High-level terraces, Indian River valley, Yukon[1]

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ABSTRACT

High-level terraces in the Indian River valley, between the confluences of Ruby Creek and Dominion Creek with Indian River, are underlain by a sand-dominated fill. The fill formed when meltwater torrents from the margin of a Late Pliocene ice sheet drained into the Indian River valley from the divide with the Stewart River basin. A lake or lakes existed in the Indian River valley at that time. Mechanisms for ponding of the lake(s) include regional glacial damming of the ancestral Yukon drainage (Glacial Lake Yukon), or local damming by alluvial fans or landslides. Sufficient evidence does not exist to effectively eliminate any of these hypotheses. Placer gravel may exist below the sandy fill in a buried segment of the pre-glacial Indian River valley near the confluence of Montana Creek.

RÉSUMÉ

Les terrasses supérieures de la vallée de la rivière Indian, entre la confluence des ruisseaux Ruby et Dominion, résultent d'un remblaiement principalement sableux. Il a eu lieu lorsque les torrents de fusion en provenance de la marge de la nappe glaciaire du Pliocène tardif se sont jetés dans la vallée de la rivière Indian à partir de la ligne de partage avec le bassin de la rivière Stewart. Il existait à cette époque un ou plusieurs lacs dans la vallée de la rivière Indian. Les mécanismes de formation du ou des lacs incluent un embâcle glaciaire régional des eaux de drainage ancestrales du Yukon (Lac glaciaire Yukon) ou un embâcle local par des cônes alluviaux ou des glissements de terrain. Les indices sont insuffisants pour éliminer l'une ou l'autre de ces hypothèses. Il existe peut-être un gravier placérien sous le remblai de sable dans un segment enfoui de la vallée pré-glaciaire de la rivière Indian près de la confluence du ruisseau Montana.

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INTRODUCTION

The Indian River basin lies beyond the pre-Reid glaciation limit that marks the all-time limit of regional glaciation by a Cordilleran ice sheet (Fig. 1 and 2 (on adjacent page)). Lateral and vertical accretion of coarse gold-bearing alluvium (White Channel Gravel equivalent) filled the Indian River valley during the Pliocene (Westgate and Froese, 2001; Westgate et al., 2002). However, during an early regional (pre-Reid) glaciation, meltwater torrents from an ice sheet in the Stewart River valley entered the Indian River valley via a gap between Wounded Moose Dome and Australia Mountain (Figs. 2, 3). This incursion deposited a black chert-bearing valley train of extra-basinal gravel (Bostock 1942, 1966; Lowey, 1999; Froese et al., 2001).

To further understand the interrelationships of these sediments and the events that caused their deposition, high terraces along Indian River were mapped and their stratigraphy investigated as a part of the Late Cenozoic geology component of the Ancient Pacific Margin National Mapping Project (NATMAP). This included measurement, description, and sampling of the sediments underlying these terraces (Fig. 2). The high terraces are complicated in composition: alluvial fan gravel locally forms the tops of mesa-like terraces or overlies and intergrades with valley train gravel. Furthermore, thick successions of sand underlie the valley train gravel or appear to be lateral facies equivalent to it.

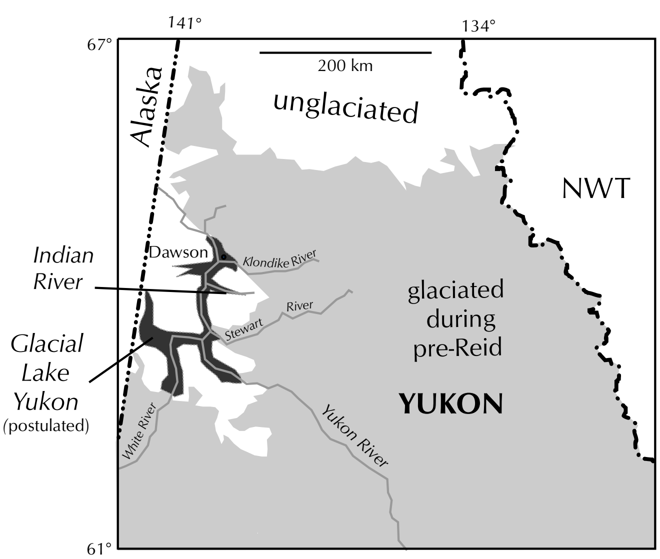


Figure 1. *Cordilleran glaciation limits and extent of Glacial Lake Yukon during the most extensive pre-Reid glaciation (modified from Duk-Rodkin, 1999 in the Stewart River valley after Jackson et al., 2001.*

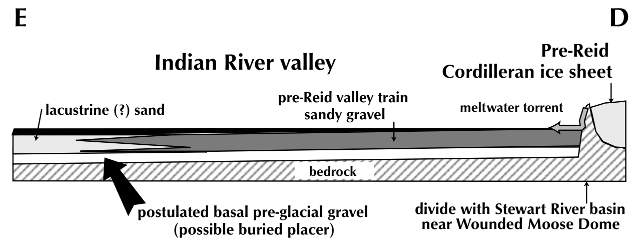


Figure 3. *Longitudinal profile (D-E) showing general facies relationships between pre-glacial gravel, pre-Reid valley train and lacustrine sand along a length of Indian River. A thick succession of valley train gravel and sand likely buries sediments equivalent to White Channel Gravel. Potential placers may exist within this buried unit.*

In this paper, we postulate that these sands are lacustrine in origin and we address the following questions:

1) What is the relationship between the valley train and the alluvial fan gravel?

2) What is the origin of the thick sand units and what relationships do they have with the valley train gravel?

3) Are there potential gold placers within this valley train gravel?

REGIONAL SETTING

Indian River, a gravel bed stream, is a tributary of Yukon River. The Indian River basin lies within the Klondike Plateau (McConnell, 1905; Mathews, 1986), a gently sloping upland south of Tintina Trench consisting of accordant summits (e.g., King Solomon Dome, Australia Mountain). The present flood plain descends about 53 m over a distance of 33 km with an overall gradient of about 1.6 m/km between the confluences of Dominion Creek and Ruby Creek, the reach of Indian River investigated in this paper.

Indian River forms the southern boundary of the Klondike placer district. Indian River and its tributaries are currently the largest placer gold producers in Yukon (LeBarge, 2002). In 2001, Indian River alone produced approximately 119 999 g (3840 ounces) of gold. Gold fineness is generally 780-843 (LeBarge, 2002). Placer diamonds have also been reported to have been recovered from gold mining operations (Casselman and Harris, 2002).

