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LATE PLEISTOCENE PALEOECOLOGY OF DALTON GULCH, TOFTY MINING DISTRICT, CENTRAL ALASKA

De Anne S.P. Stevens

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LATE PLEISTOCENE PALEOECOLOGY OF DALTON GULCH, TOFTY MINING DISTRICT, CENTRAL ALASKA

De Anne S.P. Stevens[1]

Abstract

A placer mine cut at Dalton Gulch in the Tofty mining district, central Alaska, contains a rich and varied late Pleistocene vertebrate fauna dated at 33,260 ± 670 radiocarbon yr B.P. (marine isotope stage 3), a time of general climatic amelioration in Beringia. In addition to a large-mammal fauna consisting of mammoth, bison, caribou, and giant elk, the assemblage includes arctic ground squirrel and collared lemming. Both large- and small-mammal faunas are typical of late Pleistocene faunas of Interior Alaska, and this site is exceptional in the abundance of well-preserved remains. Underlying gravels near the base of the section contain pollen taxa consistent with an interglacial environment (presumably marine isotope stage 5), with a probable age in the range of 70,000–130,000 yr B.P.

INTRODUCTION

Note: In 1997, the Alaska Division of Geological & Geophysical Surveys carried out a field mapping project in the Tanana A1 and A2 quadrangles. The materials presented here are the results of that work. This legacy report was drafted at that time and contains the original interpretations and figures. Conditions at the Dalton Gulch pit have since drastically changed, so this report documents part of the geologic record that is no longer visible.

The Tofty (Hot Springs) mining district is located in the western part of the Yukon-Tanana upland between the Yukon and Tanana rivers and is approximately 10 km northwest of the town of Manley Hot Springs (fig. 1). The gold-bearing placer deposits in the eastern part of the district are present on buried benches in the east-west trending trough between Roughtop Mountain to the north and Manley Hot Springs Dome to the south (figs. 1 and 2). The principal drainages include Cache and Sullivan creeks, which flow southwestward into Patterson Creek and thence into the Tanana River to the west. Access to the Tofty mining district is by gravel road from Manley Hot Springs.

Stream valleys in this part of the Yukon-Tanana upland are spectacularly asymmetrical (Hopkins and Taber, 1962). North- and east-facing slopes are consistently steep, and south- and west-facing slopes are consistently gentle. The gentle south- and west-facing valley walls are ancient slip-off slopes, and their bedrock surfaces consist of a series of strath terraces and discontinuous channels that are hidden beneath aprons of redeposited loess in some places and fans of colluvial debris in others. Many of the terraces and channels have been stripped and mined for gold and tin in the Tofty district. Mining efforts target the gravel-bedrock contact, where gold and cassiterite (tin ore) have been concentrated by ancient streamflow.

The Yukon-Tanana upland has been of geologic interest since before the turn of the century. The earliest geologic reconnaissances were carried out by Spurr, Collier, Brooks, and Prindle of the U.S. Geological Survey (Mertie, Jr., 1934), and the first geologic map of the area was completed by Eakin in 1913. The gold and tin placers of the Tofty district have been the subject of several reports, notably those of Eakin (1912, 1913, 1915), Mertie

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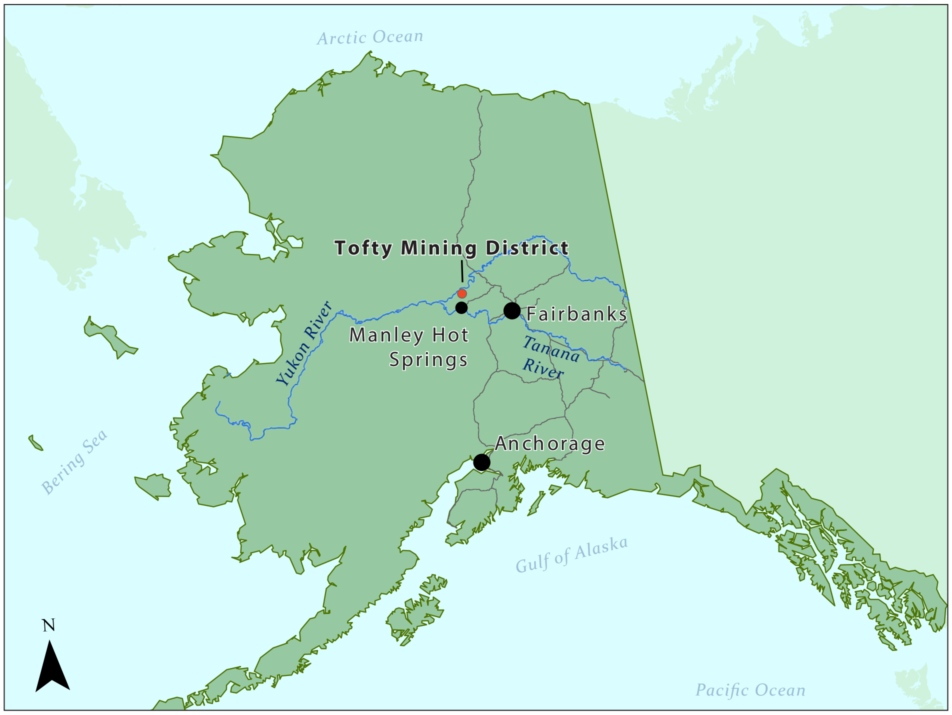

