
Yukon Geological Survey

BULLETIN 14

**Placer geology of the Stewart River (115N&O) and
part of the Dawson (116B&C) map areas,
west-central Yukon, Canada**

by
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Cover photo: Shaft timbering exhumed by Schmidt Mining on the Elis Bench on Thistle Creek, a tributary of the Stewart River, in the Yukon.

Preface

A study of the geological setting of placer deposits in the Stewart River and part of the Dawson map areas was carried out from 1998 to 2001 by Grant Lowey, Placer Geologist, Yukon Government. The last comprehensive study of the placer deposits of this area was done by R.G. McConnell nearly one hundred years ago. McConnell's reports described the placers as they existed soon after they were discovered, while this report describes the placer deposits after 100 years of mining.

This area contains several significant placer districts including the world renowned Klondike goldfields, and accounts for more than 85% of the Yukon's total gold production. The study area continues to be mined today, although reserves have been decreasing.

This study characterizes placer deposits in this largely unglaciated region of Yukon, relates the geology of the placer deposits to the regional surficial and bedrock geology, and determines the potential of undiscovered placer deposits in the area. The result is the provision of a comprehensive and up-to-date placer geoscience database for the Stewart River and part of the Dawson map areas. This database should encourage the development of existing placer gold deposits and the exploration for new placers.

The important contribution and support of the local placer miners, prospectors and mining companies to this project is greatly appreciated. We hope that the publication will assist in future exploration, development and mining in the Yukon, and that it will be a valuable information source for other scientists and the interested public.

Préface

Une étude du contexte géologique des placers dans la région cartographique de la rivière Stewart et d'une partie de la région cartographique de Dawson a été réalisée de 1998 à 2001 par Grant Lowey, géologue spécialiste des placers au gouvernement du Yukon. La dernière étude complète des placers de cette région est celle de R.G. McConnell, il y a près de cent ans. Les rapports de McConnell décrivent ces placers tels qu'ils étaient suite à leurs découverte, alors que ce rapport les décrits après 100 ans d'exploitation minière.

Cette région renferme plusieurs districts de placers importants, notamment les champs aurifères du Klondike de renommée mondiale, d'où proviennent plus de 85 % de la production aurifère totale du Yukon. L'exploitation minière se poursuit actuellement dans cette région, malgré la décroissance des réserves.

L'étude caractérise les placers de cette région du Yukon, en grande partie non glaciée, établit des liens entre la géologie des placers et la géologie régionale des formations superficielles et du substratum rocheux, et détermine le potentiel en placers non découverts dans la région. Le fruit de cette étude consiste en une base de données géoscientifiques sur les placers, complète et à jour, pour la région cartographique de la rivière Stewart et d'une partie de la région cartographique de Dawson. Cette base de données devrait stimuler la mise en valeur des placers aurifères existants, ainsi que l'exploration à la recherche de nouveaux placers.

L'importante contribution et l'appui soutenu à ce projet, au niveau local, de la part des mineurs, des prospecteurs et des sociétés d'exploitation des placers sont grandement appréciés. Nous espérons que le document permettra d'appuyer les futures activités d'exploration, de mise en valeur et d'exploitation minière au Yukon et qu'il constituera une source précieuse d'information pour d'autres scientifiques et le public intéressé.

Grant Abbott

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Abstract

Placer gold deposits are widespread throughout the largely unglaciated Stewart River and southern part of the Dawson map areas. These deposits include the world famous Klondike goldfields, the historic Fortymile and Sixty Mile goldfields, and well known placers along Black Hills, Scroggie, Thistle and Kirkman creeks. Although the deposits have been mined for over 100 years and have produced an estimate 311 tonnes of gold, they still account for about 85% of the Yukon's annual placer gold production.

The placer deposits are classified into three levels of gravel with four main units: high-level gravel, which usually forms prominent, continuous high-level terraces and is subdivided into the White Channel Gravel (which is locally subdivided into a lower White Gravel and an upper Yellow Gravel unit) and Klondike Gravel; intermediate-level gravel, which mostly forms relatively small, irregularly distributed intermediate to low-level terraces; and low-level gravel, which represents alluvium along present day creeks, gulches and rivers. The White Channel Gravel, presently the most important gold-bearing unit, is up to 46 m thick and characterized by a predominance of quartz clasts (which are generally more abundant in the White Gravel than in the Yellow Gravel). It is considered Early Pliocene to earliest Late Pliocene in age (~5 to 3 Ma). The Klondike Gravel, not considered an economical placer, is up to 53 m thick and is distinguished by chert clasts derived from the Ogilvie Mountains, located northeast of the map areas. It was deposited as glaciofluvial outwash during the end of the initial and most widespread of the pre-Reid glaciations, and is probably latest Early Pliocene to earliest Late Pliocene (~3 Ma). The intermediate-level gravel, the least important economically, is up to 9 m thick. The low-level gravel, historically the most important gold-bearing unit (it has been mined three or four times), is 5 m thick in creeks and up to 20 m thick in rivers. The intermediate-level and low-level gravel have similar amounts of quartz, igneous rock and metamorphic rock particles, although locally, the low-level gravel contains sedimentary rock particles. The intermediate-level gravel is thought to be Late Pliocene to Early Pleistocene (~3 Ma to 750 Ka) in age and the low-level gravel is considered Late Pleistocene to Holocene in age. Practically all of the placers are fluvial in origin and were deposited primarily in braided streams that flowed parallel to the present day streams along which the deposits occur.

Gold recovered from the various levels of gravel is detrital in origin and was mainly derived from early Mesozoic auriferous quartz veins. The concentration of gold in the gravel is related to a hierarchy of physical scales: at the lithofacies scale (metres), bed roughness determined sites of gold deposition; at the element scale (tens of metres), gravel bars were preferentially enriched in gold; at the reach scale (hundreds of metres), stream gradient was an important factor; at the system scale (hundreds of kilometres), braided river environments transported large amounts of gold; and at the sequence scale (thousands of kilometres), economic placers formed initially in the high-level White Channel Gravel and later in the intermediate- and low-level gravel.

The evolution of the various goldfields was controlled by several external processes: the high-level White Channel Gravel rests unconformably on the White Channel strath, which is interpreted as an erosional 'tectonic' terrace that formed during isostatic uplift and under conditions of dynamic equilibrium; the White Channel Gravel and Klondike Gravel are interpreted as a depositional 'climatic' terrace that formed during a reversal in the tectonically induced downcutting, which is attributed to the initial and most extensive of the pre-Reid glaciations; the intermediate-level gravel is interpreted as minor erosional 'complex response' terraces that formed during static equilibrium when there

Placer geology of the Stewart River and Dawson map areas

were pauses in valley-floor degradation, which are attributed to the subsequent and less extensive pre-Reid glaciations; and the low-level gravel formed also during valley-floor degradation and may represent a return to dynamic equilibrium conditions. Hence, the dominant forcing mechanisms controlling the formation of the placer deposits were isostatically compensated exhumation and climatic change related to the repeated glaciation of the Yukon. In addition, the lowering of base level from high-level, to intermediate-level and finally to low-level gravel was accompanied by a decrease in accommodation space (as indicated by an overall decrease in gravel thickness), which resulted in an increase in the concentration of the placer gold.