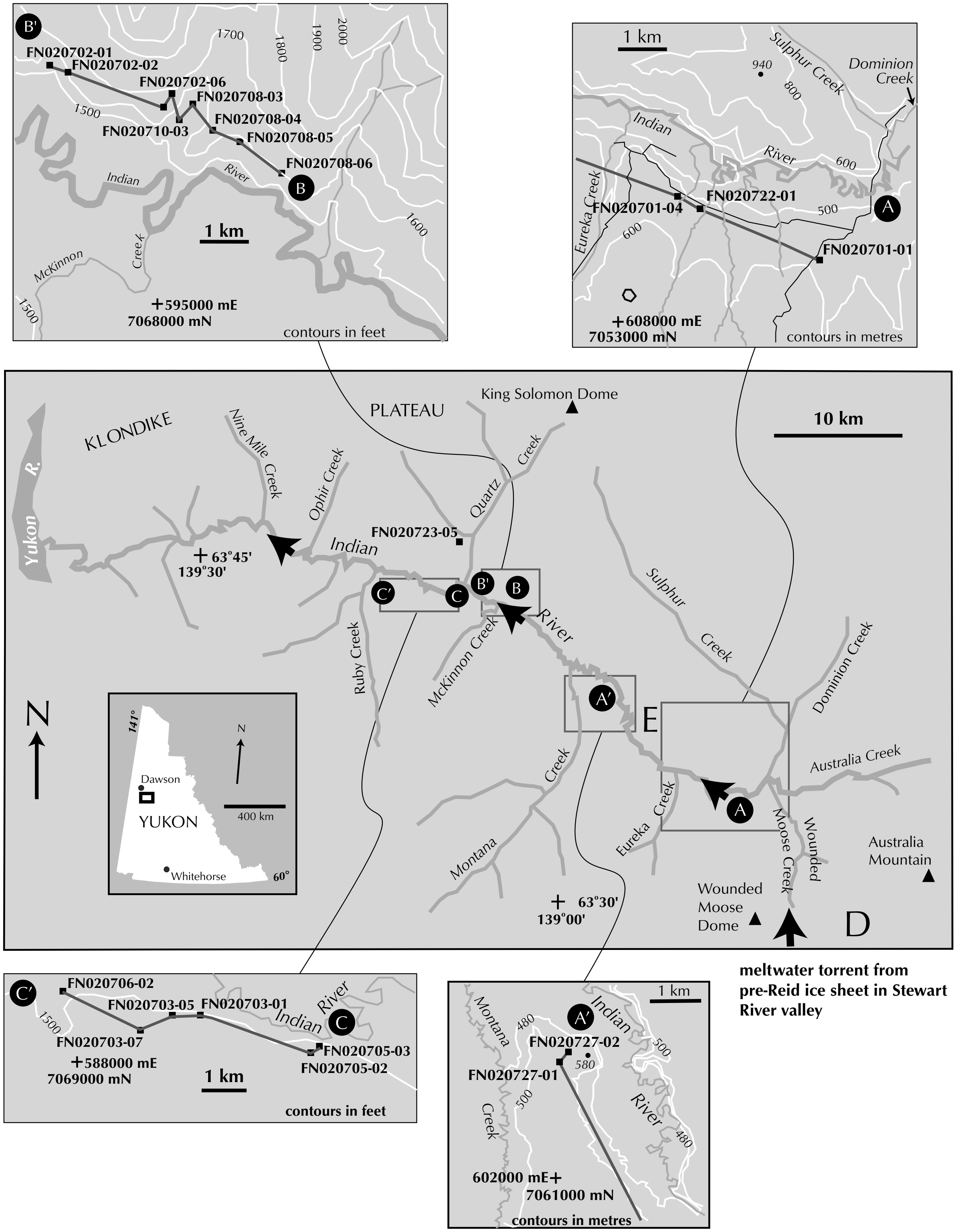


Figure 2. *Location map. Boxes indicate central parts of exploded views arrayed above and below. Profiles D-E, A-A', B-B' and C-C' are depicted in Figures 3, 6, 7 and 8, respectively. Base stations are shown by small solid squares and FN numbers.*

PREVIOUS WORK

Bostock (1942, 1966) noted black chert pebbles in outwash gravel of the Indian River valley and deduced that they were deposited by torrents draining the margin of an early Cordilleran ice sheet that reached the divide between Indian River and Stewart River basins near Wounded Moose Dome. Milner (1984) presented a comprehensive report on the geomorphology of the Indian River valley in the vicinity of Quartz Creek, as well as the metallurgy, grade and potential volume of gold, for the purpose of encouraging placer development in this area. Morison et al. (1998) described four sections in the high-level terrace in the Indian River valley upstream of the mouth of Quartz Creek. Lowey (1999) described Indian River drainage basin placers and used a system composed of five classes to group the placer deposits. He assigned the high-level terraces along Quartz Creek and Indian River to Bench Placer 1 and 2, respectively. These are characterized by approximately 16 m of slightly muddy, sandy gravel dominated by quartz clasts. Lowey (1999) interpreted this gravel as representing paleofloodplain deposits of a braided stream. Duk-Rodkin (1999) mapped glacial limits in the divide areas of Indian River basin and identified minor channels that carried meltwater from an early Cordilleran ice sheet into upper Australia Creek, as well as the major channel near Wounded Moose Dome previously noted by Bostock (1966). Froese et al. (2001) have dated placer deposits along Dominion Creek, a major tributary of Indian River, relative to the geopolarity time scale.

THIS STUDY

Accurate terrace elevation determinations were vital for the success of this study. Elevations determined from 1:50 000-scale topographic maps or single frequency handheld global position system devices were not adequate. A dual frequency global position system (DFGPS) survey was conducted along the Indian River valley to determine terrace elevations. This methodology has a decimetre-scale accuracy.