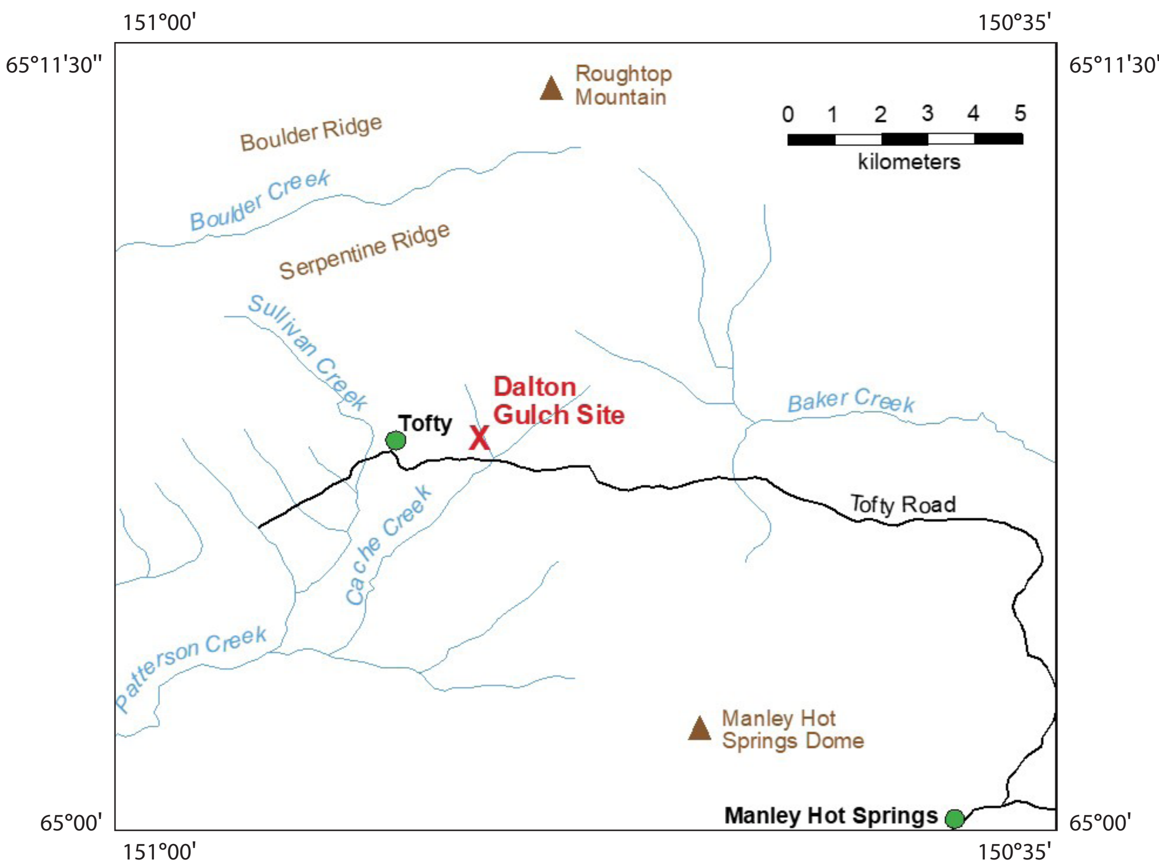

Figure 1. Location map of the Tofty mining district and Dalton Gulch site, central Alaska.

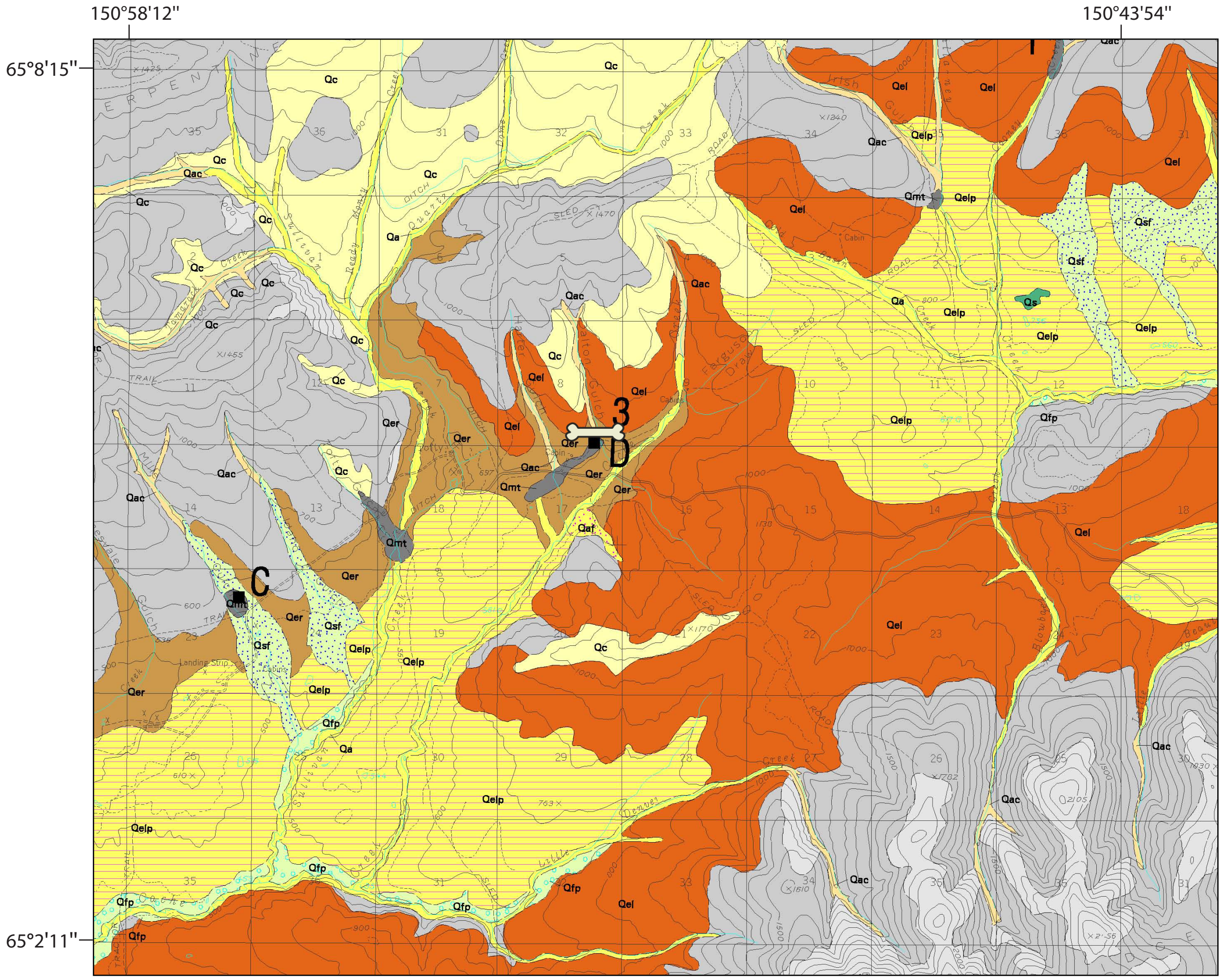

Figure 2. Portion of a geologic map of the Tanana A-1 and A-2 quadrangles showing the general distribution of bedrock and unconsolidated deposits in the Tofty area (Pinney, 1998a). Bone symbol marks the Dalton Gulch site. Qa-alluvium; Qac-alluvial and colluvial valley fill; Qap-alluvial plain; Qc-colluvium; Qel-loess; Qelp-pitted loess; Qer-reworked upland silt; Qfp-floodplain alluvium; Qmt-mine tailings; Qs-swamp; Qsf-silt fan. Gray areas are bedrock and thinly covered bedrock.

(1934, 1937), Thomas (1957), Wayland (1961), and Yeend (1990). Repenning and others (1964) described a fossil rodent fauna preserved in redeposited sediments in a Tofty mine pit, the first such assemblage in Alaska to be rigorously documented. Geologic mapping of the Tanana Quadrangle was completed at a scale of 1:250,000 by Chapman and others (1975, 1982), and the Tofty–Manley area was mapped by the Alaska Division of Geological & Geophysical Surveys at a scale of 1:63,360 (Pinney, 1998a, b; Reifenstuhl and others, 1998a, b).