A resource appraisal of the map areas, based on a 'deposit model by analogy' approach that considered factors diagnostic for predicting the occurrence of undiscovered placers (such as the presence and type of gravel, the occurrence of auriferous lodes, the presence of known placer gold deposits, and the occurrence of soil and silt geochemical gold anomalies), shows that streams range from 'highly diagnostic' to 'unfavourable' for the occurrence of placer gold deposits. The streams with the highest placer gold potential (i.e., slightly diagnostic), have already been extensively mined: Bonanza, Sulphur and the upper part of Dominion creeks, the lower part of the Indian River, and the upper part of the Sixty Mile River. Other streams with potential are those ranking 'highly suggestive'. This also includes many streams that have been extensively mined: Hunker and Gold Run creeks, the lower part of the Klondike River, Allgold Creek, the upper part of the Indian River, the lower part of Montana Creek, tributaries to the upper part of the Sixty Mile River, the Fortymile River, Maisy May, Thistle, Kirkman and Ten Mile creeks, and the Moosehorn Range area. It also includes several streams that have not been mined: Fifty Mile Creek and the North Ladue River and several of its tributaries. The remaining streams ranked in the map areas range from 'moderately suggestive' to 'slightly suggestive', and although several of these streams have also been extensively mined (i.e., the lower part of Dominion, Black Hills and Scroggie creeks and the upper part of Matson Creek), some have not (i.e., unnamed tributaries of the North Ladue River and unnamed tributaries of the White River). Note that the majority of streams in the map area are unranked because no data was available, hence the probability of occurrence of placer gold for these streams is unknown.

Résumé

Les placers aurifères sont répandus dans l'ensemble de la région cartographique de la rivière Stewart et de la partie sud de la région cartographique de Dawson, régions en grande partie non glaciées. Ces régions renferment les champs aurifères du Klondike, reconnus mondialement, les champs aurifères historiques de Fortymile et de Sixty Mile, ainsi que des placers bien connus le long des ruisseaux Black Hills, Scroggie, Thistle et Kirkman. Bien que l'exploitation de ces gisements dure depuis plus de 100 ans, avec une production estimée de 311 tonnes d'or, de nos jours, ils comptent encore pour environ 85 % de la production annuelle d'or placérien au Yukon.

Les placers sont classés en graviers répartis sur trois niveaux et formant quatre unités principales : des graviers de niveau supérieur, qui forment habituellement des terrasses hautes bien définies et continues et qui se subdivisent en graviers de White Channel (subdivisés par endroits en graviers blancs, dans la partie inférieure, et en une unité de graviers jaunes, dans la partie supérieure) et en graviers du Klondike; des graviers de niveau intermédiaire, qui forment la plupart du temps des terrasses intermédiaires à inférieures, réparties de manière irrégulière; et des graviers de niveau inférieur, qui sont des alluvions le long de ruisseaux, de ravins et de cours d'eau contemporains. Les graviers de White Channel, formant actuellement l'unité aurifère la plus importante, ont une épaisseur de 46 m et sont caractérisés par une prédominance de clastes de quartz (généralement plus abondants dans les graviers blancs que dans les graviers jaunes). On estime que la formation des graviers se situerait entre le Pliocène précoce et le Pliocène tardif initial (~5 à 3 Ma). Les graviers du Klondike, qui ne sont pas considérés comme renfermant des placers rentables, font jusqu'à 53 m d'épaisseur et se distinguent par la présence de clastes de chert dérivés des monts Ogilvie, situés au nord-est des régions cartographiques. Ces graviers se sont déposés sous forme de dépôts d'épandage fluvioglaciaire vers la fin des glaciations pré-Reid initiales, qui sont les plus répandues, et datent probablement du Pliocène précoce terminal au Pliocène tardif initial (~3 Ma). Les graviers de niveau intermédiaire, dont la valeur économique est la moins importante, font jusqu'à 9 m d'épaisseur. Les graviers de niveau inférieur, l'unité aurifère la plus importante d'un point de vue historique (ils ont été exploités trois ou quatre fois), ont une épaisseur de 5 m le long des ruisseaux et de plus de 20 m le long des cours d'eau plus importants. Les graviers des niveaux intermédiaire et inférieur renferment des quantités similaires de particules de quartz, de roches ignées et de roches métamorphiques, bien que les graviers de niveau inférieur contiennent par endroits des particules de roches sédimentaires. On estime que les graviers de niveau intermédiaire datent du Pliocène tardif au Pléistocène précoce (~3 Ma à 750 Ka), alors que les graviers de niveau inférieur dateraient du Pléistocène tardif à l'Holocène. À toutes fins pratiques, tous les placers sont d'origine fluviatile et se sont principalement déposés dans des cours d'eau anastomosés qui s'écoulaient parallèlement aux cours d'eau contemporains, le long desquels se trouvent les gisements.

L'or extrait des divers niveaux de graviers est d'origine détritique et dérive principalement de filons aurifères de quartz, datant du Mésozoïque précoce. La concentration en or dans les graviers est liée à une hiérarchie d'échelles physiques : à l'échelle du lithofaciès (en mètres), la rugosité des lits a déterminé les lieux de sédimentation de l'or; à l'échelle des éléments (en dizaines de mètres), un enrichissement préférentiel s'est produit dans les bancs de gravier; à l'échelle du tronçon de cours d'eau (en centaines de mètres), la pente des cours d'eau constituait un facteur important; à l'échelle des réseaux hydrographiques (en centaines de kilomètres), dans des milieux de cours d'eau anastomosés, de grandes quantités d'or étaient transportées; et, à l'échelle des séquences (en milliers de kilomètres), des placers rentables se sont initialement formés dans les graviers de White Channel de niveau supérieur et, plus tard, dans les graviers des niveaux intermédiaire et inférieur.

L'évolution des divers champs aurifères a été influencée par plusieurs processus externes : les graviers de White Channel de niveau supérieur reposent en discordance sur la terrasse rocheuse de White Channel, qu'on interprète comme une terrasse « tectonique » formée par érosion pendant un relèvement isostatique et dans des conditions d'équilibre dynamique; selon l'interprétation, les graviers de White Channel et les graviers du Klondike constituent une terrasse climatique sédimentaire, formée au cours d'une inversion de l'érosion verticale due au soulèvement tectonique, érosion attribuable aux glaciations pré-Reid initiales qui sont aussi les plus étendues; les graviers de niveau intermédiaire sont interprétés comme constituant des terrasses mineures de « réponse complexe », formées par érosion en période d'équilibre statique, alors que l'érosion du fond de la vallée connaissait des interruptions attribuables aux glaciations pré-Reid subséquentes moins étendues; et les graviers de niveau inférieur, qui se sont également déposés durant l'érosion du fond de la vallée, pourraient indiquer un retour des conditions d'équilibre dynamique. Ainsi, les forces prédominantes qui ont agi sur la formation des placers ont été l'exhumation par compensation isostatique et les changements climatiques liés aux glaciations répétées au Yukon. En outre, l'abaissement du niveau de base des graviers, depuis le niveau supérieur au niveau intermédiaire et finalement au niveau inférieur, combiné à une diminution de l'espace disponible (comme l'indique une diminution globale de l'épaisseur des graviers), ont résulté en une augmentation de la concentration en or placérien.

