Late Pleistocene Paleoecology of Dalton Gulch, Tofty Mining District, Central Alaska

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ABSTRACT

A placer mine cut at Dalton Gulch in the Tofty mining district, central Alaska, contains a rich and varied late Pleistocene vertebrate fauna that is firmly dated to 33,260 ± 670 yr B.P., a time of general climatic amelioration in Beringia known as the Boutellier interval. In addition to a large-mammal fauna consisting of mammoth, bison, caribou and giant elk, the assemblage included rodents identified as arctic ground squirrel and collared lemming. Both large- and small-mammal faunas are typical of late-glacial faunas of interior Alaska, but this site is exceptional in its abundance of well-preserved remains.

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 material presented here is a result of that work. Conditions at the Dalton Gulch pit have drastically changed, so this information documents part of the geologic record that is likely 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 (Figure DS1). The gold-bearing placer deposits of the eastern part of the district occur on buried benches in the east-west trending trough between Roughtop Mountain to the north and Manley Hot Springs Dome to the south (Figures DS1 and DS2). The principle drainages include Cache Creek and Sullivan Creek, 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, while 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 multiple strath terraces and discontinuous channels which lie 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, in the Tofty district, tin. Mining efforts target the gravel-bedrock contact, where gold and cassiterite (tin ore) have been concentrated by ancient streamflow.

The Yukon-Tanana area 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 a number of reports, notably those of Eakin (1912, 1913, 1915), Mertie (1934, 1937), Thomas (1957), Wayland (1961), and Yeend (1989). Repenning et al. (1964) described a fossil rodent fauna preserved in redeposited sediments in a 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 et al. (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, 1998b; Reifenstuhl et al., 1998a, 1998b).

Gold was first discovered in the Tofty mining district during the winter of 1906–1907, and it has been a producer of placer gold and tin ever since (Eakin, 1912, 1913, 1915; Mertie, Jr., 1934, 1937). The area is extensively 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, mining operations using hydraulicking methods at Dalton Gulch (Figure DS3), a tributary to Cache Creek, exposed a thick sequence of frozen 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, allowed us to develop a paleoecological reconstruction of the late-glacial environment of the area and establish 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 which flows over a thick mantle of redeposited loess on the southeast-facing slope of Cache Creek (Figure DS2). 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 upon a southwest-sloping bedrock bench composed of dark gray, Permo-Triassic 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 century, and log-lined shafts and tunnels are frequently encountered as frozen silt is melted (Figure DS4). These 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 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 (Figure DS5).

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 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, containing 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 35,100 +2800/-2080 yr B.P. (GX–23481) (Table DS1). We regard this date as a minimum age because of the large sigma, and the deposit is probably much older. We measured imbricate clasts 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. (Note that Yeend [1989] 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).

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 can not 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 37,800 +4470/-2860 yr B.P. (GX–23482) (Table DS1). Like the date reported for unit A, we regard this 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 megafossils. 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, containing 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 AMS radiocarbon age of 33,260 ± 670 yr B.P. (GX–23475) (Table DS1). We have confidence in this date due to its low sigma and feel it gives an accurate age for the bone-bearing sediments.

We interpret units B and C 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 the fact that the enclosing sediment accumulated quite slowly. 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 can not 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 that the underlying deposits. Wood collected from the basal contact has a conventional radiocarbon age of 7910 ± 110 yr B.P. (GX–23483), and a calibrated age range of 8990–8410 cal yr B.C. (Table DS1).

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 et al. (1964) reported similar deposits overlying late-Pleistocene silt in a nearby placer cut at Sullivan Creek. They obtained seven radiocarbon dates from 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 date obtained at Dalton Gulch may 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 (Figure DS2, unit Qmt). These are likely related to recent mining activity and are thus not relevant to this analysis.

FAUNAL REMAINS

The most remarkable aspect of Dalton Gulch pit is the extreme abundance of fossil material (Figure DS6). The fossils listed in Table DS2 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 minimum limiting age for the assemblage.