DFGPS METHODOLOGY

A summary of the theory of DFGPS can be found in Shimamura et al. (2000). As part of this survey, a base station was set up in the Dawson City area over a week-long period in early July, 2002 (Fig. 4a). Nine roving GPS stations were set up for observational periods of an hour or more in the Indian River valley during this period (Fig. 4b). Base and roving stations consisted of an Ashtech choke ring antenna, mounted on a surveying tripod. Transportation to roving stations was by truck, helicopter and foot. Stations were marked by 22-cm iron stakes, and tripods were centred over them using a tribrach. Stakes were left in the ground under a small rock cairn in the event of resurveying. An Ashtech Zxtreme GPS receiver was connected to an antenna by coaxial cable at each site. The base station (FN01) was situated at the GSC field camp at Callison Industrial Park, Dawson City, in the Klondike River Valley (Fig. 4a). An elevation mask was set to 5° at all GPS stations in order to reduce multipath error. At each station, the specific antenna height was calculated and entered into the receiver prior to starting the session. Sessions ran for at least one hour, with the base station session running concurrently. The data was periodically downloaded from the PCMCIA cards within the two receivers to a notebook computer. While at the field camp, the quality of the receiver data was checked using the DOS-based program TEQC (Transformation, Editing, Quality Check). The data was digitally transmitted to the Pacific Geoscience Centre/GSC in Sidney, BC for further post-processing.

LOCATION, ELEVATION AND DESCRIPTION OF SECTIONS

A laser range finder, Suunto PM-5 clinometer and pocket transit were used for trigonometric leveling in open traverses, tying section stations to the GPS benchmark stations. The data was logged in the field notebook and the trigonometry was later calculated using an Excel spreadsheet. Plan and cross-sectional plots of the traverses were plotted using AutoCAD version 13.

Detailed sedimentologic descriptions were completed at over 25 sites. Samples were collected from representative units for grain size, pebble lithology, paleoecology and heavy mineral analysis. Units were correlated based upon lithology, degree of weathering, grain size and stratigraphic position.

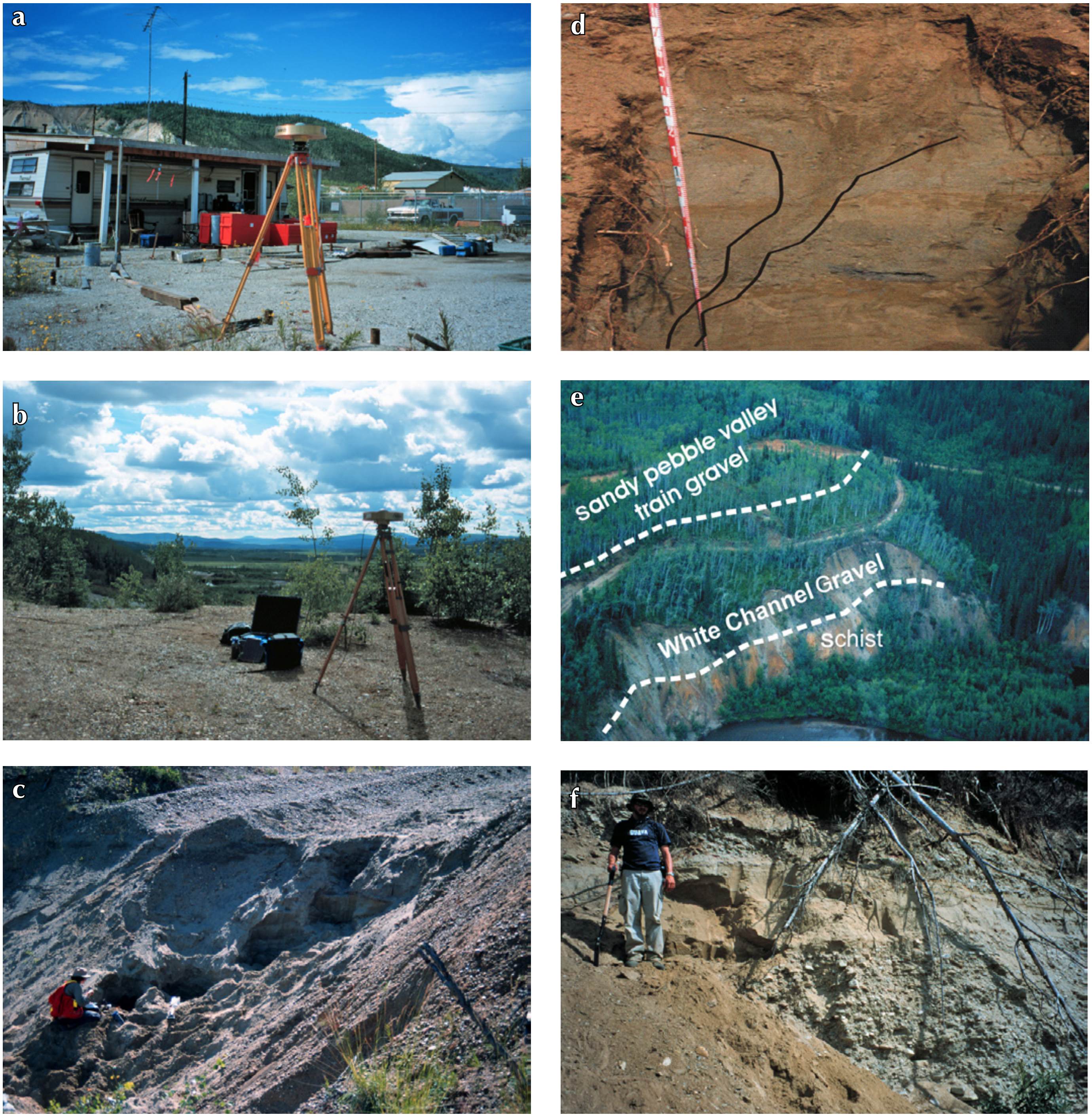


Figure 4. (a) *GPS base station (FN01) at Dawson City. Gravel exposure in background is Klondike Gravel at Jackson Hill (540 m).* ***(b)*** *GPS rover station in the Indian River valley (view upstream).* ***(c)*** *Thick sand bed 2 km upstream from the mouth of Eureka Creek. Sand abruptly overlies planar stratified coarse gravel immediately below seated person (Station FN020701-04).* ***(d)*** *Ice-wedge pseudomorph (indicated by line) buried within bedded fine sand and silty sand near the confluence of Montana Creek (Station FN020727-01).* ***(e)*** *A complete section through the fill underlying a high terrace on north side of Indian River valley (in the area of FN020702-02). Sandy pebble gravel and pebbly sand (top of section) contain chert pebbles. Underlying White Channel Gravel is derived from the Indian River basin upstream (right) or uplands to the north (top of photo).* ***(f)*** *White Channel equivalent gravel shown in B-B', section FN020708-06 (stratigraphically below sand unit).*