During the winter of 1906–1907 gold was first discovered in the Tofty mining district, which has since been a producer of placer gold and tin (Eakin, 1912, 1913, 1915; Mertie, Jr., 1934, 1937). The area is blanketed with permafrost-rich silt, and most early mining was carried out by sinking deep shafts through the fine-grained, frozen overburden into the pay gravels below. Some of these shafts were as much as 30 m deep in the Cache Creek area in the eastern part of the district (Eakin, 1912, 1913). The unreliable water supply in this continental setting sometimes required pumping to the elevated dump boxes for sluicing and recycling of impounded wastewater, adding considerably to the cost of mining (Mertie, 1934). In 1997, hydraulic mining at Dalton Gulch (fig. 3), a tributary of Cache Creek, exposed a thick sequence of frozen

Figure 3. Dalton Gulch pit in 1997. Photos by D.S.P. Stevens, 1997. White line in right photo is the approximate location of measured section in figure 4.

organic silt containing abundant plant and animal remains. The exceptional exposure and preservation of the Dalton Gulch site, coupled with the generous cooperation of the Neubauer family, allow a paleoecological reconstruction of the late Pleistocene environment of the area and establishes a stratigraphic framework for the gold-bearing deposits of the Tofty mining district.

STRATIGRAPHY AND AGE OF THE SEDIMENTS

The Dalton Gulch placer mining pit is a deep trench occupying the lower valley of a small consequent stream that flows over a thick mantle of redeposited loess on the southeast-facing slope of Cache Creek (fig. 2). Older parts of this trench extend at least a kilometer southward along the former course of Cache Creek.

In the Dalton Gulch placer pit, the thick silt mantle rests unconformably on gravel, which rests in turn on a southwest-sloping bedrock bench composed of dark gray, Cretaceous phyllite with abundant quartz veins and local sulfide mineralization. Total thickness of sediment exposed in the mine pit ranges from 15–20 m, with the thickest deposits at the south end toward the axis of Cache Creek. The section discussed here was measured along the southern part of the west wall of the active pit, at the juncture between older northeast-trending workings and the more recent north-trending extension up Dalton Gulch. The area was extensively drifted during the early part of the last century, and log-lined shafts and tunnels are frequently encountered as frozen silt is melted (fig. 4). The unconsolidated deposits are extensively frozen and contain ice lenses, interstitial ice, and syngenetic ice wedges. Ice wedges at the site are up to 12 m high and 3 m wide, are spaced approximately 10 m apart, and extend to within 3 m of the present ground surface along an irregular upper contact that probably represents

Figure 4. Log cribbing was used to reinforce shafts dug by early drift miners. Photo by D.S.P. Stevens, 1997.

an old melting front. Up to six stratigraphic units, designated units A-F from oldest to youngest, can be recognized in the wall of the pit (fig. 5).

Unit A consists of 6.55 m of dark gray, well sorted pebble gravel with sand and silt interbeds up to 75 cm thick becoming increasingly abundant near the top. The unit is cross bedded, with large wood pieces and imbricated clasts. The clasts are subangular to rounded and have a maximum size of approximately 20 cm in diameter. The upper 2 m consists of a series of channels filled with smaller clasts, detrital wood, and finer interbeds. The upper contact zone is especially rich in twigs and other plant remains, including spruce cones. Unit A is frozen and contains principally interstitial ice, but some ice wedges extend downward into the gravel. The lowermost wood exposed in the section, collected from a 10-cm-thick silt lens 137 cm below the top of the unit, yielded a radiocarbon age of 35,070 +2,800/-2,080 yr B.P. (GX–23481) (table 1). This date is regarded as a minimum age because of the large sigma value, and the deposit is probably much older. Imbricate clast orientations were measured and established that paleocurrent directions at the head of Dalton Gulch indicate southerly flow from the headwaters of present-day Dalton Gulch. Imbrication on the bench at the mouth of the pit indicates westerly flow from the head of Cache Creek valley or possibly even from the Baker Creek flats[2].