Two genera of tundra rodents are represented in the Dalton Gulch fossil collection (Table DS2). 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. *Discrostynyx* 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, 1956; Repenning et al., 1964; Pitelka, 1967). Physical adaptations and its extreme northern distribution today illustrate its specialization for existence in northern climates (Guthrie, 1968b). 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 (Figure DS7). *Spermophilus* is best adapted to areas of loose soil on well-drained slopes where permafrost is several feet below the surface (Bee and Hall, 1956; Repenning et al., 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)(Figure DS8). 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-glacial faunas of interior Alaska and have been described from the organic-rich Pleistocene silt deposits in creek valley bottoms near Fairbanks (Péwé, 1957; 1975; Guthrie, 1968b) and elsewhere in the Tofty area (Repenning et al., 1964).

Large-mammal fossils collected at Dalton Gulch include mammoth, bison, caribou, and giant elk (Table DS2). 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*)(Figure DS9). 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 (Gangloff, R., personal communication, 1997). Specimens identifiable to species level are woolly mammoth (*Mammuthus primigenius*)(Figure DS10). Caribou (*Rangifer sp.*) (Figure DS11) 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 (Matheus, P., personal communication, 1997) (Figure DS12). 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, 1981; Guthrie, 1968a, 1990).

The Dalton Gulch fauna provides a new opportunity to reconstruct the nature of 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* suggests 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 Greenland. 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 35,100 +2800/-2080 yr B.P. (GX–23481) (Figure DS3). Sample 97DP030-P2 was collected from a silty interbed at the upper contact of unit A (Figure DS3) 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 7910 ± 110 (GX–23483) (range 8990-8410 cal yr B.C.)(Figure DS3).

Pollen spectra (Table DS3; Figure DS13) show that the 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 would suggest. Samples 97DP030-P1 and 97DP030-P2 reflect pollen types that are broadly consistent with a modified boreal forest or forest tundra ecosystem. Alder (*Alnus*) pollen dominates the assemblages, with variable but relatively high 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 possibly even forested. Wood identifiable to genus level appears to be in all cases *Picea.* Birch (*Betula*) percentages are quite low, indicating that birch was very rare and probably accounted for only a small fraction of the vegetative cover. *Betula* also produces abundant pollen, and the extremely low percentages may reflect transport over considerable distances. Grasses (*Gramineae*) account for a significant percentage of sample 97DP030-P1 and, while 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. This adds to the evidence suggesting that unit A may in fact have been deposited during the last interglacial.

The Holocene pollen spectrum at Dalton Gulch (sample 97DP030-P3) is fairly 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 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 now sits 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 full-glacial time 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 75,000–115,000 yr B.P. Subsequent deposition of loess during the early Wisconsin full-glacial Happy interval corresponding to isotope stage 4 (Hopkins, 1982) was followed by another cycle of silt retransport in response to a period of climatic amelioration. This warm period between about 50,000 and 30,000 years ago, the Boutellier interval or interstadial, corresponds to isotope stage 3 (Hopkins, 1982). Unit C, which we have confidently dated to 33,260 ± 670 yr B.P., was deposited during this time. The comparatively mild Boutellier interval was followed by a last extremely dry, cold, periglacial period, the Duvanny Yar interval, that lasted until about 14,000–12,000 years ago (Hopkins, 1982). At Dalton Gulch the Duvanny Yar interval was marked principally by the growth of ice wedges that attained heights in excess of 12 m in the organic-rich silts. The drastic warming that ushered in the early Holocene melted the tops of the ice wedges and was accompanied by an increase in precipitation that resulted in erosion and removal of an unknown thickness of silt. Deposition resumed about 8000 years ago (range 8500–8900 cal yr B.C.) 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 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.