RESULTS

GRAVEL TYPES

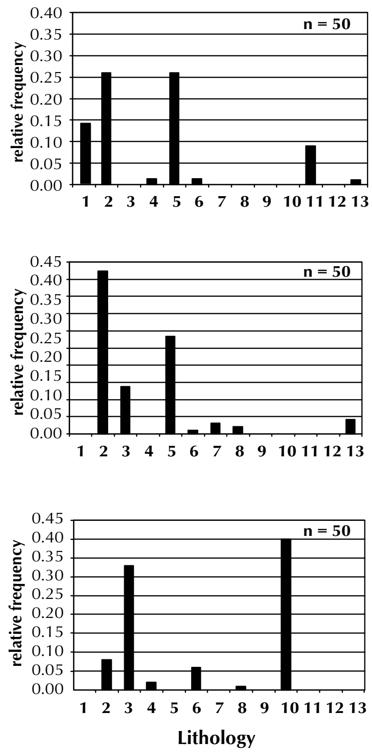
Three categories of gravel lithologies are found within the high terraces along Indian River. These are called types 1, 2 and 3 for convenience (Fig. 5). Type 1 gravels are derived predominantly from the northern tributaries of Indian River. Pebble and coarser clasts consist of milky quartz, metaquartzite, mica schist, and lesser amounts of gneiss. Type 2 gravel reflects contribution of southern tributaries that are underlain by the Carmacks Group (Lowey and Hills, 1986; Lowey et al., 1986) to Indian River. The dominant lithologies in type 2 gravels include light- and dark-coloured quartzite with green and black mica schist. Type 3 contains lithologies that are exotic to the Indian River basin, most notably black chert and black chert-pebble conglomerate most likely derived from the Devono-Mississippian Earn Group in central Yukon. Type 3 was deposited as a valley train (outwash), by torrents from a Cordilleran ice sheet that crossed the divides between the Stewart River basin and Indian River (Bostock, 1942, 1966; Duk-Rodkin, 1999).

HIGH-LEVEL TERRACE STRATIGRAPHY

Three stratigraphic lines (A-A', B-B', C-C') present the stratigraphy of the high-level terraces, moving in a downstream direction (Figs. 2, 6, 7, 8). All elevations (right-hand scale) denote the upper surface of terrace gravel. The left-hand scale indicates section thickness.

Dominion Creek to Montana Creek

Figure 6 (section A-A') depicts the succession of sediments found in exposures along the south side of the Indian River valley between Dominion and Montana creeks. The surface of the highest terraces descends approximately 60 m over about 12 km or at an average gradient of 5 m/km. The gravel directly underlying the surface fines downstream from a pebble gravel at station FN020701-01 to a pebbly coarse sand at station FN020727-01. A borrow pit exposes 25 m of gravel at Station FN020701-04. The gravel contains black chert and chert-pebble conglomerate indicating that it is outwash (type 3). The lowest 2.5 m of the section is horizontally stratified sandy pebble gravel. This is abruptly overlain by about 5 m of massive to cross-laminated sand and slightly pebbly sand (Fig. 4c). The section progressively coarsens upward into interbedded pebbly coarse sand and sandy pebble gravel. A Wounded Moose paleosol (Smith et al., 1986) has developed within the upper 2 m of the section.



Lithology of sample JJF072, typical younger fan gravel derived from north side of the Indian River valley

TYPE 1

Lithology of sample JJF053, typical older fan gravel derived from south side of the Indian River valley

TYPE 3

Lithology of sample JJF057, typical valley train gravel

TYPE 3

LITHOLOGY LEGEND
1. meta-quartzite
2. quartzite (light-coloured)
3. quartzite (dark-coloured)
4. milky quartz
5. mica schist (green and black)
6. schist
7. intermediate volcanic rocks
8. mafic volcanic rocks
9. jasper/coloured chert
10. black chert
11. gneiss
12. granitoid
13. unknown/weathered

Figure 5. *Pebble lithologies of selected gravel samples illustrating differences of gravels derived from the north and south sides of the Indian River valley and valley train gravel.*

A thick sequence of fine sand also occurs in a smaller exposure at station FN020722-01 (Fig. 6) located about 480 m to the east. Approximately 9 km further downstream, stations FN020727-01 and FN020727-02 lie in exploration trenches cut into the upper part of a sedimentary fill within an entirely buried reach of the Indian River valley immediately upstream of the present confluence of Montana Creek (Fig. 2). The present anomalous course of Indian River is between bedrock cliffs immediately to the north of the buried preglacial valley. Sections at FN020727-01 and FN020727-02 are predominantly fine sand interbedded with sandy pebble gravel (Fig. 6). They contain several disconformities marked by ice-wedge pseudomorphs. These indicate

