Age of the gold-bearing White Channel Gravel, Klondike district, Yukon

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ABSTRACT

Four new glass-fission-track age determinations on three distal tephra beds, together with published magnetostratigraphic and $^{40}Ar/^{39}Ar$ age data, securely place a Late Pliocene age (2.6-3.3 Ma) on the upper White Channel Gravel in the Klondike district of the Yukon. No tephra beds have been found in the lower White Channel Gravel, so its age is only loosely constrained by paleomagnetism and paleobotany, which suggest a post-Miocene and pre-Late Pliocene age.

RÉSUMÉ

Quatre nouvelles datations par la méthode des traces de fission dans le verre de trois couches de téphra distales ainsi que des datations magnétostratigraphiques et $^{40}Ar/^{39}Ar$ publiées permettent de conférer un âge du Pliocène tardif (2,6-3,3 Ma) au gravier supérieur de White Channel dans le district de Klondike au Yukon. Aucune couche de téphra n'a été localisée dans le gravier inférieur de White Channel. C'est pourquoi son âge n'est basé que sur des données paléomagnétiques et paléobotaniques qui le font remonter à une période postérieure au Miocène et antérieure au Pliocène tardif.

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INTRODUCTION

Much of the placer gold in the Klondike district of the Yukon has been recovered from the White Channel Gravel, a quartz-rich fluvial deposit, commonly preserved as high-level terraces along valleys that radiate from the King Solomon Dome in that part of the Klondike uplands framed by the Klondike and Indian rivers, and Dominion Creek (Figs. 1, 2; McConnell, 1905, 1907; Lowey, 1998). McConnell (1907) thought the White Channel Gravel was probably of Pliocene age, and subsequent studies have supported this view. Tempelman-Kluit (1980) envisaged a Late Miocene erosional surface of low relief and elevation, uplifted and dissected by rejuvenated streams. The White Channel Gravel is thought to have been deposited during the early phase of this uplift, probably during the Pliocene. Morison (1987) interpreted the presence of *Corylus* sp. as evidence of a Pliocene age. Further support comes from the work of Kunk (1995), who obtained hornblende $^{40}Ar/^{39}Ar$ age estimates of 2.64 to 3.01 Ma on Quartz Creek tephra in the upper White Channel Gravel at Quartz Creek (Figs. 1, 3). A zircon-fission-track age determination of 0.80 (± 0.40 Ma) on the same tephra is clearly too young given the physiographic and stratigraphic setting of the White Channel Gravel (Morison et al., 1998). Paleomagnetic and stratigraphic information likewise suggested to Froese et al. (2000) that deposition of the White Channel Gravel spanned the Pliocene.

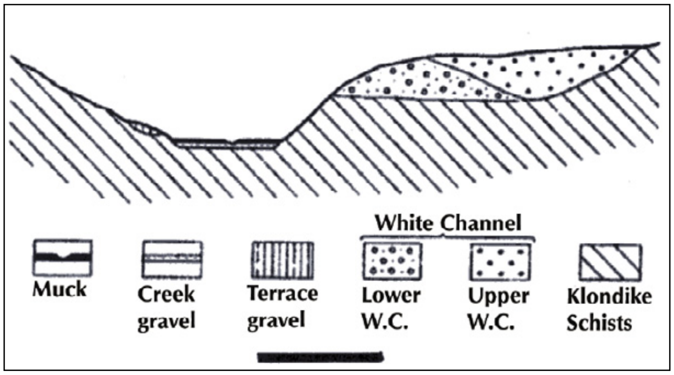

Figure 2. *Generalized geological section across Hunker Creek showing the upper and lower units of the White Channel Gravel and its physiographic setting (modified after Froese et al., 2000). Scale bar represents 100 m.*