Acknowledgments

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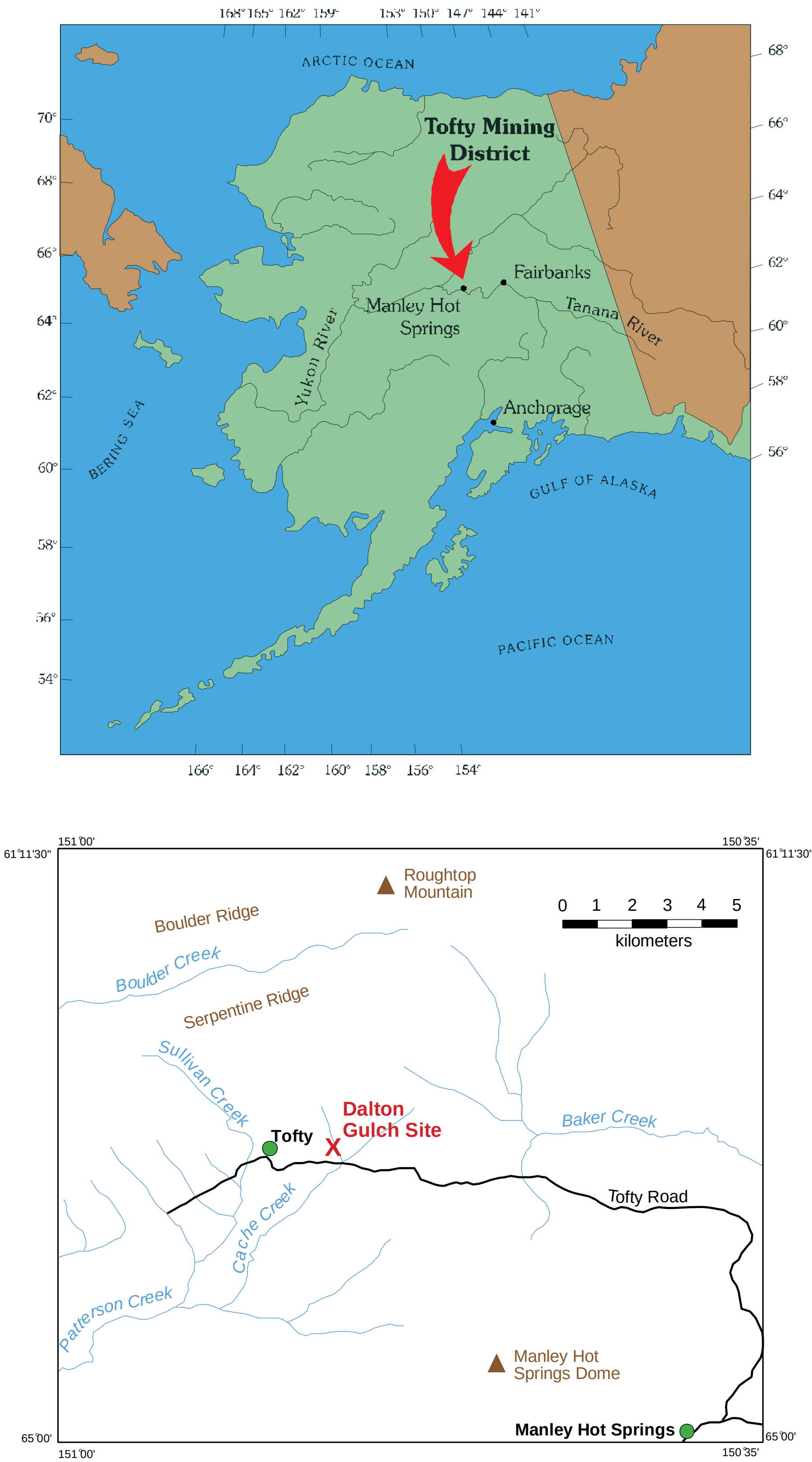

Figure DS1. Location map of the Tofty mining district and Dalton Gulch site, central Alaska