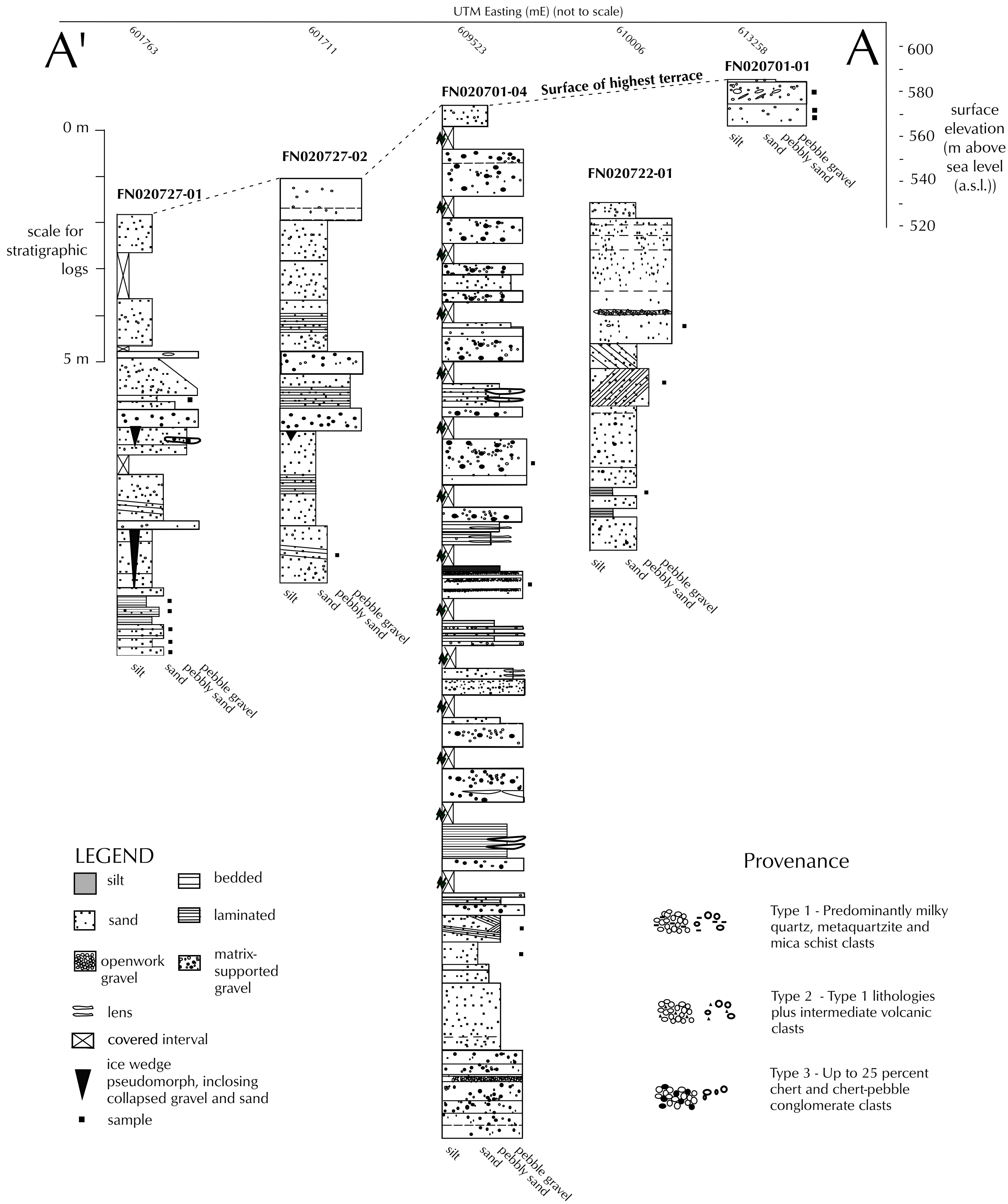


Figure 6. *Stratigraphic line A-A' on high-level terrace between Wounded Moose and Montana creeks. Profile location depicted on Figure 2.*

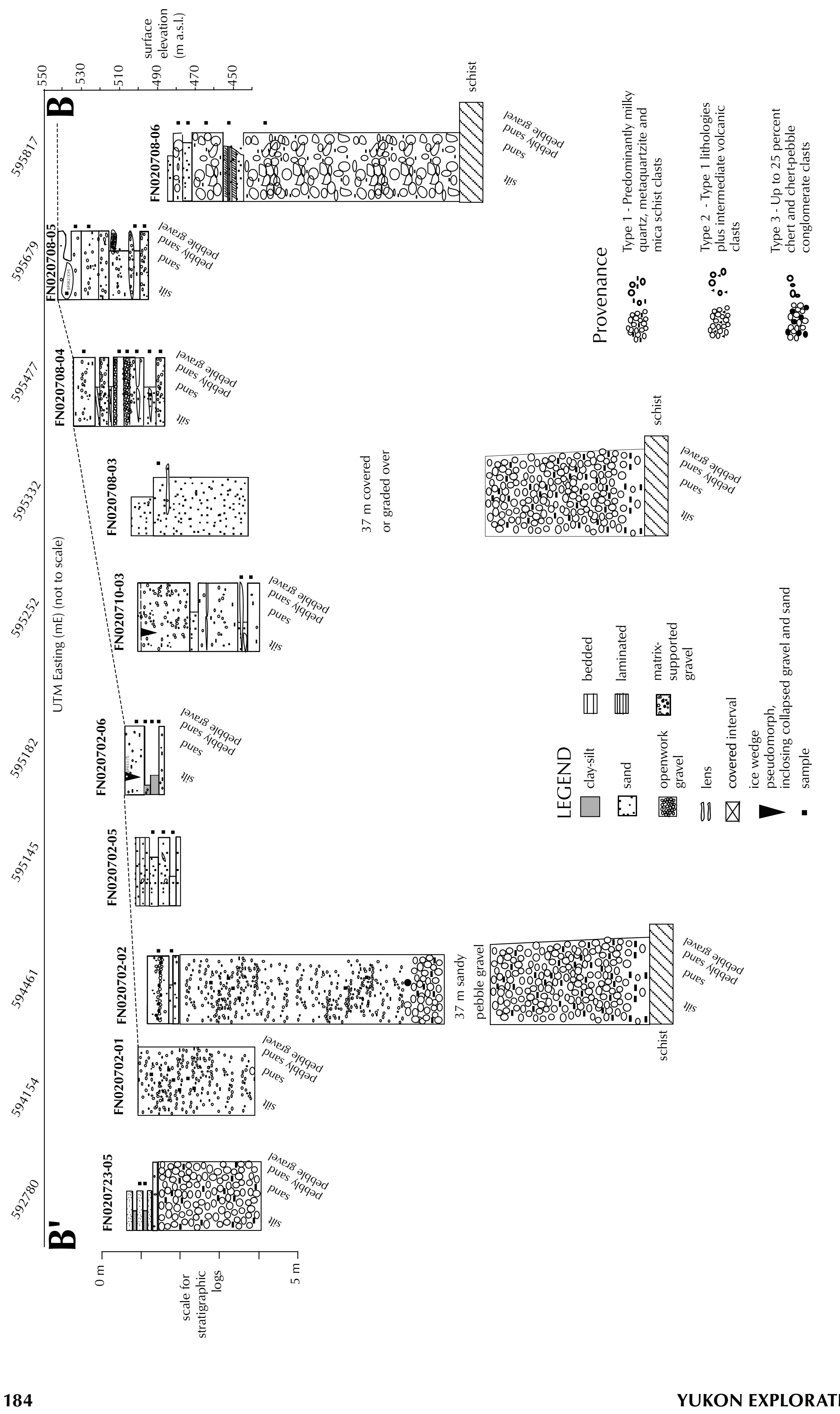


Figure 7. *Stratigraphic line B-B' on high-level terrace upstream of the mouth of Quartz Creek. Gaps in sections are not to scale. Profile location depicted on Figure 2.*