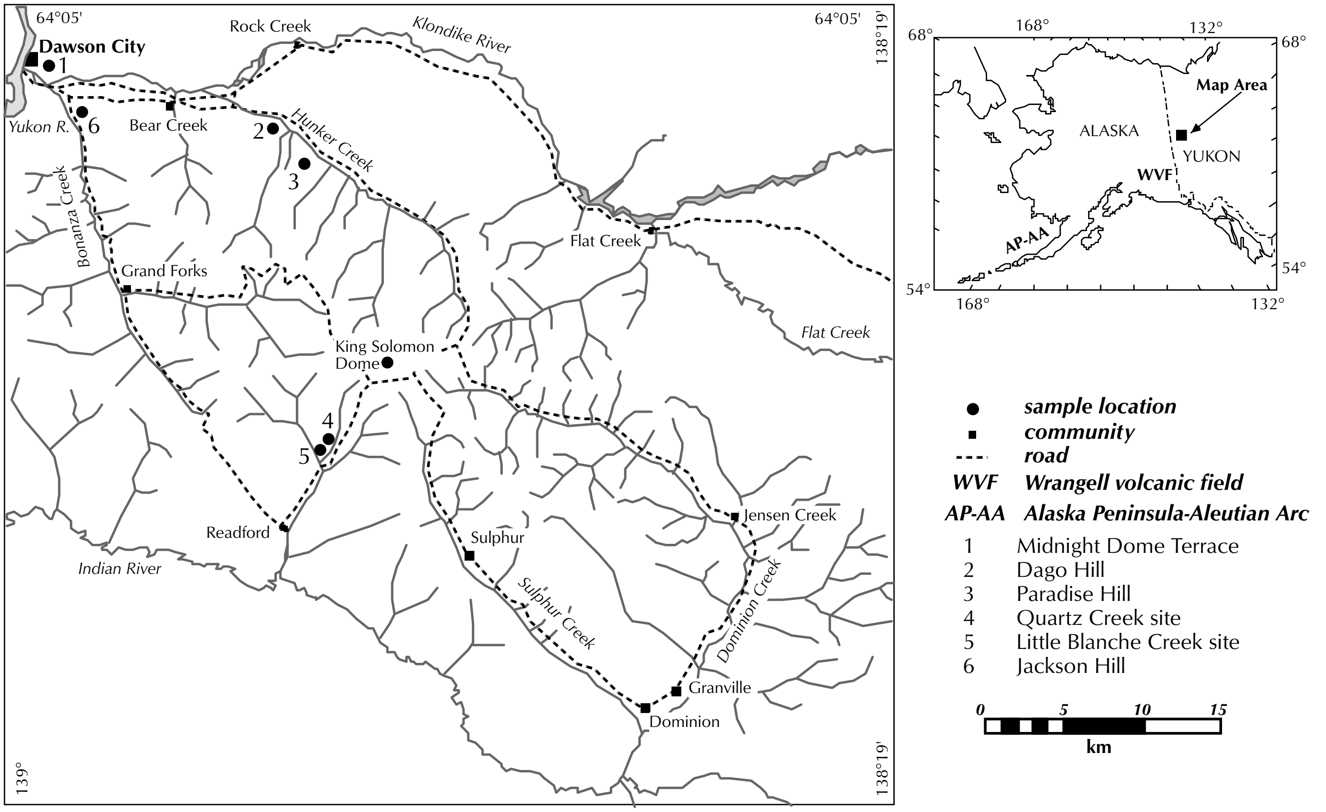

Figure 1. *The Klondike district of the Yukon showing locations of sites where sediments are exposed that provide information on the age of the White Channel Gravel. Inset map shows source regions (WVF and AP-AA) of volcanoes that contributed tephra to the Klondike region during the late Cenozoic.*

Four distal tephra beds occur in and just above the upper White Channel Gravel and provide an opportunity for an improved chronology through application of glass-fission-track (ft) dating methods (Westgate, 1989; Sandhu et al., 1993; Sandhu and Westgate, 1995). The objectives of this paper are to give the compositional characteristics of these distal tephra beds, noting their significance with respect to source volcanoes, and to present five glass-ft age estimates, which the authors evaluate in the light of other age constraints, including biostratigraphic controls.

LITHOSTRATIGRAPHIC SETTING OF TEPHRA BEDS

McConnell (1905, 1907) first recognized the lower (white) and upper (yellow) subdivisions of the White Channel Gravel on the basis of colour, lithology, and clast preservation. The older unit is typically quartz-rich gravel, which, in places, has been altered. The younger unit has a similar lithology, although the clasts are better preserved, and contains periglacial features such as ice-wedge casts and involutions (Froese et al., 2000). It is locally separated from the older gravels by an unconformity.

Four geological sections are particularly pertinent to the problem of the age of White Channel Gravel, namely, the Quartz Creek site, Dago Hill, Paradise Hill and Jackson Hill (Figs. 1 and 3). Quartz Creek tephra (UT1001, UT1634) occurs within the sedimentary fill of an ice-wedge cast in the upper White Channel Gravel at Quartz Creek (locality 4, Fig. 1; Sandhu, et al., 2001). Two tephra beds are exposed at Paradise Hill: Little Blanche Creek tephra (UT1623) is preserved as pods, up to 5 cm thick (Fig. 4), about 4 m below the top of the upper White Channel Gravel; and Paradise Hill tephra (UT1624) has been reworked into multiple, thin, discontinuous beds over a stratigraphic interval of 20 cm in sands and silts about 50 cm above the top of the upper White Channel Gravel. Colluvial silt with organic-rich beds overlies Paradise Hill tephra (Fig. 3). The mode of occurrence of Dago Hill tephra (UT1553) is very similar to that of Little Blanche Creek tephra, except that in this case only a wispy lens was preserved in the upper White Channel