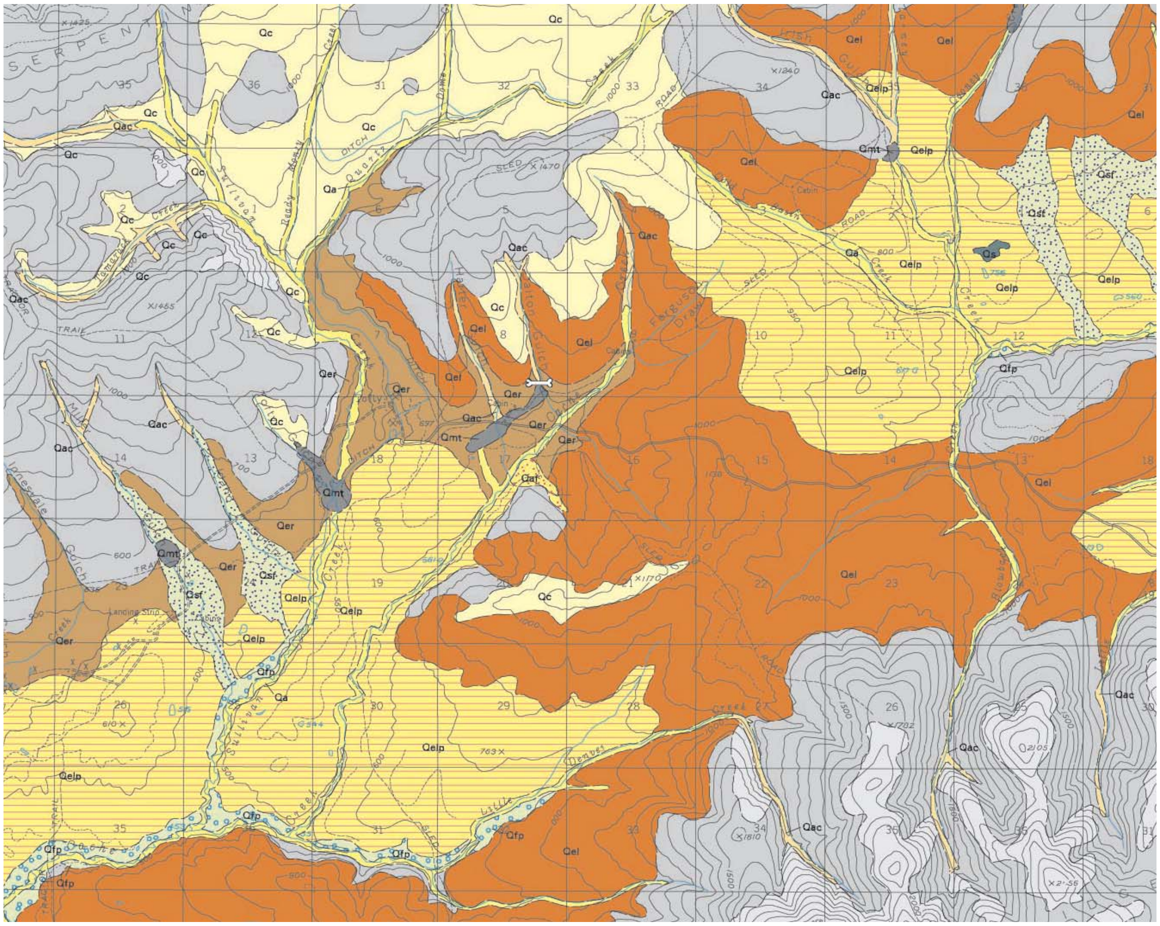

Figure DS2. Portion of a geologic map of the Tanana A-1 and A-2 quadrangles showing the general distribution of bedrock and unconsolidated deposits in the Tofty area. Bone symbol marks the Dalton Gulch site. Qa-alluvium; Qac-alluvial and colluvial valley fill; Qap-alluvial plain; Qc-colluvium; Qel-loess; 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.