Une évaluation des ressources dans les régions cartographiques, basée sur une approche de type « modèle de sédimentation par analogie » qui tenait compte de facteurs diagnostiques permettant de prévoir la présence de placers non découverts (comme la présence et le type de graviers, la présence d'or filonien, de placers aurifères connus et d'anomalies géochimiques aurifères dans le sol et dans des silts), indique que les cours d'eau se classent de « hautement propices » à « non favorables » quant à la présence de placers aurifères. Les cours d'eau qui présentent le plus grand potentiel en or placérien (c.-à-d. faiblement propices), ont déjà fait l'objet d'une exploitation intense : les ruisseaux Bonanza et Sulphur et le cours supérieur du ruisseau Dominion, le cours inférieur de la rivière Indian, ainsi que le cours supérieur de la rivière Sixty Mile. D'autres cours d'eau prometteurs se classent comme « hautement prometteurs ». Cette classe comprend également de nombreux cours d'eau qui ont été en grande partie exploités : les ruisseaux Hunker et Gold Run, le cours inférieur de la rivière Klondike, le ruisseau Allgold, le cours supérieur de la rivière Indian, le cours inférieur du ruisseau Montana, les affluents du cours supérieur de la rivière Sixty Mile, la rivière Fortymile, les ruisseaux Maisy May, Thistle, Kirkman et Ten Mile, ainsi que la région de la chaîne des monts Moosehorn. Elle comprend, en outre, plusieurs cours d'eau qui n'ont pas encore été exploités : le ruisseau Fifty Mile et la rivière Ladue Nord, ainsi que plusieurs de ses affluents. Le reste des cours d'eau classés dans les régions cartographiques se rangent dans les classes de « moyennement prometteurs » à « faiblement prometteurs » et, bien que plusieurs de ces cours d'eau aient été intensément exploités (c.-à-d. le cours inférieur des ruisseaux Dominion, Black Hills, Scroggie, ainsi que le cours supérieur du ruisseau Matson), certains ne l'ont jamais été (c.-à-d. les affluents non nommés de la rivière Ladue Nord et de la rivière White). Il faut remarquer que la majorité des cours d'eau dans les régions cartographiques ne sont pas classés en raison de l'absence de données, de sorte qu'on ignore les probabilités de présence d'or placérien dans ces cours d'eau.

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INTRODUCTION

SCOPE OF STUDY

Placer gold deposits are widespread throughout the Stewart River and southern part of the Dawson map areas, herein referred to as the ‘study area’ (and placer gold is the only mineral of economic importance to have been found, although there are rumours that platinum and diamonds have been recovered from several placers). These deposits include the world famous Klondike goldfields (Bonanza, Hunker, Eldorado, Dominion, Gold Run, Sulphur and Quartz creeks), the historic Fortymile River and Sixty Mile River goldfields (Little Gold, Glacier, Miller, Bedrock and Matson creeks), and well known placers along Black Hills, Scroggie, Barker and Kirkman creeks. Approximately 435 812 kg (14,011,702 ounces) of gold (or about 85% of the Yukon’s placer gold production) were produced from these deposits in 1986–2003 (W.P. LeBarge, pers. comm., 2004), making this area the most important historic and present placer gold producing region in the Yukon. Despite nearly continuous mining for over 100 years, these deposits continue to yield thousands of ounces of gold per year, and placer mining remains a major industry in Yukon’s economy. However, placer reserves are declining (Van Kalsbeek, 1998), and given the historic and economic importance of the study area, there is a need for a comprehensive and up-to-date description of the placer deposits.

The main purpose of this study is to describe and document the geology (i.e., deposit thickness, composition, texture, sedimentary structures, gold content and age) of known placer deposits throughout the study area. Other purposes of the project are to interpret the formation of the placer deposits, to relate the geology of the placer deposits to the regional surficial and bedrock geology, and to determine the potential for undiscovered placer deposits in the area. The objective of the study is to aid in the mining and exploration of placer deposits in the study area by providing a comprehensive and up-to-date placer geoscience database. A study was completed for the Mayo area by W.P. LeBarge et al. (2002)

The study is based on 195 visits to active and abandoned placer mines during 1998–2001 (Appendix 1 and Map 1 (in pocket)). Fieldwork consisted mainly of placer deposit mapping, which involved constructing panel diagrams or profiles of two-dimensional exposures of placer deposits (mostly the pit walls of placer mining operations) according to the method outlined by Miall

(1996). These panel diagrams are essentially ‘vertical geologic maps’ and they are constructed in much the same way: beginning with a base map (a line drawing or photo-mosaic of the pit wall), foot traverses are made across the profile, sedimentologic and stratigraphic observations and measurements are recorded on the base map, and sedimentary structures or contacts are ‘walked-out’. A three-page field report form (i.e., a station location page, a stratigraphic-sedimentologic section page, and a panel diagram page; Figure 1) was designed to record these observations. Sections and profiles were tentatively correlated by lithocorrelation (cf., Schoch, 1989), which was confirmed by chronocorrelation if radiometric age dates were available. The Cenozoic time scale in Williams et al. (1993) was used (Table 1).

During fieldwork, representative samples were collected for analysis of particle size, particle shape, particle composition, heavy mineral contents and radiocarbon dates. Particle size analysis (Appendix 2) followed the method of Folk (1974) and utilized the classification of Blair and McPherson (1999). Particle shape (i.e., roundness and sphericity; Appendix 3)

Table 1. Cenozoic time scale (from Williams et al., 1993).

Quaternary	0	Holocene
	10 Ka	----- Upper Pleistocene
	125 Ka	----- Middle Pleistocene
	750 Ka	----- Lower Pleistocene
Tertiary	1.8 Ma	Pliocene
	5 Ma	----- Miocene
	22.5 Ma	----- Oligocene
	38 Ma	----- Eocene
	54 Ma	----- Paleocene
	65 Ma	

was determined by comparing approximately 200 to 250 particles that were pebble-size or larger to the comparison chart of Powers (1989); particle composition (Appendix 4) was determined by identifying the rock type of approximately 200 to 250 particles that were pebble-size and larger. Heavy minerals (Appendix 5) were collected from panned-concentrates and made into grain mounts and thin sections, which were then examined microscopically following standard petrographic techniques. The radiocarbon dating (Appendix 6) was performed by Beta Analytical Inc. and Geochron Laboratories.