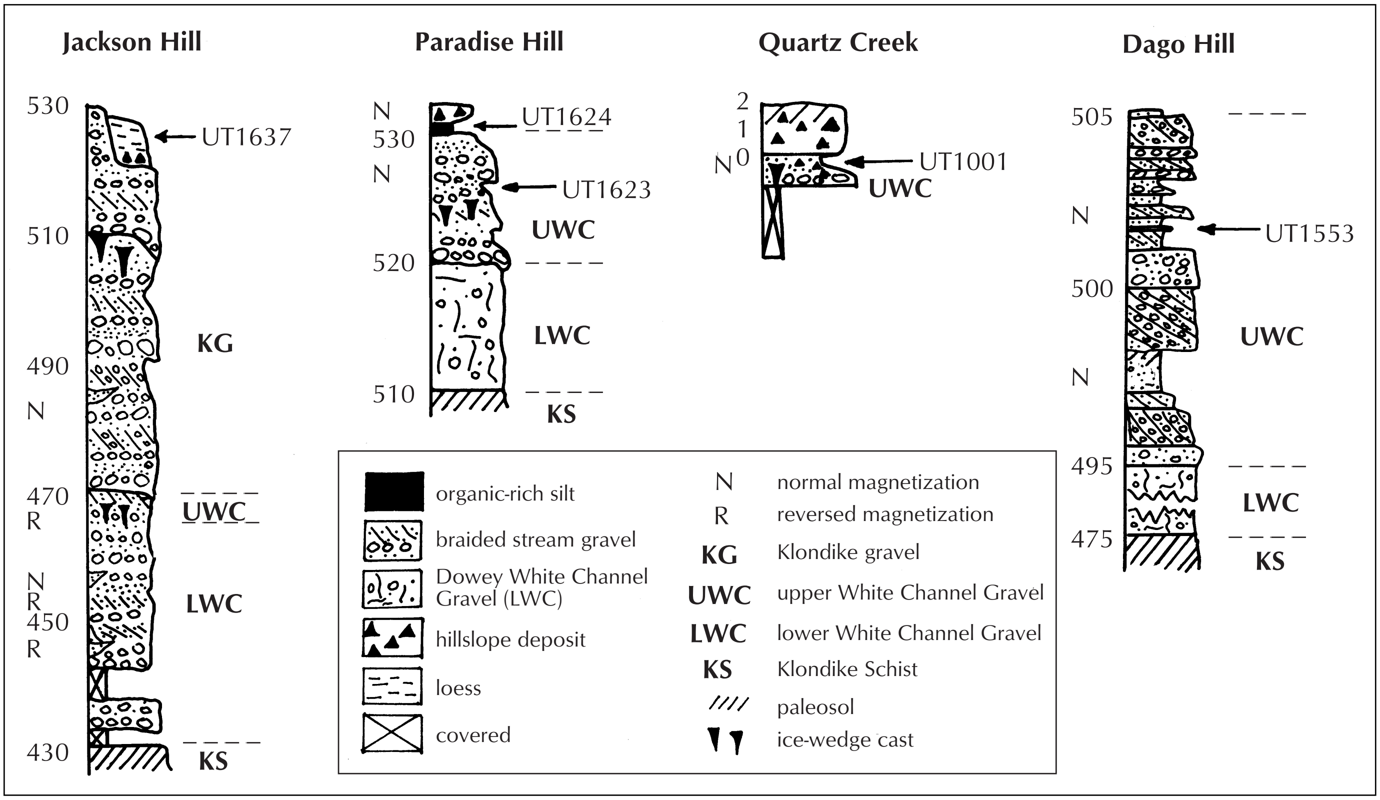

Figure 3. *Lithostratigraphic setting of tephra beds and paleomagnetic measurements at Jackson Hill, Paradise Hill, Quartz Creek and Dago Hill (modified from Sandhu et al., 2001, p. 249). Identity of tephra beds as follows: UT1637, VT tephra; UT1623, Little Blanche Creek tephra; UT1624, Paradise Hill tephra; UT1001, Quartz Creek tephra; UT1553, Dago Hill tephra. Elevation in metres is given for all sites except Quartz Creek, where only the thickness is given.*

Gravel (Fig. 5). In all, three tephra beds offer the potential of improving age controls on the upper White Channel Gravel (Quartz Creek, Little Blanche Creek and Dago Hill), with one other, Paradise Hill tephra, likely giving a close minimum age for this unit.

DESCRIPTION OF TEPHRA BEDS

Quartz Creek, Little Blanche Creek and Paradise Hill tephra beds are crystal-rich with abundant hornblende, plagioclase and Fe-Ti oxides, and minor amounts of hypersthene, apatite and zircon. Their rhyolitic glass (Fig. 6) is mostly in the form of highly inflated pumice, although some chunky glass of low vesicularity is present, but very rare, in Quartz Creek and Paradise Hill tephra beds. These three tephra beds can be readily distinguished from one another on the basis of their glass composition, each bed possessing a homogeneous population (Table 1; Fig. 7). Quartz Creek tephra is relatively enriched in K, Little Blanche Creek tephra has relatively high values for Al, Fe, and Ca (Table 1), and Paradise Hill tephra has the highest values of heavy rare-earth elements in its glass (Fig. 7b). In addition, their compositional fields are quite distinct on the K_2O-Al_2O_3 plot (Fig. 7c). These compositional characteristics, including the weak Eu anomaly in their rare-earth-element profiles (Fig. 7b), demonstrate that these three tephra