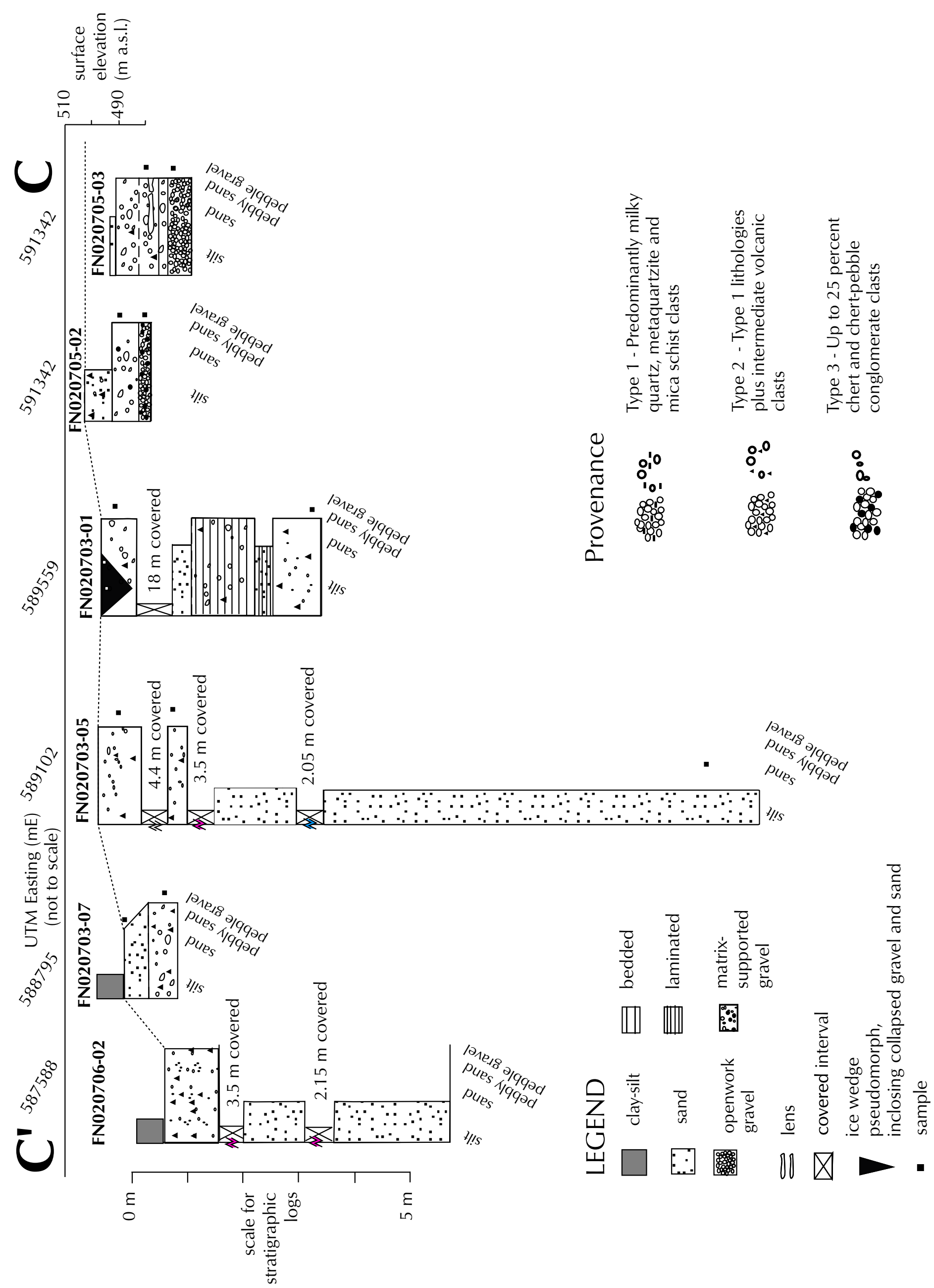


Figure 8. *Stratigraphic line C-C' on high-level terrace between McKinnon and Ruby creeks. Gaps in sections are not to scale. Profile location depicted on Figure 2.*

periods of nondeposition under periglacial conditions during which the sandy fill was exposed and then buried when deposition of the valley fill resumed. The fill is part of the Indian River valley train because black chert sand and pebble clasts occur throughout the exposure.

High-level terrace stratigraphy immediately upstream from the mouth of Quartz Creek

Section B-B' (Fig. 7) depicts the succession of sediments underlying the terraces upstream of Quartz Creek. These sediments are exposed in roadcuts, exploration trenches and natural cliffs discontinuously extending 3 km upstream from the mouth of Quartz Creek along the north side of the Indian River valley. At sections FN020702-02, FN020710-03 and FN020708-06, type 1 sandy cobble-pebble gravel (Fig. 4c) overlies bedrock and fines upwards. At section FN020702-02, the most complete section, gravel grades upward into a type 3 chert-bearing gravel approximately 6 m below the top of the exposure. The succession at FN020702-02 is identical to the well known upward succession of White Channel Gravel and Klondike Gravel in the area of the confluence of Bonanza Creek and Klondike River (e.g., Froese et al., 2000, their Fig. 7) and is apparently the same age. The gravels at both locations reflect the incursion of the most extensive pre-Reid Cordilleran ice sheet into the region (Fig. 1). Type 3 gravel is commonly cut by ice-wedge pseudomorphs. The gravel grades laterally into sand and pebbly sand in and around section FN020702-02 (Fig. 4e), indicating a change from gravelly flood plain or alluvial fan to low- energy conditions during the culmination of the sedimentary fill. Section FN020723-05 is situated along lower Quartz Creek at the top of the White Channel Gravel that fills the bottom of this valley. It lies upstream from the influence of the valley train gravel. A cut created by an exploration cat trail indicates that the White Channel Gravel grades upward into interbedded fine laminated sand and silt. It lies at about the same altitude as FN020708-03 and may represent the same low-energy environment that influenced sedimentation along the lower part of Quartz Creek valley.