The first part of this report discusses the geologic setting and general stratigraphy, sedimentology, and origin and evolution of placers in the study area. This is followed by descriptions of the placer deposits according to drainage areas (i.e., Klondike River, Appendix 7; Indian River, Appendix 8; Sixty Mile River-Fortymile River, Appendix 9; Stewart River-Yukon River, Appendix 10; Ladue River, Appendix 11; and miscellaneous other areas,

Appendix 12). Finally, the resource appraisal analysis and results are explained. Some of the data presented in this report have been published elsewhere (i.e., Lowey, 1998, 1999a,b, 2000, 2001a,b,c,d, 2002) and some of the data have been entered into the Yukon Placer Database (LeBarge, 2002).

LOCATION AND ACCESS

The study area includes the entire Stewart River map area (115N&O) and the southern part of the Dawson map area (116C&B), between 63° and 64°30' N, and 138° and 141° W in west-central Yukon (Fig. 2; Map 1). It covers an area of approximately 25 384 km², or 36 1:50 000-scale topographic maps. Almost all of the placers lie within the Dawson Mining District; the exception is the Moosehorn Range area, which lies within the Whitehorse Mining District. As mentioned previously, placer mining areas are arranged into five drainage basins: (1) the Klondike River drainage, representing most of the Klondike goldfields, includes Bonanza, Eldorado, Hunker, Bear and Flat

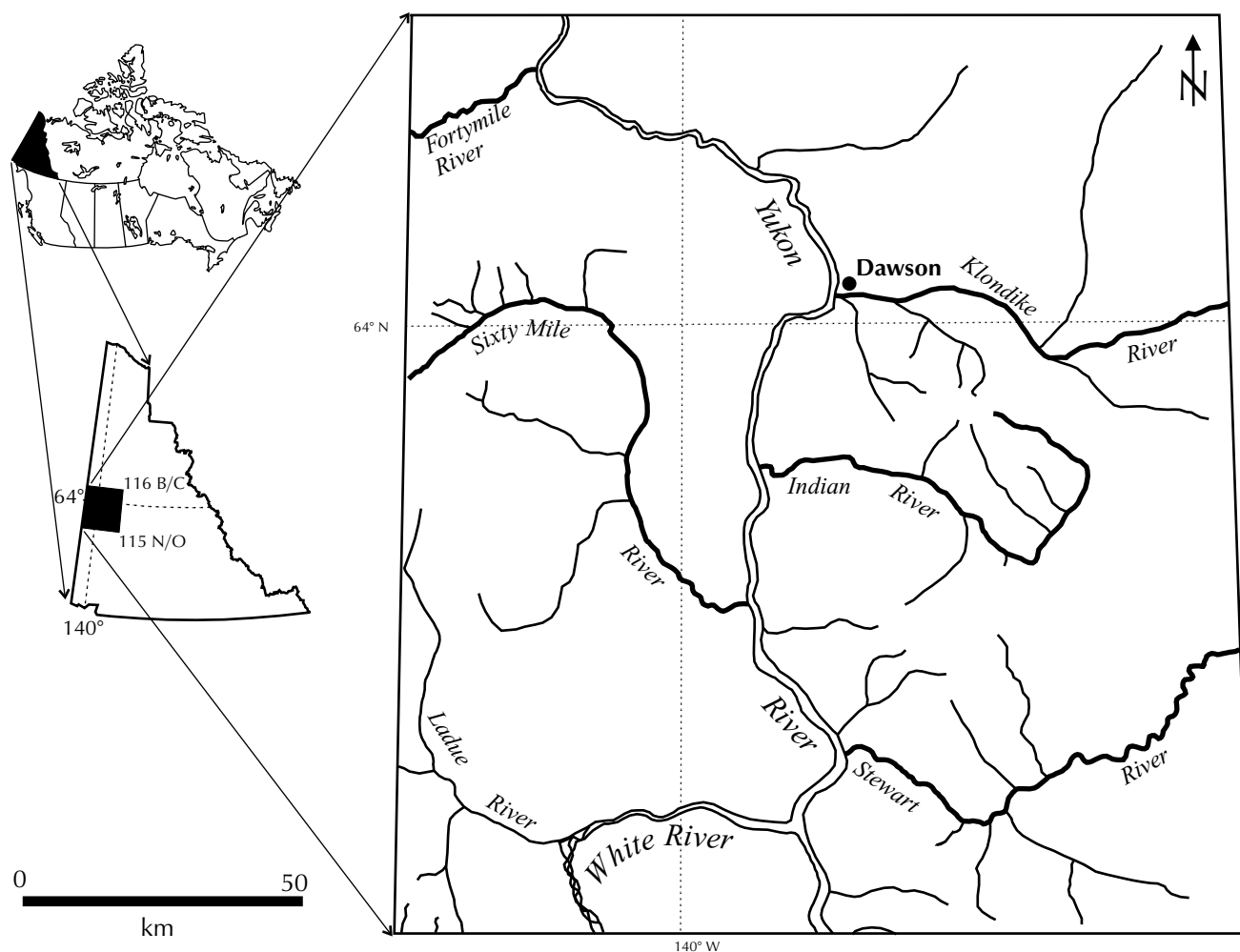


Figure 2. Location map of the study area, Stewart River (115N,O) and part of the Dawson (116B,C) map areas.

creeks and their tributaries; (2) the Indian River drainage, representing the remainder of the Klondike goldfields, includes Dominion, Sulphur, Eureka and Montana creeks and their tributaries; (3) the Sixtymile River drainage includes Miller, Glacier, Little Gold, Fiftymile, Matson and Ten Mile creeks (also included in the description of the Sixtymile River drainage is the Forty Mile River area); (4) the Stewart River-Yukon River drainages includes Excelsior, Henderson, Maisy May, Black Hills, Scroggie, Barker, Frisco, Thistle and Kirkman creeks; and (5) the Ladue River drainage includes the Moosehorn Range area.

Many of these placer mining areas are accessible by road from Dawson City, which is the main settlement in the area and is located at the terminus of the Klondike Highway. The Klondike goldfields are serviced by the Hunker Creek, Bonanza Creek, Upper Bonanza Creek, Dominion Creek, Sulphur Creek, Quartz Creek and Indian River roads. The Sixty Mile River and Fortymile River goldfields are serviced by the Top of the World Highway and the Sixty Mile River and Clinton Creeks roads. Matson Creek placers are serviced by the Matson Creek road (via the Sixty Mile River road). Placers along Eureka, Blackhills, Maisy May and Henderson creeks are serviced by the Eureka Creek, Blackhills Creek, Maisy May Creek and Henderson Creek roads via the Dominion Creek and Sulphur Creek roads. Placers along Thistle and Kirkman creeks are accessible by boat via the Yukon River, and placers along Scroggie Creek are accessible by boat via the Stewart River. The Moosehorn Range placers can be reached by helicopter or fixed wing aircraft, and most of the placer mining districts have private airstrips.