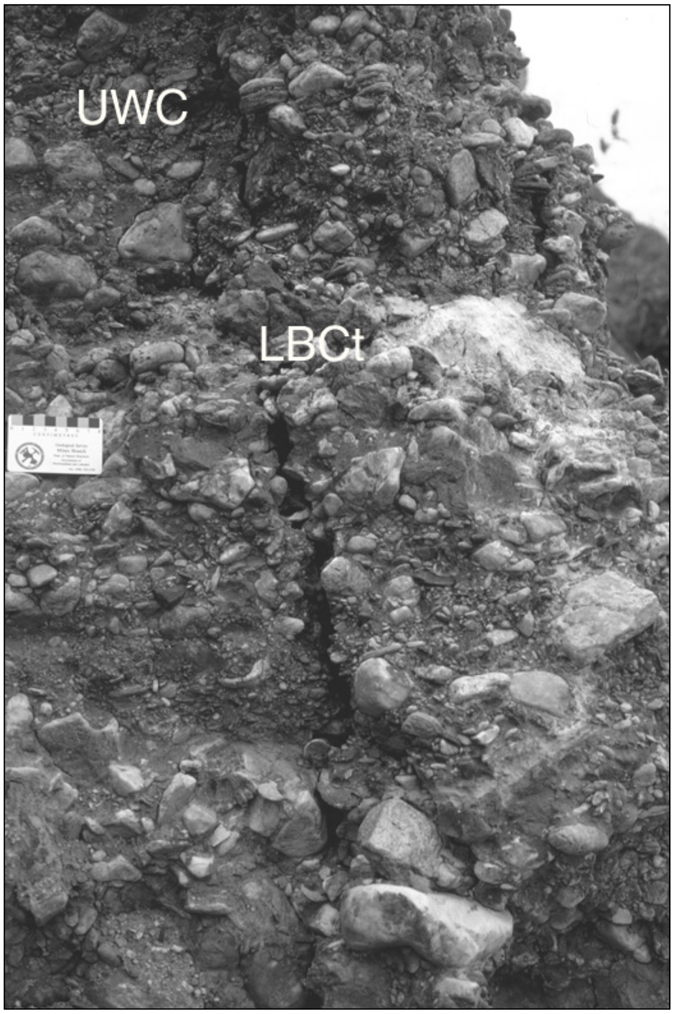

***Figure 4.** Little Blanche Creek tephra (LBCt, UT1623) in the upper White Channel gravel (UWC) at Paradise Hill. Scale is in centimetres.*

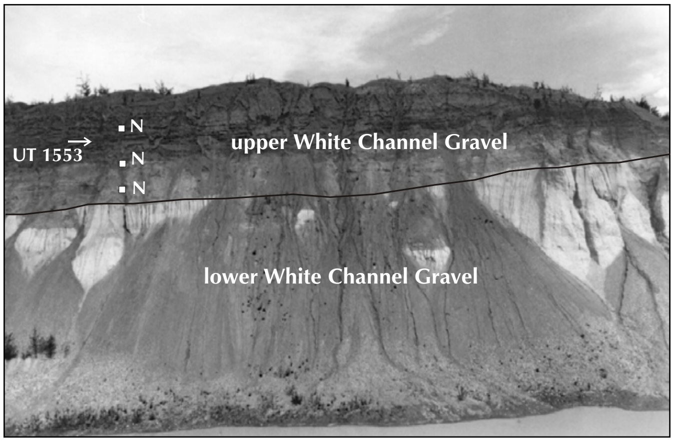

***Figure 5.** Relationship between the upper and altered lower White Channel Gravel at Dago Hill. These two units are here separated by a conspicuous unconformity. The stratigraphic position of Dago Hill tephra (UT1553) and normally (N) magnetized sediment are shown in the upper White Channel gravel.*

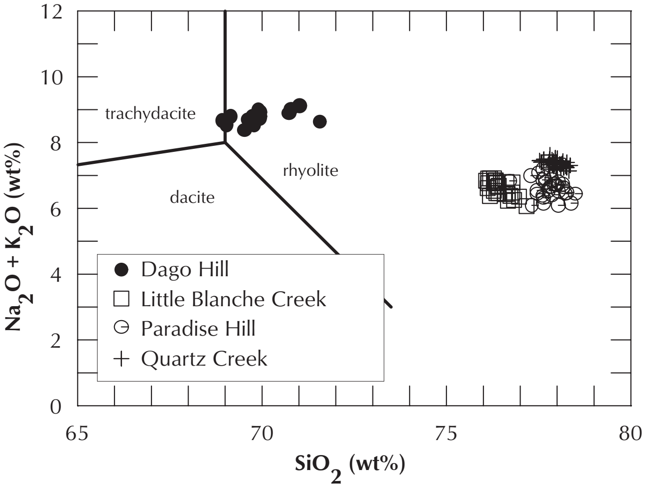

***Figure 6.** Chemical classification of tephra beds in the upper White Channel Gravel and immediately overlying sediment based on the composition of their glass shards using the total alkali-silica (TAS) diagram.*

beds belong to the type II class of Preece et al. (1999) and come from vents in the Wrangell volcanic field of Alaska (Fig. 1).

Dago Hill tephra is very different. It has abundant bubble-wall glass shards, mostly of a brownish hue. The small amount of material available prevented a representative description of its mineralogy. However, being a type I tephra bed (see below), crystals would be sparse and consist of plagioclase and pyroxene with minor amounts of amphibole, magnetite, ilmenite, apatite and zircon. Glass shards have a rhyolitic composition with some shards straddling the boundary between the trachydacite