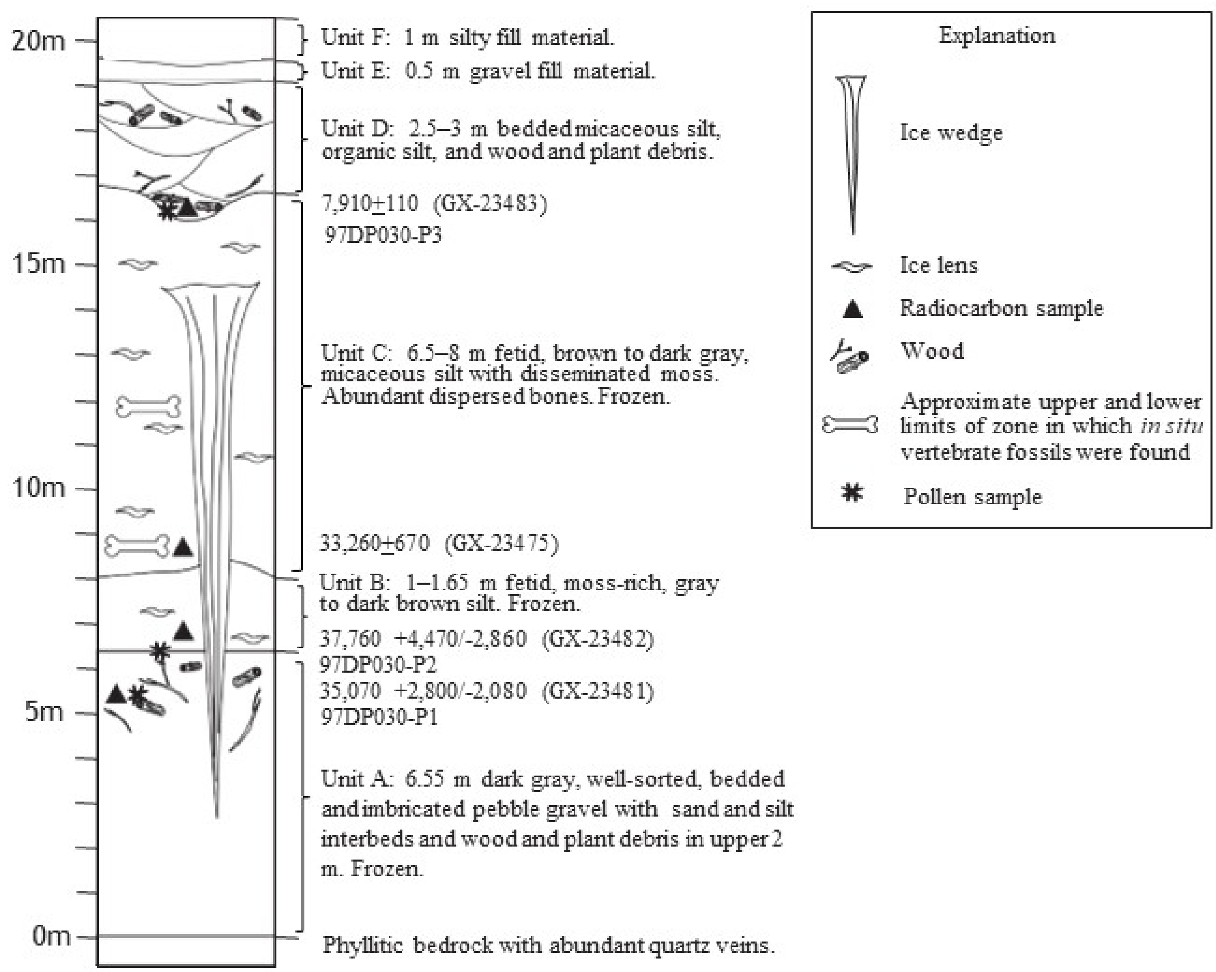

Figure 5. Stratigraphic section of unconsolidated sediments exposed in southern part of west wall in active Dalton Gulch placer mine, Tofty mining district.

[2]Note that Yeend (1990) argues for an ancient trunk drainage whose head is represented by the bench placers in the Eureka mining district and whose lower course is recorded by the placers of the Tofty mining district.

Table 1. Summary of radiocarbon dates associated with Dalton Gulch site. Age in ^{14}C yr B.P. is conventional age in years before A.D. 1950 with quoted laboratory counting error of one standard deviation. Age calibration of terrestrial samples is limited to samples younger than 18,360 ^{14}C yr B.P. Calibrated age is the one-sigma limit of age ranges based on tree-ring corrections of Pearson and Stuiver (1993). Calibration and weighted averaging were performed using a computer program by Reimer and others (2013). All ages include a correction for natural $^{13}C/^{12}C$ isotopic fractionation.

Laboratory/ field number	Material and stratigraphic context	Chronological significance	Age (14C yr B.P.)	Calibrated age range (yr B.P.)
GX-23481 [97DP030-C1]	Wood from silt lens in unit A gravel, 137 cm below top of unit	Minimum age for deposition of gold-bearing gravels	35,070 + 2,800 / - 2,080 (May be considered infinite)	—
GX-23482 [97DP030-C2]	Organic-rich silt with twigs from unit B silt, 20 cm above base of unit	Minimum age for onset of organic silt deposition	37,760 + 4,470 / - 2,860 (May be considered infinite)	—
GX-23483 [97DP030-C3]	Wood from basal contact of unit D silt	Minimum age for onset of high-energy silt deposition	7,910 ± 110	8,600–8,975 (median 8,765)
GX-23475 [97DP030-C4]	Desiccated tissue recovered from *in situ* *Spermophilus* remains in unit C, approximately 75 cm above base of unit	Dates lower part of unit C organic silt; maximum limiting age of unit C	33,260 ± 670	—

Unit B consists of 1.00–1.65 m of gray to dark brown, fetid, moss-rich (sphagnum?), organic silt with a prominent twiggy zone near the base. This unit is frozen, containing interstitial ice, segregation ice, ice veins, and ice lenses. Ice wedges extend through unit B into the gravel below. As it melts, the silt exhibits a prismatic or platy texture resulting from the ice partings. When dry, the silt is yellow-brown in color. No *in situ* faunal remains were found, although this unit cannot be ruled out as a potential source of some of the out-of-context fossils found on the floor of the pit. Organic-rich silt with abundant small twig fragments collected from ca. 20 cm above the base of the unit yielded a radiocarbon age of 37,760 +4,470/-2,860 yr B.P. (GX–23482) (table 1). Like the date reported for unit A, this is regarded as a minimum age for the deposit.

Unit C consists of 6.5–8.0 m of fetid, brown to dark gray, micaceous silt with a few small, scattered, angular pebbles and abundant mammal fossils. The silt is very compact and dense, contains abundant disseminated moss and twig fragments, and dries to a yellow-brown color. The irregular upper contact is erosional, with incised channels up to 1 m deep. This unit is frozen and contains interstitial ice, segregation ice, ice veins, and ice lenses. The upper contacts of the prominent large ice wedges preserved at this site are all within the upper part of unit C. All *in situ* faunal remains recovered from the Dalton Gulch site came from the lower half of this unit, and it is likely that most of the out-of-context material also originated here. Desiccated tissue collected from an *in situ* fossil rodent carcass preserved approximately 75 cm above the base of the unit has an Accelerator Mass Spectrometry (AMS) radiocarbon age of 33,260 ± 670 yr B.P. (GX–23475) (table 1). The confidence in this date is high due to its low sigma value and believe that it gives an accurate age for the bone-bearing sediments in unit C.

Units B and C are interpreted as loess slightly retransported from upper slopes and incorporating considerable detrital organic matter. The silt forms a smooth apron thickening downslope that was probably formed by coalescing silt fans. The syngenetic ice wedges attest to slow accumulation of the enclosing sediment. Faunal remains are mostly fragmentary and some show damage that may be consistent with transport over short to moderate distances. No evidence of gnawing or chewing was recognized on the remains, but predation and scavenging cannot be ruled out. The concentrated, commingled variety of remains supports the contention that this is not a purely primary accumulation of material.

Unit D rests unconformably on unit C and consists of 2.5–3.0 m of interbedded, brown, micaceous silt and organic silt with abundant wood and plant debris. Silt beds are typically on the order of 0.25–0.50 cm thick. The unit is cross bedded and trough cross-stratified, with a deeply incised, scoured base. Unit D is not frozen and is noticeably less coherent than the underlying deposits. Wood collected from the basal contact has a conventional radiocarbon age of 7,910 ± 110 yr B.P. (GX–23483), and a calibrated age range of 8,600–8,975 cal yr B.P. (median 8,765 cal yr B.P.; table 1).

The deposits of unit D reflect a significant change in the nature of sedimentation at the site from a low-energy to a comparatively high-energy environment. It is unclear whether this transition can be linked to profound climatic factors or is the result of changing local conditions. Repenning and others (1964) reported similar deposits overlying late-Pleistocene silt in a nearby placer cut at Sullivan Creek. They obtained seven radiocarbon ages for wood ranging from 200 yr B.P. to more than 38,000 yr B.P. and concluded that the silt was deposited after devastating forest fires that were reported to have taken place around the turn of the century. Thawing and gullying of the freshly-exposed surfaces on nearby slopes buried the older silty sediments in a blanket of reworked material. The single age obtained at Dalton Gulch could thus be misleading as a time-marker for the change in sedimentation represented by Unit D.

