organic material.	Muscle fmm scalp *Ovibos* (same animal as SI-454).	O.W. Geist, 1940.	do	do	do	Stuckenrath and Mielke (1970).
21,300±1,300 (hide soaked in glycerine by collector—date invalid?)	L-601	With beaver dam. Also in association with gravel "stringers."	Skin and flesh of *Mammuthus* primigenius (baby mammoth).	O.W. Geist, August 1948; submitted by W.R. Farrand.	do	do	do	Olson and Bmecker (1961, p. 165); Farrand (1961).
22,540±900	SI-292	Frozen silt rich in minute particles of organic matter.	Hornsheath of *Bootherium nivicoleus*.	O.W. Geist, 1935.	do	do	do	Long and Mielke (1967, p. 380).
31,980±4,490	SI-843	Frozen silt	Hornsheath of Bison *preoccidentalis*.	O.W. Geist, no date, submitted by R.D. Guthrie.	do	do	do	Stuckenrath and Mielke (1973).

TABLE 4.—*Radiocarbon dates from central Alaska*—Continued

Date (year before present)	Lab. No.	Stratigraphic location	Material	Collector and date	Location: Site	Location: Quadrangle	Location: Sec. T. R. or lat and long	Reference
Goldstream Formation—Continued								
5,340±110 (spurious date; T.L. Péwé).	SI–845	Frozen silt	Hornsheath of Bison *preoccidentalis*.	O.W. Geist, 1939; submitted by R.D. Guthrie.	Goldstream area.	Fairbanks D–2.	SE¼ sec. 31, T. 2 N., R. 1 E.	Stuckenrath and Mielke (1973).
11,000±280	I–1370	Under 10 m frozen silt near portal of permafrost tunnel.	wood log (conifer root).	G. Swinzow, 1965.	Goldstream Creek CRREL permafrost tunnel.	do.	do.	Buckley, Trautman, and Willis (1968, p. 246).
11,400±450	I–1369	Near portal of permafrost tunnel.	Wood (log)	do	do.	do.	do.	Do.
13,470±472	I–2196	do	do.	do	do	do	do	Sellmann (1967, p. 17).
14,280±230	I–2197	do	Bone	do	do.	do	do.	Buckley, Trautman, and Willis (1968, p. 246).
31,400+2,900 −2,100	I–1842	Flattop ice wedge below unconformity; 10 m from surface in tunnel.	Organic residue in ice wedge.	P.V. Sellmann, 1965–66.	do	do.	do.	Do.
32,300+2,000 −1,600	I–1843	do	do.	do	do	do.	do.	Do
33,700+2,500 −1,900	I–1841	Below unconformity; 10 m below surface.	Twig	do	do	do	do.	Buckley, Trautman, and Willis (1968, p. 248).
33,200±1900	I–4493	In winze in silt 40 cm above contact with Fox Gravel.	Woody material.	P.V. Sellmann, 1971.	do	do	do.	Sellmann (1972).
33,750±2,000	I–4494	In winze in reworked Fox Gravel; 1–1.5 m below contact with overlying Goldstream Formation.	do	do	do	do	do	Do
>39,900	I–4588	In basal room; in Fox Gravel (reworked?). 1 m above bedrock contact.	Small log	do.	do	do.	do	Do.
2,510±570	I–2120	8½ m from surface in ventilating shaft of permafrost tunnel adjacent to flattopped ice wedge (spurious date—"not enough organic material. . ." P.V. Sellmann).	Fine fibrous organic material.	P.V. Sellmann, 1966.	do	do	do.	Buckley, Trautman, and Willis (1968, p. 248); Sellman (1967, p. 17).
30,700+2,100 −1,600	I–2121	11 m from surface in ventilating shaft of permafrost tunnel.	do.	do.	do.	do	do	Do.
11,735±130	ST–1631	In frozen silt rich in organic matter.	Internal piece of hornsheath from type specimen of *Bison (Bison) preoccidentalis*.	O.W. Geist (1937); submitted by T.L. Péwé.	Upper Cleary Creek.	Livengood A–1.	NW¼ sec. 17, R. 2 E., T. 3 N.	Péwé (1975).
12,460±320	SI–290	do.	do	O.W. Geist (1937); submitted by C. Ray.	do.	do.	do	Mielke and Long (1969, p. 177).
16,400±2,000 (black carbon method)	M–38	do	Hornsheath of Bison (*Superbison*) *crassicornis*.	O.W. Geist, no date, submitted by O.W. Geist.	Creek near Fairbanks.	do.	do.	Crane (1956, p. 670).
11.750±250	I–441	From silty peat underlain by weathered pebble gravel and overlain by peat, silt, and gravel.	wood tis..	D.M. Hopkins	Omega Creek mining cut.	Tanana A–1.	NW¼ sec. 14, T. 4 N., R. 14 W.	Trautman (1964, p. 272).
22,680±300	SI–456	In frozen silt rich in organic matter.	Tendon from left tibia of Felix *atrox*.	O.W. Geist, 1938; submitted by C. Ray.	Upper Ester Creek.	Fairbanks D–3.	NW¼ sec. 12, T. 1 S., R. 3 W.	Stuckenrath and Mielke (1970, p. 203).
26,760±300	SI–355	do	Bone (*Equus*).	H.L. Foster, 1965; submitted by F.C. Whitmore.	Lost Chicken Creek.	Eagle A–2.	SE¼ sec. 32, T. 21 N., R. 18 E.	Mielke and Long (1969, p. 177).
>35,000	W–475	At unconformity between Ready Bullion Formation and Goldstream Formation (probably reworked from lower part of Goldstream Formation, T.L. Péwé).	Log	T.L. Pewe, 7/7/55.	Sheep Creek	Fairbanks D–2.	SE¼ sec. 17, T. 1 N., R. 2 W.	Rubin and Alexander (1958, p. 1479).
>35,000	W–476	Woody horizon, 2 m below unconformity at top of Goldstream Formation.	Twigs..	do.	do.	do.	do	Do.
>39,000	W–895	Near top of sandy pebble gravel (could be pre-Wisconsinan, D.M. Hopkins, 1972).	Wood (1–2-cm diameter).	D.M. Hopkins.	Sullivan placer pit Sullivan Creek near Tofty.	Tanana A–2.	NE¼ sec. 18, T. 3 N., R. 16 W.	Rubin and Berthhold (1961, p. 93); Repenning, Hopkins, and Rubin (1964, p. 182).
>39,000	GX–360	Near base(?) of Goldstream Formation.	wood	R.D. Guthrie, 1964.	Dawson Cut at mouth of Engineer Creek.	Fairbanks D–2.	SE¼ sec. 1, T. 1 N., R. 1 W.	Krueger and Weeks (1966, p. 146).