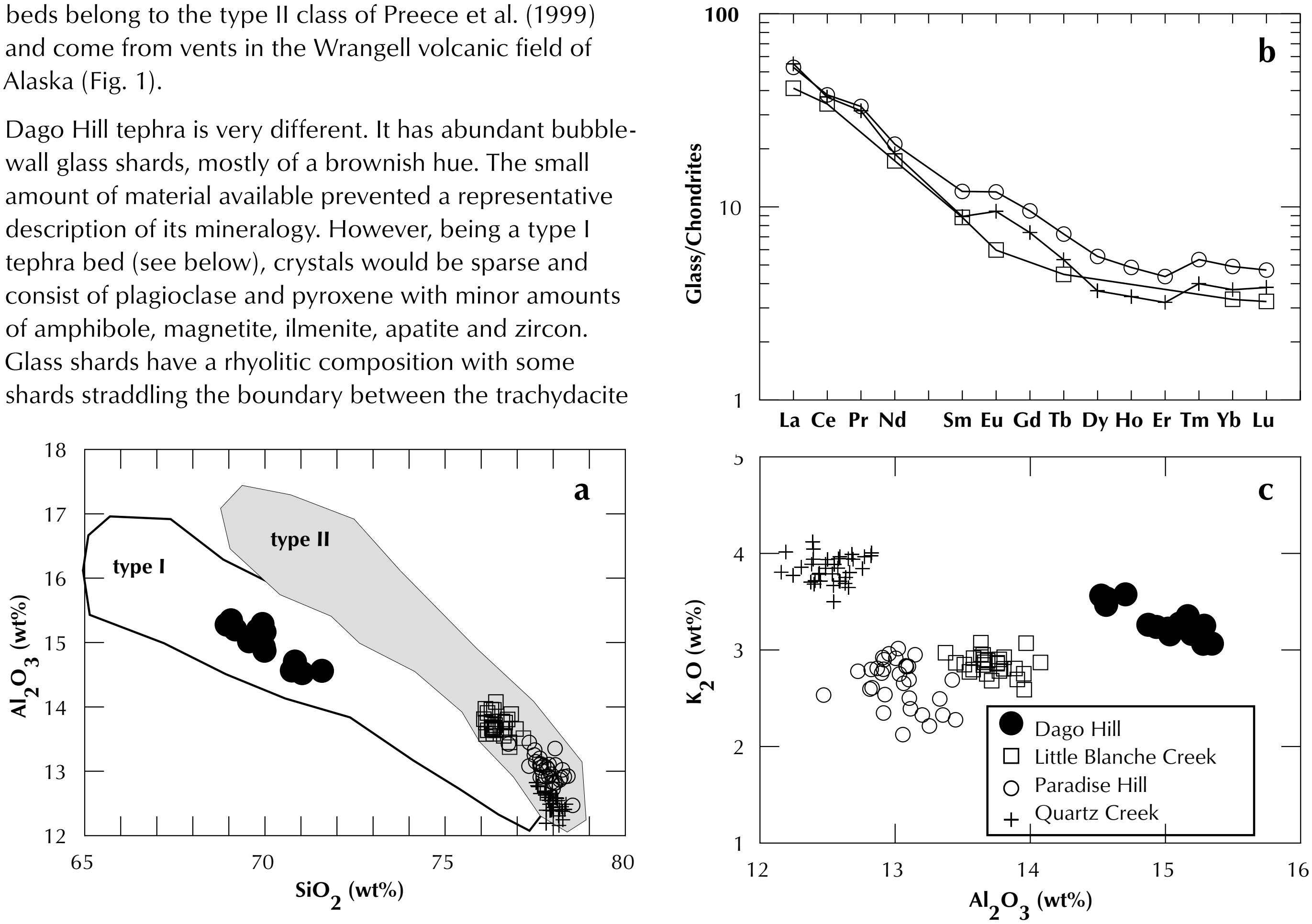

Figure 7. *Major- and rare-earth-element composition of glass shards in Dago Hill, Paradise Hill, Little Blanche Creek, and Quartz Creek tephra beds.* ***(a)*** *Classification of tephra beds into type I and type II groups of Preece et al. (1999).* ***(b)*** *Rare-earth element profiles of the type II tephra beds showing pronounced enrichment of light rare-earth elements over heavy rare-earth elements and weak Eu anomaly.* ***(c)*** *Oxide variation plot showing good separation of the four tephra beds on the basis of their K and Al contents.*

Table 1. *Average glass major-element composition of tephra beds.*

	Dago Hill		Little Blanche Creek		Paradise Hill		Quartz Creek	
SiO_2	70.00	(0.77)	76.46	(0.26)	77.83	(0.36)	77.96	(0.21)
TiO_2	0.56	(0.06)	0.18	(0.07)	0.16	(0.05)	0.17	(0.06)
Al_2O_3	14.99	(0.29)	13.72	(0.17)	13.03	(0.21)	12.52	(0.16)
FeO_t	3.69	(0.29)	1.14	(0.08)	0.89	(0.07)	0.83	(0.07)
MnO	0.13	(0.03)	0.05	(0.02)	0.03	(0.03)	0.03	(0.02)
CaO	1.38	(0.21)	1.53	(0.07)	1.23	(0.16)	0.93	(0.05)
MgO	0.43	(0.09)	0.29	(0.03)	0.22	(0.04)	0.16	(0.03)
Na_2O	5.44	(0.14)	3.75	(0.24)	3.93	(0.20)	3.52	(0.13)
K_2O	3.29	(0.17)	2.85	(0.11)	2.65	(0.24)	3.84	(0.13)
Cl	0.07	(0.02)	0.03	(0.02)	0.03	(0.02)	0.04	(0.02)
H_2O_d	3.94	(1.63)	5.55	(1.52)	5.41	(1.04)	5.06	(0.93)
n	15		27		31		37	

Notes: Analyses (wt%) done on a Cameca SX-50 wave-length dispersive microprobe operating at 15 kV accelerating voltage, 10 μm beam diameter, and 6nA beam current.

Standardization achieved by use of mineral and glass standards. Analyses recast to 100% on a water-free basis. (#) = standard deviation, n = number of analyses, FeO_t = total iron oxide as FeO, H_2O_d = water by difference. Average composition based on non-zero values for the following samples: Dago Hill (UT1553), Little Blanche Creek (UT1054, UT1455, UT1623), Paradise Hill (UT1556, UT1624), Quartz Creek (UT1001, UT1053, UT1544). Compositional data on Quartz Creek tephra is from Sandhu et al., 2001, p. 252.

and rhyolite fields on the total alkali-silica (TAS) diagram (Fig. 6). The silica content at a given Al_2O_3 concentration is low relative to the type II tephra beds (Fig. 7A) and indicates a type I identity (Preece et al., 1999), the source vent being located in the Alaska Peninsula-Aleutian arc region (Fig.1).