The remaining two stratigraphic units, E and F, consist of up to 1.5 m of silt and gravel fill materials (fig. 2, unit Qmt) that are likely related to recent mining activity and are not relevant to this analysis.

FAUNAL REMAINS

The most remarkable aspect of Dalton Gulch pit is the abundance of fossil material (fig. 6). The fossils listed in table 2 were collected over the course of three short visits and include only the better-preserved specimens. Extremely fragmental, unidentifiable material at the site was not collected. Several large pieces of fossil mammoth ivory and a mammoth tooth (believed to be the left equivalent of specimen 97DP030-F27) were left with the miners. The collection includes both large and small mammals and provides a unique opportunity to broadly reconstruct the late Pleistocene landscape of the Tofty area. Because of the likelihood of reworking from older sediments, the exact ages of most of the remains are uncertain, but the AMS date obtained from tissue attached to the *in situ* bones of a ground squirrel (97DP030-F24) near the base of the bone-bearing zone in unit C provides a maximum limiting age for the assemblage.

Two genera of tundra rodents are represented in the Dalton Gulch fossil collection (table 2). The collared lemming (*Dicrostonyx* sp.) specimen consists of a fragmentary maxilla (upper jaw/palate) with two molars attached. The arctic ground squirrel (*Spermophilus* sp.) specimens include a skull, a humerus, and approximately one-quarter of an *in situ* skeleton. The humerus and partial carcass are from one or more immature animals that may have died during their first-year hibernation. Both rodent groups are characteristic of a tundra environment and are absent from the fauna living in the region today. *Dicrostynyx* avoids permanently saturated soil and typically inhabits well-drained, relatively dry and excavatable ground, usually on ridges and rolling uplands but also on lowlands where mounds and elevated grass hummocks offer sites for burrows (Bee and Hall,

Figure 6. Large-mammal fossils from Dalton Gulch placer mine: (A–D) bison; (E–H) mammoth; (I) caribou; (J) elk-moose (see text and table 2 for more details).

Table 2. Fossil fauna recovered from Dalton Gulch pit, Tofty placer district, central Alaska. Rodent fossils were identified by G. H. Jarrell and C.J. Conroy of the University of Alaska Museum. Cervalces was identified by P. Matheus of the Alaska Quaternary Center. Remaining large-mammal fossils were identified by R.A. Gangloff and K. May of the University of Alaska Museum.

Name	Genus	Field number	Description	Provenance
Order Rodentia:				
Ground Squirrel	*Spermophilus sp.*	97DP030-F13	Skull	Slopewash
	Spermophilus sp	97DP030-F24	Anterior part of carcass	Unit C
	Spermophilus sp.?	97DP030-F16	Humerus	Slopewash, probably Unit C
Collared Lemming	*Dicrostonyx sp.*	97DP030-F17	Partial maxillae	Unit C
Order Proboscidea:				
Mammoth	*Mammuthus primigenius*	97DP030-F27	Right lower M3	Unit C
	Mammuthus cf. M. primigenius	97DP030-F1	DP3 maxillary tooth	Unit C
	Mammuthus cf. M. primigenius	97DP030-F14	Partial lower M3	Drainage channel
	Mammuthus sp.	97DP030-F6	Molar fragment	Unit B or C
	Mammuthus sp.	97DP030-F20	Cervical vertebra	Unit C
Order Artiodactyla:				
Giant elk (elk-moose)	*Cervalces*	97DP030-F26	Partial occiput	Unit C
Caribou	*Rangifer sp*	97DP030-F3	Partial antler	Unit C
	Rangifer sp	97DP030-F12	Distal end of left (?) metacarpal	Slopewash
	Rangifer sp	97DP030-F21	Right metacarpal	Unit C
	Rangifer sp	97DP030-F25	Right metacarpal	Unit C
Bison	*Bison priscus*	97DP030-F2	Left radius	Slopewash, probably Unit C
	Bison priscus	97DP030-F18	Right lower M3	Unit C
	Bison priscus	97DP030-F19	Right upper M2	Unit C
	Bison priscus	97DP030-F22	Left metacarpal	Unit C
	Bison priscus	97DP030-F23	Right metacarpal	Slopewash, probably Unit C
	Bison sp.	97DP030-F4	Right femur	Drainage channel
	Bison sp.	97DP030-F8	Cervical vertebra	Unit C
	Bison sp.	97DP030-F9	Cervical vertebra	Unit C
	Bison sp.	97DP030-F10	Cervical vertebra	Unit C
	Bison sp.	97DP030-F11	Prethoracic vertebra	Unit C
	Bison sp.	97DP030-F15	Juvenile metacarpal	Slopewash

1956; Repenning and others, 1964; Pitelka, 1967). Physical adaptations and its extreme northern distribution today illustrate its specialization for existence in northern climates (Guthrie, 1968a). Living examples are found on the open tundra of the far northern parts of Alaska and Canada (Kurtén and Anderson, 1980), as well as on the Seward Peninsula. *Spermophilus* is best adapted to areas of loose soil on well-drained slopes where permafrost is a meter or more below the surface (Bee and Hall, 1956; Repenning and others, 1964). It currently inhabits tundra and brushy meadows of the extreme north and hibernates approximately 7 months of the year to survive the harsh conditions (Kurtén and Anderson, 1980). The presence of *Discrostynyx* and *Spermophilus* in the Pleistocene sediments of Dalton Gulch indicates that areas of dry and well-drained loose soil existed during the time when unit C was deposited. Both the arctic ground squirrel and collared lemming are typical of late Pleistocene faunas of Interior Alaska and have been described from the organic-rich Pleistocene silt deposits in creek valley bottoms near Fairbanks (Péwé, 1975; Guthrie, 1968a) and elsewhere in the Tofty area (Repenning and others, 1964).