MINING HISTORY

'Traces' of placer gold were found by Robert Campbell, trader for the Hudson's Bay Company, on the upper Stewart River as early as 1848, and prospector Arthur Harper claims to have found gold on the lower part of the Fortymile River in 1875, but prospectors did not begin to actively explore the Stewart River and Dawson map-areas until 1881, when a party of men travelled approximately 280 km up the Stewart River (Gates, 1994). About 50 prospectors explored the Sixty Mile River area in 1882 and the Fortymile River area in 1883, and 75 prospectors returned to the upper Stewart River area in 1884 (Gates, 1994). Although 'rich' gold was finally discovered in 1885 on gravel bars approximately 125 km up the Stewart River (i.e., Chapman's Bar and Steamboat Bar), the gold was fine grained and the prospectors restricted their mining to the active river bars (Gates, 1994).

The first coarse-grained gold – and the first placer gold recovered near the bottom of creek gravel – was discovered at Franklin Gulch on the Fortymile River in 1886 (Gates, 1994; Wright, 1976). This resulted in several 'stampedes' to the Fortymile River area, the establishment of a settlement at the mouth of the Fortymile River, and approximately 1000 prospectors/miners exploring the Yukon River basin by 1887 (Gates, 1994, Wright, 1976). In 1891, placer gold was discovered on Big Gold Creek and gold in 'paying quantities' was discovered on Miller Creek, both tributaries of the Sixty Mile River (Coutts, 1980; Gates, 1994). By 1894, gold was discovered on Glacier Creek, located between Miller and Big Gold creeks, and Miller Creek was regarded as the richest and most productive creek in the Yukon (Gates, 1994).

Also in 1894, the first gold discovered in the Klondike goldfields was found by William Redford on Quartz Creek, a tributary of the Indian River (Gates, 1994). In April, 1896, Robert Henderson discovered gold on Gold Bottom Creek, a tributary of Hunker Creek, and then in August of the same year, George Carmack, Skookum Jim and Tagish Charlie made their discovery of gold on Bonanza Creek (originally named Rabbit Creek) that resulted in the Klondike Gold Rush (Coutts, 1980; Gates, 1994). The discovery of gold on Hunker Creek is attributed to Andrew Hunker in September, 1896 (Coutts, 1980). By 1897, gold was discovered on Allgold Creek, a tributary of Flat Creek (which is a tributary of the Klondike River); Mint Gulch and Hester Creek, tributaries of Hunker Creek; Little Blanche Creek, a tributary of Quartz Creek; Dominion, Sulphur, Eureka, Montana and Ophir creeks, tributaries of the Indian River; Henderson Creek, a tributary of the Stewart River; and Frisco Creek, a tributary of the Yukon River (Coutts, 1980). Finally, in 1898, gold was discovered on Black Hills and Scroggie creeks, tributaries of the Stewart River; and Excelsior, Thistle, and Kirkman creeks, tributaries of the Yukon River (Coutts, 1980). The next important discovery of placer gold was not until 1974, when Mike Kenyon of Claymore Resources found 'abundant, easy-to-pan' coarse gold on the west side of the Moosehorn Range (Morin, 1977), just south of the study area.

PREVIOUS WORK

Placer gold deposits in the Klondike River and Indian River drainages were first described by McConnell (1905a,b, 1907), and his reports provide the most comprehensive and historic description of the deposits. Other descriptions of various aspects of these deposits can be found in Tyrrell (1907, 1912, distribution of gold), Mustart (1956, gold characteristics), Ray (1962, heavy minerals), Gleeson (1970, heavy minerals), Milner (1976, geomorphology), Naldrett (1981, stratigraphy and sedimentology), Tempelman-Kluit (1982, alteration), Morison (1985, sedimentology), Dufresene (1987, alteration), Knight et al. (1994, 1999, gold characteristics), Christie (1996, distribution of gold), Froese (1997, surficial geology and paleomagnetism), Lowey (1998, 1999a,b, 2001a,b,c,d, 2002, sedimentology and placer formation), and Preece et al. (2000), Westgate et al. (2000), Froese et al. (2001), Sandhu et al. (2001) and Westgate et al. (2003, tephrochronology and paleomagnetism). Placer deposits in the Sixty Mile River drainage were first described by Cockfield (1921), and his report also provides

the most comprehensive and historic description of these deposits. Other descriptions of various aspects of the deposits can be found in Glasmacher (1984, origin of gold), Hughes (1986, geomorphology and sedimentology), Hughes et al. (1986, geomorphology and sedimentology), and Lowey (2000, sedimentology and placer formation). Cobb (1973) and Yeend (1996) provide additional descriptions of placers on the 'American side' of the Fortymile River area. Placer deposits in the Stewart River-Yukon River drainages were first described by Cairnes (1917), and his report provides the most comprehensive, historic description of these deposits. Other descriptions of various aspects of these deposits can be found in Fuller (1994a, 1995a, geomorphology), Fuller and Anderson (1993, geomorphology), and Jackson and Huscroft (2000), Jackson (2001), Huscroft et al. (2001), Jackson et al. (2002), and Rotheisler et al. (2003, surficial geology). Descriptions of placer deposits in the Ladue River drainage, particularly the Moosehorn Range area, can be found in Morin (1977).

GEOLOGIC SETTING

BEDROCK GEOLOGY

Regional scale (1: 250 000 scale) bedrock mapping of the Stewart River map area was done by Cockfield (1921), Bostock (1942) and Tempelman-Kluit (1974), and the Dawson map area was done by Green (1972). More detailed (1:50 000 scale) mapping was completed by Debicki (1984, 1985), Lowey (1984, 1985) and Mortensen (1996). Recently, Ryan and Gordey (2001, 2002) and Ryan et al. (2003) began updating the detailed mapping in the Stewart River map area as part of the Ancient Pacific Margin NATMAP (National Mapping Program) Project.