TABLE 4.—Radiocarbon dates from central Alaska—Continued

Date (year before present)	Lab. No.	Stratigraphic location	Material	Collector and date	Location: Site	Location: Quadrangle	Location: Sec. T. R. or lat and long	Reference
Goldstream Formation—Continued								
>39,900	I–2248	Near base of Goldstream Formation.	Silty peat ----	J.V. Matthews.	McGee cut, Dalton Creek near Sullivan Creek.	Tanana A–2.	SE¼ sec. 8, T. 3 N., R. 16 W.	Matthews (1970, p. 247).
18,000±200	SI–841	In frozen silt -----------	Hornsheath of *Bison*.	O.W. Geist 1948; submitted by R.D. Guthrie.	Mining excavation near Manley Hot Springs.	Tanana A–2.	SE¼ sec. 8, T. 3 N., R. 16 W.	Stuckenrath and Mielke (1973).
>40,000	SI–291	In frozen silt rich in organic material.	Dung(?) of *Symbos giganteus*.	O.W. Geist, 1939; submitted by C. Ray.	Little El Dorado Creek.	Livengood A–2.	SE¼ sec. 27, T. 3 N., R. 1 E.	Mielke and Long (1969, p. 177).
>35,000	SI–844	In frozen silt -----------	Hornsheath of Bison.	O.W. Geist, 1938; submitted by R.D. Guthrie.	----do----	----do----	----do----	Stuckenrath and Mielke (1973).
21,065±1,365	SI–839	----------do-----------	------do------	O.W. Geist, 1947; submitted by R.D. Guthrie.	Cripple Creek.	Fairbanks D–3.	NW¼ sec. 17, T. 15, R. 2 W.	Do.
29,295±2,440	SI–842	----------do-----------	------do------	O.W. Geist, 1940: submitted by R.D. Guthrie.	----do----	----do----	----do----	Do.
>39.000	SI–840	----------do-----------	------do------	O.W. Geist, 1947: submitted by R.D. Guthrie.	----do----	----do----	----do----	Do.
Eva Formation								
>24,000	L–137P	Forest bed under 20 m of Goldstream Formation.	Rooted stump.	T.L. Péwé, 6/4/51.	Dawson Cut placer mine.	Fairbanks D–2.	SW¼ sec. 6, T. 1 N., R. 1 E.	Broecker, Kulp, and Tucek (1956, p. 157).
>56,900	Hv–1328	Forest bed at base of formation.	Stump from forest bed.	J.V. Matthews, 1964.	Eva Creek.	Fairbanks D–3.	SW¼ sec. 5, T. 1 S., R. 2 W.	Matthews (1970, p. 247); Péwé (this report, fig. 6).
Dawson Cut Formation								
<20,000	299, Univ. of Chicago	Stump rooted in underlying silty gravel at base of formation on Eva Creek section.	20-cm-diameter white spruce stump.	Collected by T.L. Péwé, 9/18/49; submitted by Oswalt.	Eva Creek.	Fairbanks D–3.	SW¼ sec. 5, T. 1 S., R. 2 W.	Arnold and Libby (1951, p. 118); Péwé (this report, fig. 6).
18,300±2,000 (black carbon date)	M–37	Same sample as 299 -------	------do------	Submitted by O.W. Geist.	----do----	----do----	----do----	Crane (1956, p. 670).
>28,000	L–137X	Same sample as 299 ----	------do------	----do----	----do----	----do----	----do----	Broecker, Kulp, and Tucek (1956, p. 57).

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974 O—585—469/32