High-level terrace stratigraphy immediately between Quartz Creek and Ruby Creek

Cross section C-C' (Fig. 8) depicts the succession of sediments underlying terraces between Quartz and Ruby creeks. These sediments are exposed in roadcuts, exploration trenches along terraces and the sides of intervening valleys along the north side of the Indian River valley between Quartz and Ruby creeks. Chert-bearing type 3 gravel is present along the surfaces of all terraces. Where undisturbed, the upper 2 m of sediment underlying the terraces commonly contain Wounded Moose paleosols, which are cut by ice-wedge pseudomorphs up to several metres in width and over 2 m in depth. Plentiful volcanic clasts also occur in this gravel, reflecting stream transport of sediment from the uplands to the south. No sections provide a complete exposure of stratigraphy from bedrock to terrace surface along this reach of the Indian River valley. However, discontinuous exposures and hand-auger probing of deposits indicate that two distinct successions of sediments underlie the terrace. The first succession type is represented by section FN020703-01. It is a composite of trench and road-cut exposures along an exploration road that descends northward to the Indian River from a high terrace. It is capped by type 3 gravel but is underlain at depth by bedded type 2 sandy pebble gravel and pebbly sand. The second succession type consists of thinly bedded or laminated to featureless silty fine sand. Sections FN020706-02 and FN020703-05 typify this succession. They are constructed from exploration trenches and hand augering of intervening slopes, which best represent this sand that can be traced along the 2 km separating these sections. This sand coarsens upward into the overlying type 3 gravel or type 2 gravel derived from uplands to the south. The sand contains scattered chert clasts. The chert-free gravelly sediments of FN020703-01 (lower interval) apparently grade laterally into or underlie the sands of FN020706-02 and FN020703-05. The lower FN020703-01 chert-free gravel is thought to be fan sediments that were built into the Indian River valley prior to, or during, the deposition of the chert-bearing sand in FN020706-02 and FN020703-05. The lower FN020703-01 chert-free gravel lies at the same elevation as similar gravel across the Indian River valley (cross section C-C') and is correlated to the White Channel Gravel.

POTENTIAL BURIED PLACERS AND DEPOSITIONAL RECONSTRUCTION

Schematic reconstructions of stratigraphy and depositional events are presented in Figs. 3 and 9. Placer gold environments, both known and potential, are noted on the reconstructions. The general scenario follows that of previous workers (Bostock, 1942, 1966; Lowey, 1999) whereby valley train gravel from the Stewart River basin covered gold-bearing braided stream floodplain gravel.

The chronology assumes equivalence of type 1 and type 2 gravels to White Channel Gravels where they overlie bedrock (e.g., base of sections FN020702-02 and FN020708-06, Fig. 7). The White Channel Gravel has been constrained in age in the Quartz Creek basin by dating of the overlying Quartz Creek tephra at about 3 Ma (Westgate and Froese, 2001; Westgate et al., 2003). The age of the deposition of the outwash gravel is assumed to be the same age as Klondike Gravel in the Dawson City area, which was deposited during the most extensive, and apparently, first regional (pre-Reid) glaciation, which has been assigned to the Late Pliocene (Westgate et al., 2001). The Wounded Moose paleosols in the upper part of the terraces indicate a minimum Early Pleistocene age.

Valley train gravel and sand units buried the White Channel Gravel in many locations. It also raised the local base level in Dominion, Eureka and Quartz creeks (Milner, 1977). There is a high potential for buried gold placers at the base of the extensive fill within the pre-glacial Indian River valley, between the present course of Indian River and Montana Creek (Fig. 9). Here, the fill of White Channel Gravel and overlying outwash diverted Indian River to the north side of a bedrock knob, where a new valley was cut by subsequent river incision. Although the placer gold content of the fill remains to be evaluated, it is thought to be of high potential for placer gold considering its location immediately downstream from known producing tributaries, Eureka and Dominion creeks. A younger analogue is the buried auriferous Middle Pleistocene Ross gravel along lower Dominion Creek (Froese et al., 2001).

MECHANISMS OF LAKE FORMATION

As noted above, sand makes up much of the fill underlying terraces along the Indian River valley. The overall gradient of the surface of the terrace fill between Dominion and Eureka creeks is approximately 3.5 m/km. This is about twice the gradient of the floodplain of the contemporary Indian River. In order to deposit the extensive sand fills, the valley gradient had to have been much gentler. We suggest, on the basis of the thinly bedded sand and silty sand that makes up much of the fill, that sedimentation occurred, at least partly, in a lake. We present two hypotheses for the origin of a lake or lakes in the Indian River valley. Neither of these can be fully tested or rejected based upon the evidence at hand due to the paucity of continuous exposures.

HYPOTHESIS A: SAND AGGRADED TO STANDS OF GLACIAL LAKE YUKON

Glacial Lake Yukon (GLY) is the name given to a lake inferred to have formed when a pre-Reid ice sheet blocked the paleo Yukon River drainage (Duk-Rodkin, 1999; Fig. 1). Spillage of ancestral Yukon drainage into Alaska resulted in the creation of the contemporary Yukon River drainage (Duk-Rodkin et al., 2001). We propose that the extensive sand units in the Indian River valley may have been deposited in an arm of GLY that extended up the valley to near the mouth of Dominion Creek. The sedimentary sequences seen within the sections described above are consistent with predictable attributes of sediments deposited into the arm of a large, rapidly formed and distantly glacially dammed lake (e.g., Smith and Ashley, 1985):

1. Where fluvial and glaciofluvial streams entered this lake, rapid facies changes from gravel to sand would be expected (e.g., FN020701-04, Fig. 6).
2. Such facies changes would be expected where a valley train suddenly becomes inundated by a rising lake. This would be succeeded by a coarsening-up sequence as coarser sediments prograded into the lake (FN020701-04, Fig. 6).
3. As glacially dammed lakes are unstable and prone to outburst floods and rapid drainage, marginal sedimentary sequences would provide evidence of fluctuations of lake elevation with subaerial exposure occurring between sedimentation intervals (e.g., FN020727-01 and FN020727-02, Fig. 6).
4. Locations distant from the ice dam would be dominated by thick accumulations of very fine sand and silt (e.g., FN020706-02 and FN020703-05, Fig. 8).

The elevation of the GLY spillway is not known. However, if the Indian River fill does prove to have been deposited in GLY, the highest elevations at which thick sand suddenly succeeds gravel, about 530 m, would be a minimum value for the initial elevation of this spillway.