Figure DS3. Dalton Gulch pit in 1997

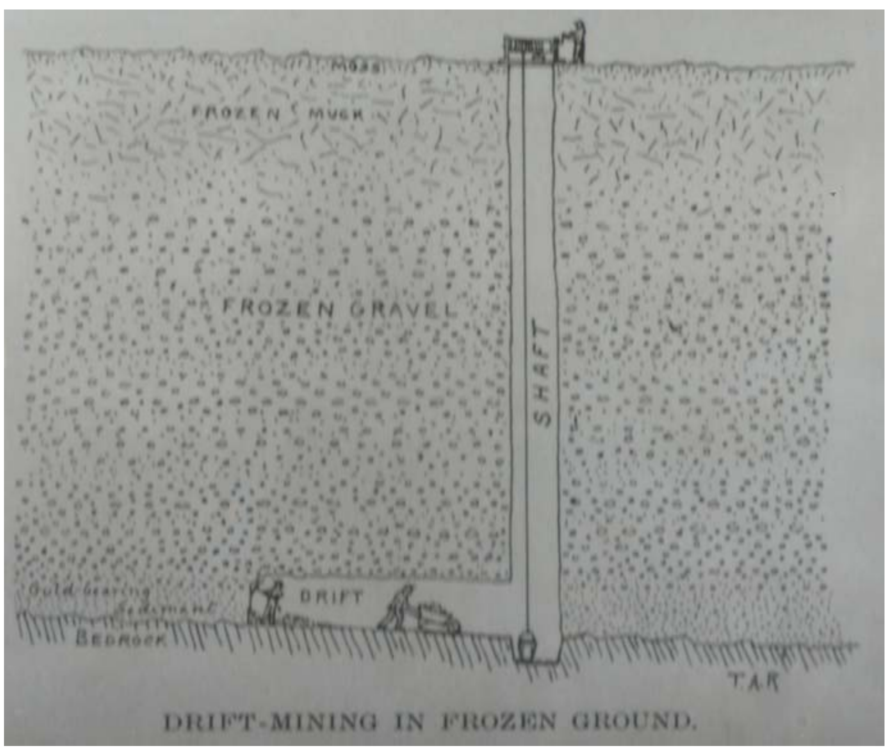

Figure DS4. Log cribbing was used to reinforce shafts dug by early drift miners

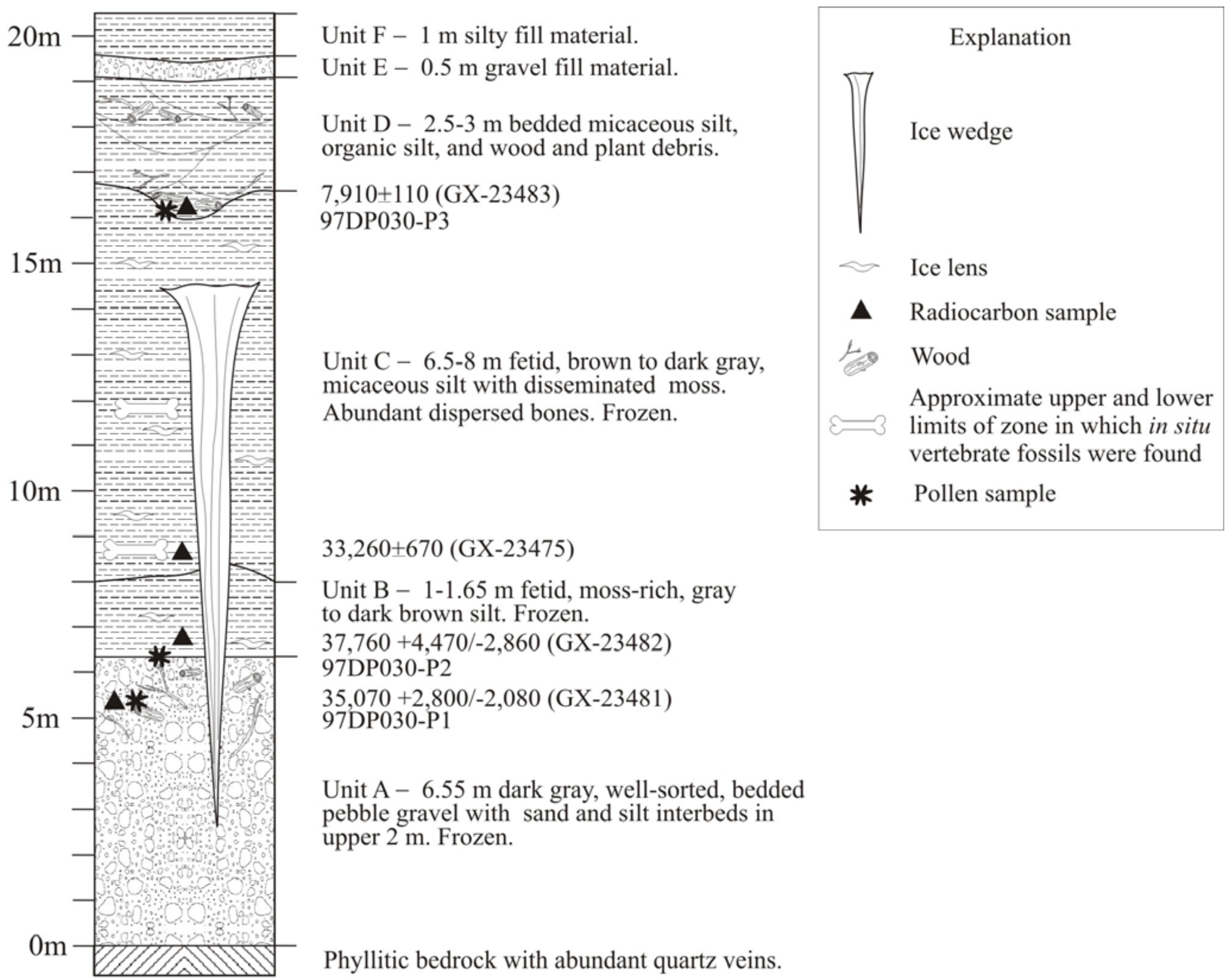

Figure DS5. Stratigraphic section of unconsolidated sediments exposed in Dalton Gulch placer mine, Tofty mining district

Figure DS6. Large-mammal fossils of Dalton Gulch: a-d) bison; e-h) mammoth; i) caribou; j) elk-moose (see text and Table DS2 for more details)