The Tintina Fault (Fig. 3; also shown as Tintina Trench on Map 1 and Map 2, in pocket), a major right-lateral strike-slip fault along which approximately 450 km of displacement occurred since the mid-Cretaceous (Gabrielse, 1985), transects the northeast corner of the study area, dividing it into two distinct geologic (and

physiographic) regions. The area southwest of Tintina Fault is mainly underlain by medium- to high-grade, polydeformed Paleozoic metasedimentary (i.e., Klondike Assemblage and Nasina Assemblage) and meta-igneous rocks belonging to the Yukon-Tanana Terrane (Plate 1a), and minor amounts of altered ultramafic rocks that are assigned to the Slide Mountain Terrane (Mortensen, 1990, 1996). The Klondike and Nasina assemblages consist mainly of quartz-chlorite schist, quartz-muscovite schist, micaceous quartzite, graphitic quartzite, quartz-feldspar-augen schist, amphibolite and orthogneiss; Slide Mountain Terrane consists mostly of greenstone and serpentinite (Debicki, 1985; Mortensen, 1990; Tempelman-Kluit, 1974). According to Mortensen (1996), these two pre-accretionary terranes were juxtaposed by regional-scale thrust faulting in Early Mesozoic time, and unconformably overlain by post-accretionary sedimentary

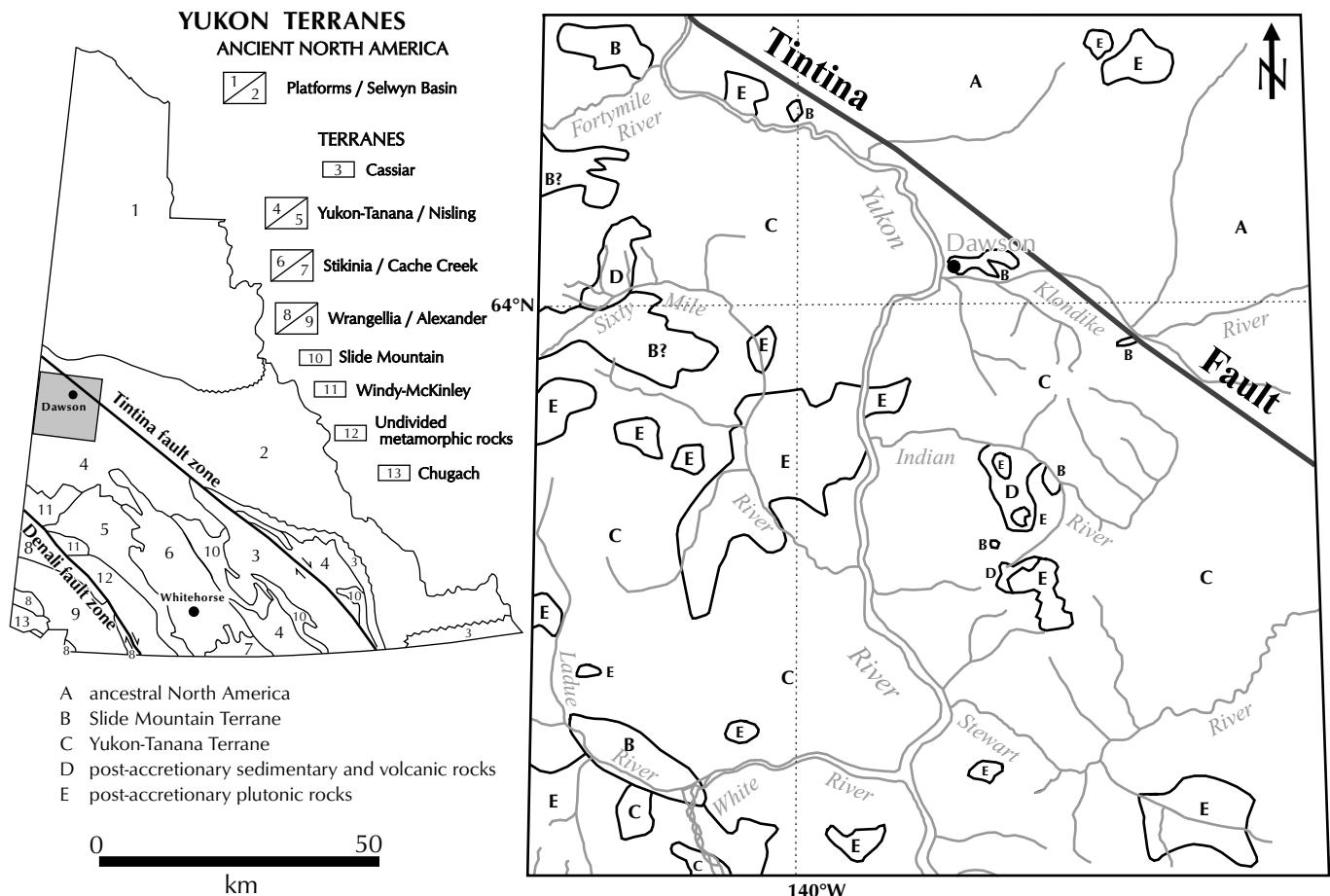


Figure 3. General bedrock geology map of the study area (modified from Green, 1972; Tempelman-Kluit, 1974; and Mortensen, 1990).

and volcanic rocks during mid- to Late Cretaceous time. The sedimentary rocks, consisting mainly of sandstone, shale and conglomerate, were assigned, in part, to the Tantalus Formation by Lowey and Hills (1988); and Lowey et al. (1986) assigned the volcanic rocks, in part, to the Carmacks Group. The area northeast of the Tintina Fault is mainly underlain by Paleozoic sedimentary rocks (i.e., chert, sandstone, mudstone, limestone and conglomerate) ancestral to North America.

LODE DEPOSITS

There are over 60 occurrences and prospects of lode gold throughout the study area (Map 2, in pocket), and almost all of these are vein deposits (Yukon MINFILE, 2003). Gold-bearing quartz veins in the Klondike River and Indian River drainage basins, which are thought to be the main source of gold for the Klondike goldfields (McConnell, 1905b, 1907; Knight et al., 1994, 1999), were studied by Hoyman (1990) and Rushton (1991). Rushton (1991) and Rushton et al. (1993) concluded that the veins are mesothermal in origin and were emplaced in the earliest Cretaceous (Plate 1b). Goldfarb et al. (2000) and Goldfarb et al. (2001) classified these veins as ‘orogenic Au deposits’ and suggested that they may be part of the intrusion-related gold deposits of the Tintina Gold Belt (see British Columbia and Yukon Chamber of Mines, 2000). According to Goldfarb et al. (2001), Kula-Farallon Plate convergence initiated gold veining along western North America at ~180 Ma, which spread southward from Alaska, through central Yukon (culminating about 140 Ma in the Klondike) and into British Columbia. Approximately 40 kg (1300 oz) of gold was produced from these veins at the Lone Star Mine (Yukon MINFILE, 1997). Ash (2001) recently proposed that the main source of gold for the Klondike goldfields was gold-quartz veins hosted by the Slide Mountain Terrane, which is now mostly eroded and preserved as isolated klippen above Yukon-Tanana Terrane basement rocks (Fig. 3). The source of gold in the Klondike goldfields is discussed further in the next section: General Stratigraphy, Sedimentology and Placer Formation.