GLASS-FISSION-TRACK AGES

The age of the distal tephra beds in the upper White Channel Gravel and overlying sediments was determined by the population-subtraction fission-track method (Wagner and Van den haute, 1992). Glass is the dated phase, and, in all cases, the fundamental requirement of a unimodal population was met (Fig. 7). Correction for partial fading of fission tracks was done in two ways. A heat treatment approach was used for tephra beds with glass shards larger than 120 μm (ITPFT method; Westgate, 1989), whereas finer grained tephra beds were corrected by comparison of the size of the induced and spontaneous fission tracks in the irradiated and natural glass aliquots of a particular tephra bed, respectively (DCFT method; Sandhu and Westgate, 1995; Westgate et al., 1997). These two procedures are entirely independent of one another, and they can thus be used on the same tephra bed — provided the glass shards are large enough — as a means of evaluating the reliability of the age data.

An internal glass standard is included in each irradiation can as a means of assessing the accuracy of the age determinations. The 2 million-year-old rhyolitic Huckleberry Ridge tephra (UT1366), derived from the cataclysmic eruption at Yellowstone, U.S.A., is used for this purpose. The sample comes from an air-fall deposit at Meade County, Kansas. Ages obtained on this glass standard for four separate irradiations are presented in Table 2. Both ITPFT and DCFT methods have been used. Ages range from 2.00 to 1.97 Ma, which is within 2% of the $^{40}Ar/^{39}Ar$ age of 2.003 ± 0.014 Ma (Gansecki et al., 1998). The relative standard error (Bigazzi and Galbraith, 1999) associated with a single age determination varies from 11-13% (Table 2), but this is dramatically reduced when several age determinations are done. For example, the weighted mean age of UT1366 based on four age determinations is 1.99 ± 0.11 Ma, giving a relative standard error of less than 6%.

Another indication that our glass-fission-track (glass-ft) age estimates are of acceptable accuracy comes from the Midnight Dome tephra (UT1552) at the Midnight Dome Terrace site (Fig. 1). Its glass-DCFT age of 1.09 ± 0.18 Ma

Table 2. *Glass-fission-track ages of the internal standard (Huckleberry Ridge tephra).*

Sample number	Date irradiated	Spontaneous track density	Corrected spontaneous track density	Induced track density	Track density on muscovite detector over dosimeter glass	Etching conditions	D_s	D_i	D_s/D_i	Age
						HF:temp:time			OR	
Analyst		10^2t/cm^2	10^2t/cm^2	10^5t/cm^2	10^5t/cm^2	%:°C:s	μm	μm	D_i/D_s#	Ma
Huckleberry Ridge tephra: internal standard										
UT1094	31/01/00	43.23 ± 1.42		4.21 ± 0.03	4.87 ± 0.04	24:21:120	6.09 ± 0.07	7.54 ± 0.09	0.81 ± 0.01	1.59 ± 0.17
JAW		(931)		(25152)	(12744)					
UT1094*			53.57 ± 1.76	4.20 ± 0.03	4.87 ± 0.04	24:21:120	6.09 ± 0.07	7.54 ± 0.09	1.24 ± 0.02#	1.97 ± 0.21*
			(931)	(25152)	(12744)					
UT1366$	26/04/00	12.80 ± 0.91		1.15 ± 0.02	5.63 ± 0.03	24:22:140	6.47 ± 0.08	6.58 ± 0.05	0.98 ± 0.01	2.00 ± 0.25$
AS		(200)		(5741)	(43489)					
UT1366$	11/09/00	23.50 ± 1.66		2.07 ± 0.01	5.47 ± 0.04	24:25:140	6.15 ± 0.11	6.19 ± 0.08	0.99 ± 0.02	1.98 ± 0.26$
AS		(200)		(10267)	(20991)					
UT1366	23/11/00	40.75 ± 1.30		4.64 ± 0.03	5.61 ± 0.05	24:25:100	5.98 ± 0.06	7.63 ± 0.09	0.78 ± 0.01	1.57 ± 0.16
JAW		(980)		(27443)	(14359)					
UT1366*			52.00 ± 1.66	4.63 ± 0.03	5.61 ± 0.05	24:25:100	5.98 ± 0.06	7.63 ± 0.09	1.28 ± 0.02#	2.00 ± 0.21*
			(980)	(27443)	(14359)					

Notes: See Table 3 for details on dating procedures and explanation of symbols. The single-crystal(sanidine) laser-fusion $^{40}Ar/^{39}Ar$ age of Huckleberry Ridge tephra is 2.003 ± 0.014 Ma(2σ error) (Gansecki et al.,1998). The weighted mean corrected age of UT1366 based on these four glass-ft age estimates is 1.99 ± 0.11 Ma.

agrees well with a position immediately below the lower boundary of the Jaramillo magnetozone (Froese et al., 2000), dated at 1.07 Ma on the geomagnetic polarity time scale of Cande and Kent (1992, 1995). This age estimate also lends weight to the accuracy of the similarly dated Mosquito Gulch tephra (UT1592; 1.45 ± 0.14 Ma), which occurs at the base of the loess sequence at the same locality, about 8 m below Midnight Dome tephra. The glass-ft age of Mosquito Gulch tephra is, in turn, supported by its occurrence halfway between the AT (UT1098; 1 Ma) and PA (UT497; 2.02 ± 0.14 Ma) tephra beds at Fairbanks, Alaska (Preece et al., 1999).