Figure DS7. Modern example of collared lemming (*Dicrostonyx) (Photo from "It's Nature")*

Figure DS8. Modern example of arctic ground squirrel (*Spermophilus)*

Figure DS9. Artist's rendering of long-horned steppe bison (*Bison priscus)(National Geographic)*

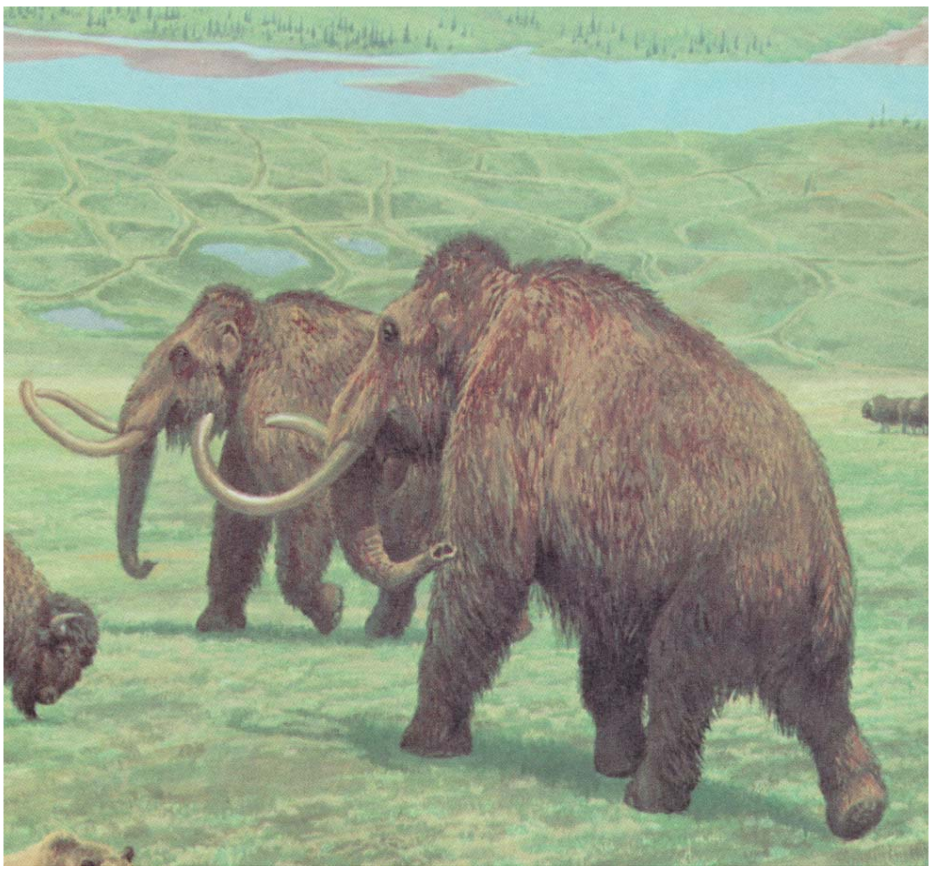

Figure DS10. Artist's rendering of woolly mammoth (*Mammuthus primigenius)(National Geographic)*