Large-mammal fossils collected at Dalton Gulch include mammoth, bison, caribou, and giant elk (table 2). Although no horse material was identified in the present collection, the miners report having found horse remains in these deposits during past years. The most common fossils represented are those of bison (*Bison*). The collection includes two teeth, one juvenile and four adult long bones, and four articulated vertebrae. Several vertebrae that may have belonged to the same animal were left with the miners. Five specimens identifiable to species level represent the long-horned steppe bison (*Bison priscus*). Mammoth (*Mammuthus*) is represented by five specimens, four of which are teeth. Specimens 97DP030-F14 and 97DP030-F27 are the molar teeth of mature animals and specimen 97DP030-F1 is that of a juvenile. The estimated ages of the adults are older than 40 AEY (African Elephant Years) and 40-50 AEY, respectively (Roland Gangloff, personal communication, 1997). Specimens identifiable to species level are woolly mammoth (*Mammuthus primigenius*). Caribou (*Rangifer* sp.) remains consist of a complete and a partial metacarpal and an antler fragment. A single partial occiput (base of skull) was identified as *Cervalces* (giant elk, or elk-moose) or a close relative (Paul Matheus, personal communication, 1997). The assemblage from Dalton Gulch is similar to other large-mammal faunas of equivalent age known in Interior Alaska (Péwé, 1975; Porter, 1979, 1984; Weber and others, 1981; Guthrie, 1968b, 1990).

The Dalton Gulch fauna provides a new opportunity to reconstruct the Tofty landscape in middle to late Wisconsinan time. *Bison priscus* is thought to have inhabited arctic steppe-tundra and open steppe landscapes characterized by extensive grasslands and thin snow cover (Vereshchagin and Baryshnikov, 1982; Guthrie, 1990). The presence of *Mammuthus primigenius* implies a fairly open landscape of meadows and steppes with shrub thickets in river valleys, and severely cold and windy winters with little snow (Vereshchagin and Baryshnikov, 1982). Caribou are very adaptable generalists and live today in the severe environment of northeast Greenland as well as in the rich coniferous forests of more temperate parts of Alaska and Canada. Along with horses, these four species are the classic indicators of Guthrie's (1982) mammoth steppe environment. *Cervalces*—a much less common fossil in Alaska—was no doubt a browser and, like moose, may have inhabited riparian thickets of tall willows. Because of their very different habitat requirements, it is somewhat surprising to find *Cervalces* with mammoth and bison in the Dalton Creek fauna.

POLLEN DATA

Three sediment samples collected from the Dalton Gulch site were analyzed for pollen content and provide important information regarding conditions in the Tofty area during the late Pleistocene and early Holocene. Sample 97DP030-P1 was collected from a silt lens 10 cm thick exposed 137 cm below the top of unit A and corresponds to the minimum wood date of 35,070 +2,800/-2,080 yr

B.P. (GX–23481) (fig. 3). Sample 97DP030-P2 was collected from a silty interbed at the upper contact of unit A (fig. 3) and includes an intact spruce cone macrofossil. Sample 97DP030-P3 is organic-rich silt at the lower contact of unit D and corresponds to the wood date of 7,910 ± 110 yr B.P. (GX–23483) (range 8,600–8,975 cal yr B.P.) (fig. 3).

Table 3. Pollen frequencies from Dalton Gulch pit, Tofty placer district, central Alaska. Pollen grain counts by A.P. Krumhardt of the University of Alaska Geophysical Institute.

	97DP030-P1 Percent	97DP030-P2 Percent	97DP030-P3 Percent
TREES AND SHRUBS			
Picea, undifferentiated	21.64	43.51	18.18
Pinus	0.00	0.76	3.31
cf. *Larix*	1.49	0.00	0.00
Betula	5.22	2.29	28.10
Alnus, undifferentiated	44.78	43.51	42.15
Salix	1.49	0.76	0.83
HERBS			
Polygonaceae	0.75	0.00	0.00
Rosaceae, undifferentiated	0.75	0.00	0.00
Tubuliflorae	0.00	0.00	0.83
Cyperaceae	4.48	3.82	4.13
Epilobium	0.00	0.76	0.00
Gramineae	19.40	4.58	2.48
(Pollen Sum)	(134)	(131)	(121)
SPORES			
Lycopodium	5.19	18.75	5.26
Trilete spores	0.65	0.00	0.00
Sphagnum	7.14	28.13	81.58
Monolete spores	68.83	37.50	7.89
Dryopteris	18.18	15.63	5.26
(Total Spores)	(154)	(64)	(38)
OTHER			
(Redeposited)	(0)	(3)	(0)
(Indeterminate)	(9)	(4)	(10)

Pollen spectra (table 3; fig. 7) show that vegetation during the time of unit A was not much different from that of the early Holocene and supports the contention that the lower deposits are much older than the radiocarbon dates indicate. Samples 97DP030-P1 and 97DP030-P2 reflect pollen types that are broadly consistent with a typical boreal forest ecosystem. Alder (*Alnus*) pollen dominates the assemblages, with variable but significant percentages of spruce (*Picea*) pollen. It should be noted that these groups are prolific pollen producers and are commonly overrepresented in pollen records. The considerable amount of wood, some of it quite large, that is preserved in the Dalton Gulch sediments supports the contention that the site was occupied by trees, and probably well-forested. Wood identifiable to genus level appears in all cases to be *Picea*. Birch (*Betula*) pollen percentages are low, indicating that birch was very rare and probably accounted for only a small fraction of the vegetative cover. *Betula* produces abundant pollen, thus the extremely low percentages could reflect transport of pollen grains over considerable distances. Grasses (*Gramineae*) account for a significant percentage of sample 97DP030-P1 and, although generally an abundant pollen producer, the group tends to give a pollen signal representative of actual abundance in localized collecting areas. Sedges (*Cyperaceae*) tend to behave like grasses in the pollen record and their abundance in the Dalton Gulch sediments, although relatively low, is probably significant. Moss spores were also counted for this study and are abundant in the late Pleistocene samples, indicating that mosses were common in the local area during this time. Of particular significance is the presence of *Sphagnum* spores, which are generally not found in full-glacial deposits. High fern spore frequencies (monolete spores and *Dryopteris*) have been seen in other interglacial sediments (see Bigelow and others, 2014). This adds to the evidence indicating that