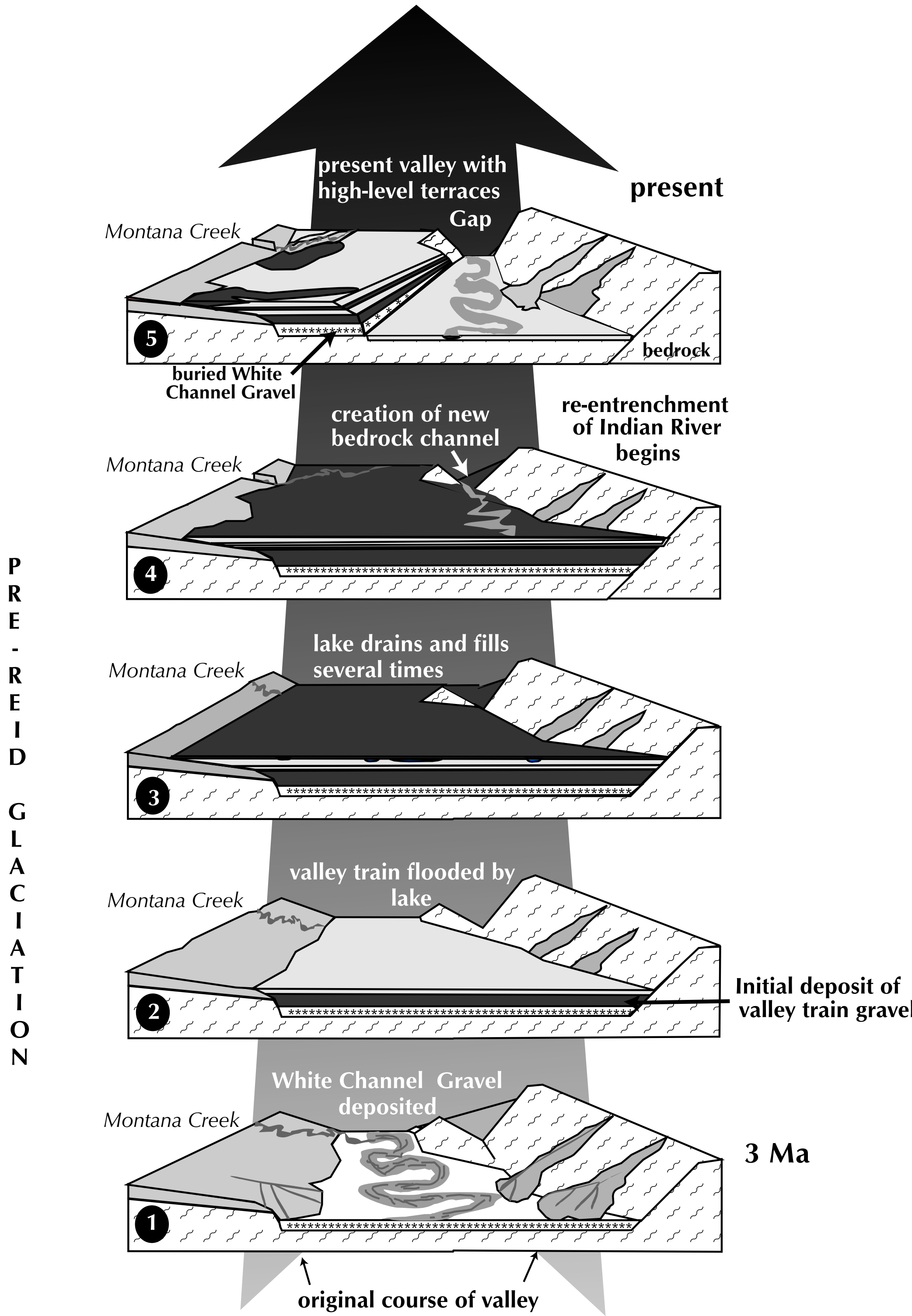


Figure 9. *Conceptual reconstruction of depositional and erosional events in the Indian River valley from about 3 Ma until present (large arrow indicates the direction of time). View downstream from vicinity of mouth of Eureka Creek. Sequence explains the diversion of Indian River through the narrow bedrock gap opposite the mouth of Montana Creek and the likely burial of White Channel Gravel (indicated by small stars) within a buried segment of the preglacial Indian River valley between lower Montana Creek valley and the present course of Indian River. The present Indian River valley represents 2 Ma of incision.*

HYPOTHESIS B: SAND AGGRADED TO TEMPORARY LAKES FORMED BY THE DAMMING OF INDIAN RIVER BY ALLUVIAL FAN GRAVEL OR LANDSLIDE

Alternatively, the intervals of low energy sedimentation could represent a temporarily dammed lake or string of lakes created by the impoundment of ancestral Indian River by alluvial fans or landslides. For example, in the narrow section of the Indian River valley below Ophir Creek (Fig. 2), rapid building of a fan, from one or more tributaries in this area or a landslide, could have lowered the stream gradient in the Quartz Creek area, which explains the deposition of extensive fine sand along the reach spanned by C-C'. Similarly, sands seen in the A-A' and B-B' reaches may have been deposited in lakes impounded by fans built out into the Indian River valley. Although no evidence of such landslides or an alluvial fan has been noted in the Indian River valley, upward of 3 Ma of incision and lateral erosion by Indian River could have erased evidence of such events.

There is no way to presently exclude either the glacially dammed lake or the fan/landslide hypotheses due to the relative paucity, and fragmented nature, of terrace sediment exposures.

CONCLUSIONS

The gravel fill underlying the high terraces along Indian River reflects three sources: schistose terrain to the north of the river (type 1), terrain underlain by extensive volcanic rocks to the south of the river (type 2), and valley train deposits (type 3) containing extensive amounts of black chert and chert-pebble conglomerate external to the basin. The type 1 and 2 gravels, where they overlie buried bedrock straths that mark the floor of ancestral (pre-glacial) Indian River valley, are equivalent in age to White Channel Gravel. The emplacement of the valley train fill likely has preserved these potentially auriferous gravels in a buried portion of the pre-glacial Indian River valley in the area of the confluence of Montana Creek and Indian River. This segment of the pre-glacial course was preserved due to the cutting of a new course to the north by the Indian River following valley train sedimentation.

Extensive bodies of sand occurring within the Indian River valley fill were deposited in one or more lakes. Two hypotheses are proposed to explain the development of the lake or lakes. The first is that an arm of Glacial Lake Yukon, impounded during the most extensive pre-Reid glaciation, extended up the Indian River valley. The second is that one or more alluvial fans or landslides affected the gradient of the valley, forming local lakes or reaches of reduced gradients. Insufficient exposures are present to effectively test these hypotheses.

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