Figure DS11. Modern example of caribou (*Rangifer) (http://people.trentu.ca/sbocking/Bocking-projects.html)*

Figure DS12. Artist's rendering of giant elk, or elk-moose/stag-moose (*Cervalces*) *(http://commons.wikimedia.org/wiki/File:Life_restoration_cervalces_scotti.jpg)*

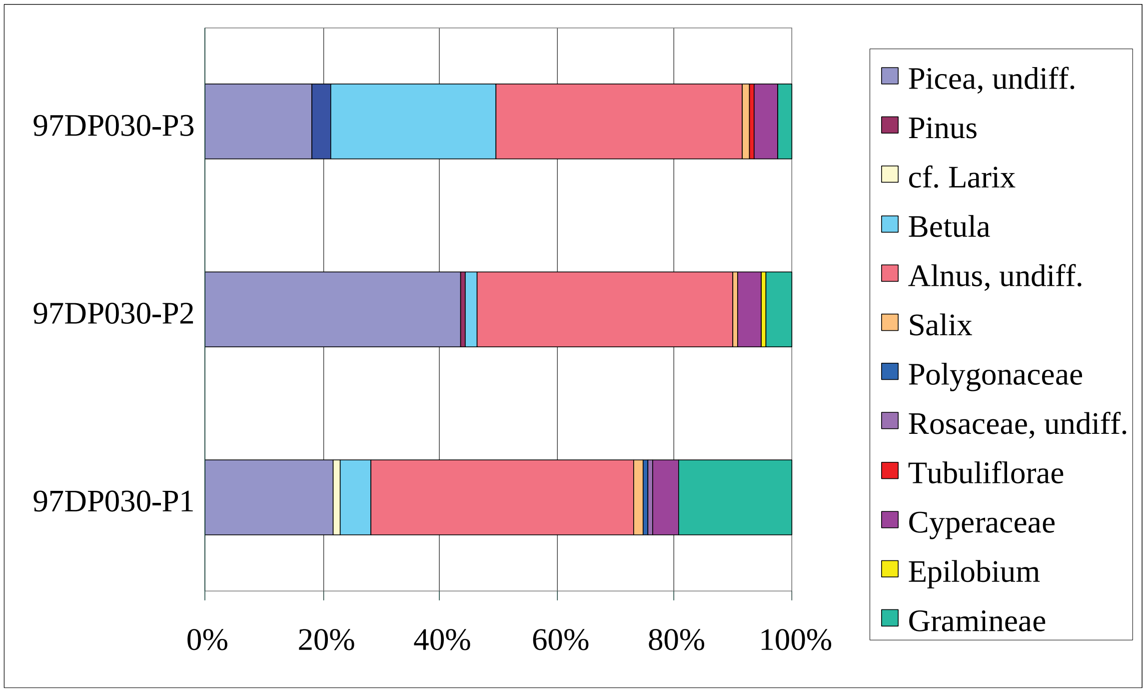

Figure DS13. Histogram of pollen frequencies from Dalton Gulch site, Tofty district, central Alaska

Table DS1. 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) and is rounded to the nearest 10 yr. Calibrated age incorporates an error multiplier of 2 to account for noncounting sources of laboratory error. Calibration and weighted averaging was performed using a computer program by Stuiver and Reimer (1993). All ages include a correction for natural $^{13}C/^{12}C$ isotopic fractionation.]

Laboratory/field number	Material and stratigraphic context	Chronological significance	Age (^{14}C 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	8990 - 8410
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	33,260 ± 670	---

Table DS2. 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 sp.*	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

Table DS3. 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)