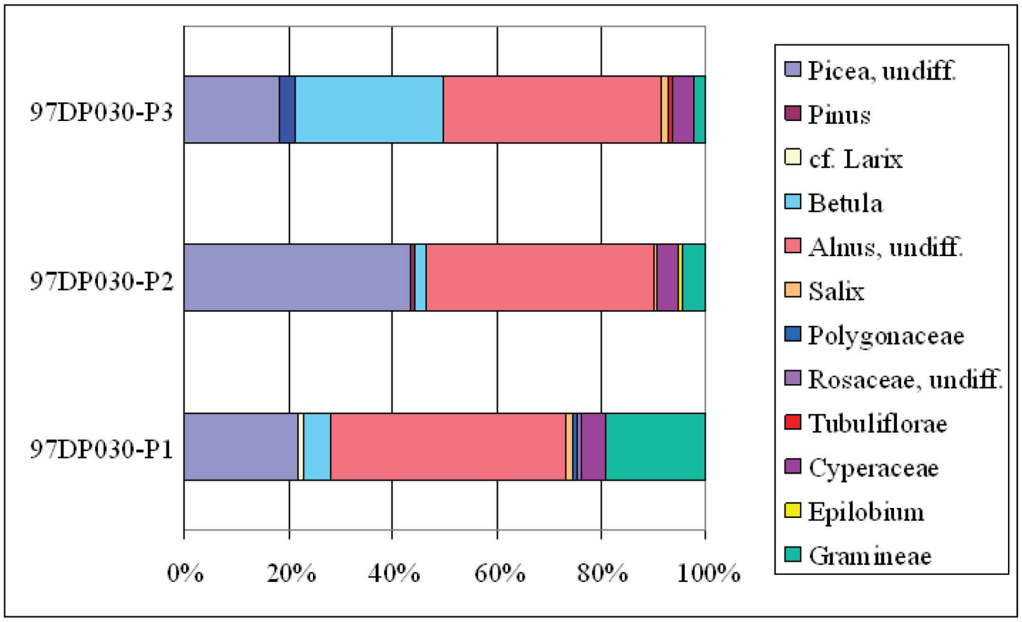

Figure 7. Histogram of pollen frequencies from Dalton Gulch site, Tofty district, central Alaska (see table 3).

unit A was deposited no later than the last interglaciation, ~70-130 kyr (marine isotope stage [MIS] 5; Lisiecki and Raymo, 2005). If these pollen samples do come from MIS 5 (and not some earlier interglacial), they may date to MIS 5e (~123 kya; Lisiecki and Raymo, 2005), which is thought to be warmer than modern (Bigelow and others, 2014; Edwards and others, 2003).

The Holocene pollen spectrum at Dalton Gulch (sample 97DP030-P3) is typical of a modern type of boreal forest that includes *Alnus*, *Betula*, and *Picea* with lower proportions of grasses and mosses than the late Pleistocene spectra.

DISCUSSION

The sediments exposed in Dalton Gulch contain valuable clues to the environment of the Tofty area during late Pleistocene time. Stratigraphic and sedimentological data indicate that a stream, probably ancestral Patterson or Cache creek, occupied the bedrock bench upon which the Dalton Gulch placer mine is now located and deposited the gold-bearing fluvial gravels of unit A. This stream eventually migrated to the south and the depositional regime changed to one of silt accumulation. Loess that had been deposited on the upland slopes during past glaciations was mobilized and transported into the river valley bottoms, depositing unit B. Unit A, with its large, tree-sized wood and unit B, with its spruce cone, most likely represent some part of isotope stage 5 (the last interglaciation), with a probable age in the range of 70,000–130,000 yr B.P. (Lisiecki and Raymo, 2005).

Subsequent deposition of loess during the early Wisconsin full-glacial period corresponding to isotope stage 4 (Happy interval; Hopkins, 1982) was followed by another cycle of silt retransport in response to a period of climatic amelioration. This interstadial warm period between about 50,000 and 30,000 years ago corresponds to isotope stage 3 (Boutellier interval or interstadial; Hopkins, 1982). Unit C, which this study has confidently dated to 33,260 ± 670 yr B.P., was deposited during this time.

The comparatively mild mid-Wisconsinan interstadial was followed by a last extremely dry, cold, periglacial period (isotope stage 2) that lasted until about 14,000–12,000 years ago (Duvanny Yar interval; Hopkins, 1982). At Dalton Gulch the colder interval was marked principally by the growth of ice wedges that attained heights of more than 12 m in the organic-rich silts. Early Holocene warming melted the tops of the ice wedges and ushered in a period of erosion and removal of an unknown thickness of silt at the site, likely resulting from release of meltwater from thawing ground ice and increased frequency of wildfires. Deposition resumed about 8765 years ago (range 8,600–8,975 cal yr B.P.) with the waterlaid silt of unit D.

The Dalton Gulch site has yielded a rich late Wisconsin fauna. This well-dated assemblage of large and small mammals is an important contribution to the record of Pleistocene paleoecology of eastern Beringia. Potential future work in the area should focus on a more detailed, systematic collection of pollen samples from throughout the section, acquiring more dates, and continuing to document the faunal remains.

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David Hopkins (left) and Florence Weber (right) assisted DGGS field crews during their 1997 investigations in the Tofty mining district.

REFERENCES

Bee, J.W., and Hall, E.R., 1956, Mammals of northern Alaska on the Arctic slope: University of Kansas Museum of Natural History Miscellaneous Publications 8, 309 p.

Bigelow, N.H., Edwards, M.E., Elias, S.A., Hamilton, T.D., and Schweger, C.E., 2014, Tundra and boreal forest of interior Alaska during terminal MIS 6 and MIS 5e: Vegetation History and Archaeobotany, v. 23, p. 177–193. https://doi.org/10.1007/s00334-013-0425-z

Chapman, R.M., Yeend, W.E., Brosge, W.P., and Reiser, H.N., 1975, Preliminary geologic map of the Tanana and northeastern part of the Kantishna River quadrangles, Alaska: U.S. Geological Survey Open-File Report 75-337, 1 sheet, scale 1:250,000. https://dggs.alaska.gov/pubs/id/12006

Chapman, R.M., Yeend, Warren, Brosge, W.P., and Reiser, H.N., 1982, Reconnaissance geologic map of the Tanana Quadrangle, Alaska: U.S. Geological Survey Open-File Report 82-734, 18 p., 1 sheet, scale 1:250,000. https://dggs.alaska.gov/pubs/id/11415

Eakin, H.M., 1912, The Rampart and Hot Springs regions, *in* U.S. Geological Survey, Mineral resources of Alaska, report on progress of investigations of 1911: U.S. Geological Survey Bulletin 520, p. 271–287. https://dggs.alaska.gov/pubs/id/4819

———1913, A geologic reconnaissance of a part of the Rampart Quadrangle, Alaska: U.S. Geological Survey Bulletin 535, 38 p., 2 sheets, scale 1:250,000. https://dggs.alaska.gov/pubs/id/3412

———1915, Mining in the Hot Springs district, *in* U.S. Geological Survey, Mineral resources of Alaska, report on progress of investigations in 1914: U.S. Geological Survey Bulletin 622, p. 239–245. https://dggs.alaska.gov/pubs/id/4764

Edwards, M.E., Hamilton, T.D., Elias, S.A., Bigelow, N.H., and Krumhardt, A.P., 2003, Interglacial extension of the boreal forest limit in the Noatak valley, northwest Alaska: evidence from an exhumed river-cut bluff and debris apron: Arctic, Antarctic, and Alpine Research, v. 35, p. 460–468.

Guthrie, R.D., 1968a, Paleoecology of a late Pleistocene small mammal community from interior Alaska: Arctic, v. 1, p. 223–244.