Gold in Eureka Creek and Blackhills Creek (tributaries to Indian and Stewart rivers, respectively) is thought to have been derived from an epithermal source in the headwaters of these creeks (Dumula and Mortensen, 2002). In the Sixty Mile River drainage, Glasmacher (1984) concluded that epithermal-type and vein-type mineralization were the primary sources for the placer gold. Placer gold in the Moosehorn Range area was

derived from quartz veins in Cretaceous granodiorite (Morin, 1977; Ritcey et al., 2000). The source of placer gold throughout most of the Stewart River-Yukon River drainages basins has not been determined, and Dumula and Mortensen (2002) suggest that an undiscovered intrusion-related gold deposit similar to the Moosehorn Range area is present within the Thistle and Kirkman creek drainages. In addition, over 8200 kg (263,635 oz) of gold has been produced from the Brewery Creek mine located northeast of Tintina Fault (Mineral Resources Branch, 2002). The gold is finely disseminated in epithermally altered Cretaceous monzonite sills and Paleozoic mudstone, sandstone, conglomerate and minor limestone (Diment and Craig, 1999), but apparently no placers are associated with the deposit.

PHYSIOGRAPHY

Bostock (1948) named, outlined and described the larger physiographic units of the northern Canadian Cordillera. He subdivided the Cordillera into three great ‘systems’ (i.e., from east to west, the Eastern, Interior, and Western systems); each system was further subdivided into mountain and plateau ‘areas’, and these were further subdivided into mountains, plateaus, ranges and basins. The study area lies within the ‘Northern plateau and mountain area’ of the ‘Interior system’, which consists of two major elements (Bostock, 1948): the area southwest of Tintina Trench is characterized by relatively low, rounded hills of the Yukon Plateau (specifically, the Klondike Plateau; Plate 1c), whereas northeast of the trench, the area is characterized by relatively high, steep rugged peaks of the Ogilvie Mountains (Plate 1d). Bostock (1948, p. 69) describes the plateau as “a maze of deep, narrow valleys, separated by long, smooth-topped ridges whose elevations are very uniform, and which are remnants of an old uplifted erosion surface.” Tempelman-Kluit (1980) thought this was a ‘mature surface of low relief’ that drained to the southwest by Miocene time and was uplifted in Late Miocene or Pliocene time. Tintina Trench is the late Tertiary graben that developed along Tintina Fault (Tempelman-Kluit, 1980).

SURFICIAL GEOLOGY

Regional-scale (1:250 000 scale) surficial mapping of the Stewart River map area has not been done, but the Dawson map area was mapped by Vernon and Hughes (1966) and Duk-Rodkin (1996). More detailed (1:50 000 scale) mapping in the Stewart River map area was completed by Fuller (1993, 1994b, 1995b) and

Morison et al. (1998). Recently, Jackson and Huscroft (2000), Huscroft et al. (2001), Jackson et al. (2001, 2002) and Rotheisler et al. (2003) began updating the detailed mapping as part of the Ancient Pacific Margin NATMAP (National Mapping Program) Project, however their maps have yet to be published. Generally, the surficial deposits range from Late Miocene-Pliocene to Holocene in age, and consist of gravel (including placer deposits), sand, silt, muck, ground ice, volcanic ash and soil. They represent alluvial, morainal, glaciofluvial, eolian and colluvial deposits, several metres to tens of metres thick, which cover valleys and most upland areas, and are punctuated by relatively unweathered castellated bedrock outcrops or tors (Plate 1e). Muck deposits in the Klondike goldfields are further described by Fraser (1995) and Kotler (1998), and volcanic ash is described by Naeser et al. (1982), Kunk (1995), Preece et al. (2000), Westgate et al. (2000) and Sandhu et al. (2001). Tarnocai (1987), Tarnocai et al. (1985) and Smith et al. (1986) describe ancient and modern soils. The surficial deposits are locally

frozen because the study area lies within the discontinuous permafrost zone.

GLACIATION

Three phases of glaciation (Fig. 4 and Map 1), termed the pre-Reid (oldest), Reid, and McConnell (youngest), have been recognized in the Yukon (Bostock, 1966; Hughes et al., 1969). Within each phase of glaciation there were several glacial advances, and possibly up to seven advances for the pre-Reid glaciation (Duk-Rodkin, 1999). The pre-Reid glaciation was the most extensive and is thought to be late Pliocene to early Pleistocene in age (~3 Ma); the Reid glaciation was less extensive, but is poorly documented and is thought to be Middle Pleistocene in age (~300 Ka); and the McConnell glaciation was the least extensive and is Late Pleistocene in age (~30 Ka; Bostock, 1966; Hughes et al., 1969; Jackson et al., 1991; Hamilton, 1994; Duk-Rodkin, 1999; Westgate et al., 2001). Several remnant soils developed on till and outwash associated with these glaciations,