Table 3. *Glass-fission-track ages of distal tephra beds in upper White Channel Gravel and immediately overlying sediments, Klondike district, Yukon.*

Sample number	Date irradiated	Spontaneous track density	Corrected spontaneous track density	Induced track density	Track density on muscovite detector over dosimeter glass	Etching conditions	D_s	D_i	D_s/D_i	Age
						HF:temp:time			OR	
Analyst		10^2t/cm^2	10^2t/cm^2	10^5t/cm^2	10^5t/cm^2	%:°C:s	µm	µm	D_i/D_s#	Ma
UPPER WHITE CHANNEL GRAVEL										
Quartz Creek tephra										
UT1001	31/01/00	39.30 ± 1.96		2.69 ± 0.02	5.01 ± 0.04	24: 22: 110	6.01 ± 0.09	7.61 ± 0.10	0.79 ± 0.02	2.36 ± 0.26
AS		(401)		(14637)	(12744)					
UT1001*			49.75 ± 2.50	2.64 ± 0.02	5.01 ± 0.04	24: 22: 110	6.01 ± 0.09	7.61 ± 0.10	1.27 ± 0.02#	3.00 ± 0.33*
			(401)	(14637)	(12744)					
UT1634$	26/04/00	24.50 ± 1.70		1.50 ± 0.01	5.63 ± 0.03	24: 23: 150	6.09 ± 0.17	6.05 ± 0.07	1.01 ± 0.03	2.93 ± 0.36$
AS		(200)		(11113)	(43489)					
									Weighted Mean Corrected Age	2.97 ± 0.24
Dago Hill tephra										
UT1553	23/11/00	17.80 ± 1.26		1.18 ± 0.02	5.61 ± 0.05	24: 25: 60	5.59 ± 0.14	6.60 ± 0.08	0.85 ± 0.02	2.68 ± 0.35
AS		(200)		(5749)	(14359)					
UT1553*			21.02 ± 1.49	1.18 ± 0.02	5.61 ± 0.05	24: 25: 60	5.59 ± 0.14	6.60 ± 0.08	1.18 ± 0.03#	3.18 ± 0.41*
			(200)	(5749)	(14359)					
SEDIMENTS IMMEDIATELY ABOVE UPPER WHITE CHANNEL GRAVEL										
Paradise Hill tephra										
UT1624	11/09/00	6.29 ± 0.46		0.84 ± 0.01	5.47 ± 0.04	24: 25: 90	5.42 ± 0.12	6.18 ± 0.09	0.88 ± 0.02	1.30 ± 0.15
JAW		(188)		(6970)	(20991)					
UT1624*			7.17 ± 0.52	0.84 ± 0.01	5.47 ± 0.04	24: 25: 90	5.42 ± 0.12	6.18 ± 0.09	1.14 ± 0.03#	1.48 ± 0.17*
			(188)	(6970)	(20991)					
UT1624	11/09/00	7.10 ± 0.64		0.86 ± 0.01	5.47 ± 0.04	24: 25: 90	5.42 ± 0.12	6.18 ± 0.09	0.88 ± 0.02	1.43 ± 0.19
AS		(125)		(4282)	(20991)					
UT1624*			8.09 ± 0.72	0.86 ± 0.01	5.47 ± 0.04	24: 25: 90	5.42 ± 0.12	6.18 ± 0.09	1.14 ± 0.03#	1.63 ± 0.22*
			(125)	(4282)	(20991)					
									Weighted Mean Corrected Age	1.54 ± 0.13

Notes: The population-subtraction method was used; details are given in Westgate et al. (1997). Samples with asterisk corrected for partial track fading by the track-size (DCFT) method (Sandhu and Westgate, 1995); samples with a dollar sign corrected by heating the spontaneous and induced glass aliquots at 150°C for 30 days, the ITPFT method (Westgate, 1989); the uncorrected age is noted simply by the sample number. Ages calculated using the Zeta approach and $\lambda_D = 1.551 \times 10^{-10} yr^{-1}$. Zeta value is 318 ± 3 based on six irradiations at the McMaster Nuclear Reactor, Hamilton, Ontario, using the NIST SRM 612 glass dosimeter and the Moldavite tektite glass (Lhenice locality) with an $^{40}Ar/^{39}Ar$ plateau age of 15.21 ± 0.15 Ma (Staudacher et al., 1982). Standard error (±1σ) on age estimate is calculated according to Bigazzi and Galbraith (1999). Area estimated using the point-counting technique (Sandhu et al., 1993). D_s = mean spontaneous track diameter, D_i = mean induced track diameter. Number of tracks counted is given in brackets. See Table 2 for information on internal standards. Information on the DCFT age of Quartz Creek tephra (UT1001*) is from Sandhu et al., 2001.

Glass-ft ages on distal tephra beds in the upper White Channel Gravel are given in Table 3. Quartz Creek tephra (UT1001, UT1634) at Quartz Creek (Fig. 1) has a DCFT age of 3.00 ± 0.33 Ma and an ITPFT age of 2.93 ± 0.36 Ma, giving a weighted mean age of 2.97 ± 0.24 Ma. This age estimate is compatible with the normal magnetic polarity of the enclosing sediments (Figs. 3, 8; C2An.1n of Cande and Kent, 1995). Dago Hill tephra (UT1553) has a DCFT age of 3.18 ± 0.41 Ma, very similar to that of Quartz Creek tephra. It also agrees with the normal polarity of sediments just above it (Fig. 3), which would belong to the normal magnetozone C2An.2n of Cande and Kent (1995) if the accuracy of this age estimate is comparable to that of the internal standard (Fig. 8). Hence, the upper White Channel Gravel is of Late Pliocene age.