———1968b, Paleoecology of the large mammal community in interior Alaska during the late Pleistocene: American Midland Naturalist, v. 79, p. 346–363.

———1982, Mammals of the mammoth steppe as paleoenvironmental indicators, *in* Hopkins, D.M., Matthews, J.V., Jr., Schweger, C.E., and Young, S.B., eds., Paleoecology of Beringia: Academic Press, New York, p. 307–329.

———1990, Frozen fauna of the mammoth steppe: University of Chicago Press, Chicago, 338 p.

Hopkins, D.M., 1982, Aspects of the paleogeography of Beringia during the late Pleistocene, *in* Hopkins, D.M., Matthews, J.V., Jr., Schweger, C.E., and Young, S.B., eds., Paleoecology of Beringia: Academic Press, New York, p. 3–28.

Hopkins, D.M., and Taber, Bond, 1962, Asymmetrical valleys in central Alaska [*abs.*]: Geological Society of America Abstracts for 1961, Special Paper 68, p. 116.

Kurtén, Björn, and Anderson, Elaine, 1980, Pleistocene mammals of North America: Columbia University Press, New York, 442 p.

Lisiecki, L.E., and Raymo, M.E., 2005, A Pliocene-Pleistocene stack of 57 globally distributed benthic $\delta^{18}O$ records: Paleoceanography, v. 20, PA1003. https://doi.org/10.1029/2004PA001071

Mertie, J.B., Jr., 1934, Mineral deposits of the Rampart and Hot Springs districts, Alaska, *in* Mertie, J.B., Jr., Composite Report [Mineral deposits of the Rampart and Hot Springs districts; Alaska & Placer concentrates of the Rampart and Hot Springs districts, Alaska]: U.S. Geological Survey Bulletin 844-D, p. 163–226. https://dggs.alaska.gov/pubs/id/4521

———1937, The Yukon-Tanana region, Alaska: U.S. Geological Survey Bulletin 872, 276 p., 1 sheet, scale 1:500,000. https://dggs.alaska.gov/pubs/id/3453

Pearson, G.W., and Stuiver, Minze, 1993, High-precision bidecadal calibration of the radiocarbon time scale, 500-2500 BC: Radiocarbon, v. 35, n. 1, p. 25–33.

Péwé, T.L., 1975, Quaternary geology of Alaska: U.S. Geological Survey Professional Paper 835, 145 p., 3 sheets, scale 1:500,000. https://dggs.alaska.gov/pubs/id/3962

Pinney, D.S., 1998a, Surficial geologic map of the Tanana A-1 and A-2 quadrangles, central Alaska: Alaska Division of Geological & Geophysical Surveys Public Data File 98-37C, 1 sheet, scale 1:63,360. https://doi.org/10.14509/1865

———1998b, Derivative engineering geologic map of the Tanana A-1 and A-2 quadrangles, central Alaska: Alaska Division of Geological & Geophysical Surveys Public Data File 98-37D, 1 sheet, scale 1:63,360. https://doi.org/10.14509/1866

Pitelka, F.A., 1967, Some characteristics of microtine cycles in the Arctic, *in* Hansen, H.P., ed., Arctic Biology: Oregon State University Press, Corvallis, p. 153–184.

Porter, Lee, 1979, Ecology of a late Pleistocene (Wisconsin) ungulate community near Jack Wade, east-central Alaska: University of Washington, Seattle, M.S. thesis, 85 p., illust., plates.

———1984, Late Pleistocene fauna of Lost Chicken Creek, Alaska: Washington State University, Pullman, Ph.D. dissertation, 200 p., illust.

Reifenstuhl, R.R., Dover, J.H., Newberry, R.J., Clautice, K.H., Liss, S.A., Blodgett, R.B., and Weber, F.R., 1998a, Interpretive geologic bedrock map of the Tanana A-1 and A-2 quadrangles, central Alaska: Alaska Division of Geological & Geophysical Surveys Public Data File 98-37B v. 1.1, 17 p., 1 sheet, scale 1:63,360. https://doi.org/10.14509/1864

Reifenstuhl, R.R., Dover, J.H., Newberry, R.J., Clautice, K.H., Pinney, D.S., Liss, S.A., Blodgett, R.B., and Weber, F.R., 1998b, Geologic map of the Tanana A-1 and A-2 quadrangles, central Alaska: Alaska Division of Geological & Geophysical Surveys Public Data File 98-37A v. 1.1, 19 p., 1 sheet, scale 1:63,360. https://doi.org/10.14509/1863

Reimer P.J., Bard, Edouard, Bayliss, Alex, Beck, J.W., Blackwell, P.G., Bronk, R.C., Buck, C.E., Cheng, Hai, Edwards, R.L., Friedrich, Michael, Grootes, P.M., Guilderson, T.P., Haflidason, Haflidi, Hajdas, Irka, Hatté, Christine, Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, Bernd, Manning, S.W., Niu, Mu, Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., and van der Plicht, Johannes, 2013, IntCal13 and MARINE13 radiocarbon age calibration curves 0-50000 years calBP: Radiocarbon, v. 55, n. 4. https://doi.org/doi:10.2458/azu_js_rc.55.16947

Repenning, C.A., Hopkins, D.M., and Rubin, Meyer, 1964, Tundra rodents in a late Pleistocene fauna from the Tofty placer district, central Alaska: Arctic, v. 17, n. 3, p. 176–197.

Thomas, B.I., 1957, Tin-bearing placer deposits near Tofty, Hot Springs district, central Alaska: U.S. Bureau of Mines Report of Investigations 5373, 56 p. https://dggs.alaska.gov/pubs/id/21197

Vereshchagin, N.K., and Baryshnikov, G.F., 1982, Paleoecology of the mammoth fauna in the Eurasian arctic, *in* Hopkins, D.M., Matthews, J.V., Jr., Schweger, C.E., and Young, S.B., eds., Paleoecology of Beringia: Academic Press, New York, p. 267–279.

Wayland, R.G., 1961, Tofty tin belt, Manley Hot Springs district, Alaska: U.S. Geological Survey Bulletin 1058-I, p. 363–414, 2 sheets. https://dggs.alaska.gov/pubs/id/3607

Weber, F.R., Hamilton, T.D., Hopkins, D.M., Repenning, C.A., and Haas, Herbert, 1981, Canyon Creek, a late Pleistocene vertebrate locality in interior Alaska: Quaternary Research, v. 16, p. 167–180.

Yeend, Warren, 1990, Gold placers, geomorphology, and paleo-drainage of Eureka Creek and Tofty areas, Alaska, *in* Dover, J.H., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1989: U.S. Geological Survey Bulletin 1946, p. 107–109. https://dggs.alaska.gov/pubs/id/4503