At the nearby Paradise Hill site (Figs. 1 and 3), another tephra bed was found in the upper White Channel Gravel, namely, the Little Blanche Creek tephra (UT1623). This unit is not datable by glass-ft methods because of its highly pumiceous glass, but the abundance of hornblende suggests that it might be possible to determine its age by the $^{40}Ar/^{39}Ar$ method. The same tephra bed has been found in White Channel Gravel to the south of the King Solomon Dome drainage divide along Quartz Creek (locality 5, Fig. 1; Preece et al., 2000).

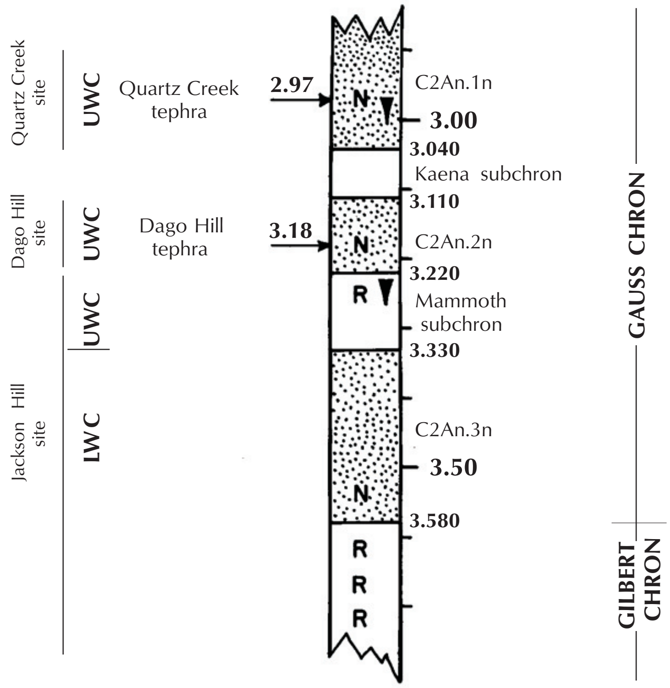

Figure 8. *Proposed correlation of the upper and lower White Channel Gravel to the geomagnetic polarity time scale of Cande and Kent (1995). Ages in Ma.*

Another rhyolitic tephra bed was discovered at Paradise Hill in silts just above the White Channel Gravel (Fig. 3). We have named this unit the Paradise Hill tephra (UT1624), and, although its glass is predominantly pumiceous, it does have some bubble-wall shards of low vesicularity that have enabled us to determine its age by the glass-DCFT method (Table 3). Given its stratigraphic position, we anticipated an age slightly younger than 3 Ma, based on the ages of Quartz Creek and Dago Hill tephra beds. The weighted mean age of Paradise Hill tephra is 1.54 ± 0.13 Ma, which is considerably younger than expected. The top of the White Channel Gravel at this locality must be defined by a significant unconformity.

DISCUSSION

Only one $^{40}Ar/^{39}Ar$ age determination has been made on the distal, late Cenozoic tephra beds of the Klondike region. Quartz Creek tephra has a minimum age of 2.71 Ma, a total gas (maximum) age of 3.01 Ma, and an isochron age of 2.64 ± 0.24 Ma (Kunk, 1995). Our glass-fission track age of 2.97 ± 0.24 Ma is in good agreement with the former two age estimates and within 1σ of the isochron age. Hence, a Late Pliocene age for this tephra bed and its enclosing sediments can be considered secure, as is the age of the upper White Channel Gravel with its paleomagnetic measurements (Froese et al., 2000) calibrated with fission-track ages that place its range between 2.6-3.3 Ma (Fig. 8).

The correlation of the White Channel Gravel to the geomagnetic time scale of Cande and Kent (1995) shown in Figure 8 is suggested if we accept the criteria of Froese et al. (2000) for identification of the lower White Channel and upper White Channel Gravel, note their paleomagnetic measurements, and assume that the accuracy of the glass-ft age of Dago Hill tephra is comparable to that of the internal standard (Table 2). This correlation suggests that climatic conditions conducive to the growth of ice wedges in the Klondike region started some time during the Mammoth Subchron and that part of the lower White Channel Gravel was deposited during the Gilbert Chron.

The age of the lower White Channel Gravel is only loosely constrained by its associated paleomagnetism and a single pollen sample recovered from the middle part of this unit at Jackson Hill (Fig. 3). This sample is dominated by Picea and *Pinus* pollen with Abies and traces of *Corylus* and *Poacea* (J. White, unpublished Geological Survey of Canada Paleontological report 7-JMW-1996; sample C-248449). This assemblage is similar to other Pliocene flora that have been recovered from sediments at sites in adjacent Alaska, including the Nenana gravel and Circle terrace gravel, but is most similar to the slightly younger Lost Chicken flora (Ager et al., 1994; White et al., 1997). Relevant to a maximum age estimate for the lower White Channel Gravel, however, is the absence of *Tsuga* (hemlock) pollen. At other late Miocene-earliest Pliocene sites in Alaska, particularly at Nenana and Circle, the presence of Tsuga has been used to infer a latest Miocene age or early Pliocene age (ca. 5 Ma). Thus, we conclude, based on the limited paleobotanical evidence presently available, that the lower White Channel Gravel is post-Miocene and pre-Late Pliocene and likely represents approximately 2 million years of gravelly deposition in the Klondike.

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