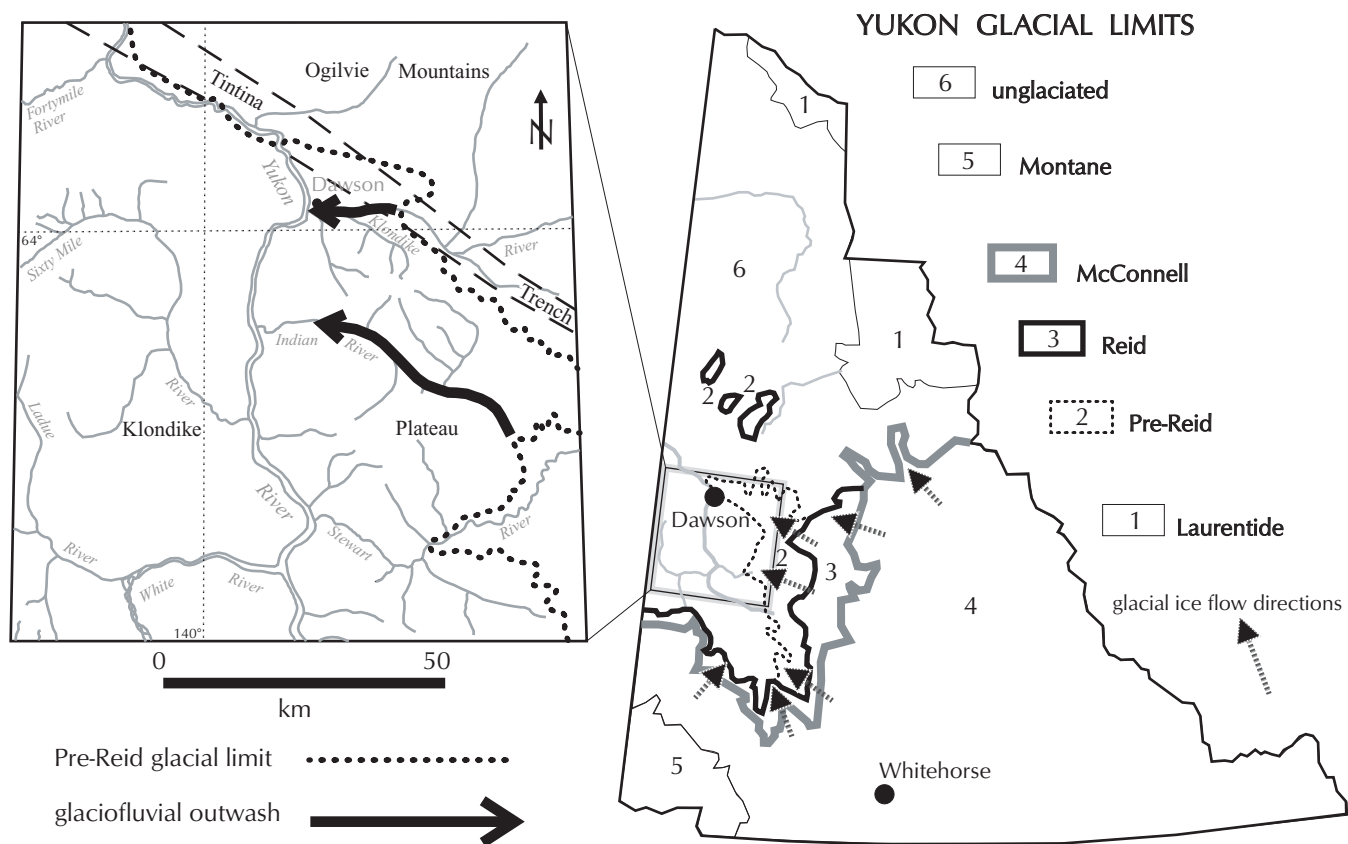


Figure 4. Physiography and glacial limits map of the study area (modified from Bostock, 1966; and Hughes, 1968).

and they are termed the 'Wounded Moose paleosol' (i.e., developed on pre-Reid deposits), the 'Diversion Creek paleosol' (i.e., developed on Reid deposits) and the 'Stewart neosols' (i.e., developed on McConnell deposits; Smith et al., 1986; Tarnocai, 1987; Tarnocai et al., 1985).

Generally, the area northeast of, and including, Tintina Trench, was glaciated during the pre-Reid, Reid and McConnell glaciations (these consisted mainly of independent valley glacier systems, Hughes et al., 1969), whereas the area southwest of Tintina Trench was largely unglaciated, with the exception of the pre-Reid glaciation in the mid-part of the Stewart River valley (which consisted of a continuous Cordilleran ice sheet, Hughes et al., 1969) and alpine glaciation (Plate 1f) in the Fiftymile Creek area that may be Reid (Lowey, 2000) or pre-Reid in age (Nelson and Jackson, 2003). Also, there is considerable debate regarding the glacial limits associated with the earliest and most extensive of

the pre-Reid glaciations (Jackson et al., 2001): Bostock (1966) placed these limits near Maisy May Creek in the Stewart River valley, whereas Duk-Rodkin (1999) placed the limits almost at the confluence with the Yukon River. Recent mapping by Jackson (2001) and stratigraphic and sedimentological results presented in this report corroborate the glacial limits defined by Bostock (1966).

Glaciofluvial outwash, termed the Klondike Gravel, is widespread in the Flat Creek area, and also occurs as high-level terraces along the Klondike, Indian and Fortymile rivers. The outwash is related to the deglaciation of the initial and most widespread of the pre-Reid glaciations. For example, Bostock (1966, Fig. 4) recognized the 'train of chert bearing gravel' along the Indian River as glaciofluvial outwash that can be traced to a pass in the headwaters of Australia Creek, and which was used by meltwater from a pre-Reid glaciation in the Stewart River valley.

GENERAL STRATIGRAPHY, SEDIMENTOLOGY AND PLACER FORMATION

INTRODUCTION

This section includes a description of the general stratigraphy and sedimentology of placer deposits throughout the study area, and provides an interpretation of the formation and evolution of those placer deposits. Detailed descriptions and interpretations of placers according to drainage basins are provided in the next section (Placer Mining Areas). Stratigraphic units described in this report are mainly classified according to their relative stratigraphic position (i.e., topographic level) and observable physical characteristics such as texture and clast composition.

STRATIGRAPHY

Introduction

Historically, placer deposits in the Klondike goldfields are classified into three levels of gravel with four main units: McConnell (1905b) originally classified the gravel into “high level gravels,” which he subdivided into “white channel gravels” (and which were further subdivided into “white gravels” and “yellow gravels”) and “river gravels,” “gravels at intermediate levels,” which he referred to as “terrace gravels,” and “low level gravels,” which he subdivided into “gulch gravels,” “creek gravels” and “river gravels.” McConnell (1907) elevated the “white channel gravels” to a formal stratigraphic unit by referring to it as the “White Channel gravels.” This classification was

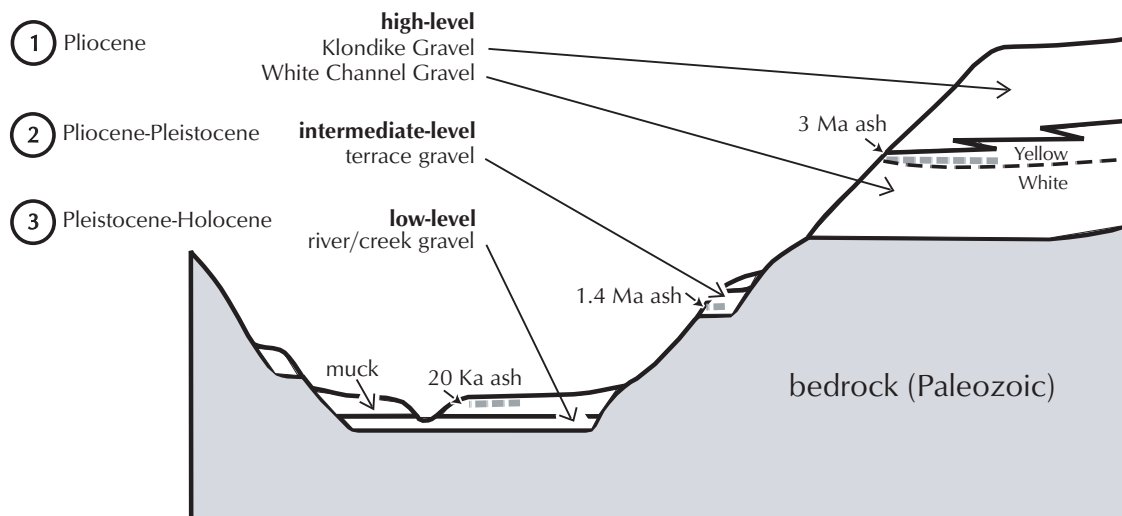
generally applied by Cairnes (1917) to placers in Scroggie, Barker, Thistle and Kirkman creeks, and by Cockfield (1921) to the Sixty Mile River goldfields. Gleeson (1970) elevated the “high level river gravels” to a formal stratigraphic unit and renamed it the “Klondike gravels.” Naldrett (1981), following Péwé’s (1975) nomenclature for Quaternary stratigraphic units in Alaska, assigned the White Channel Gravel the stratigraphic code “Qwc,” the Klondike Gravel the code “Qkl,” and creek gravel the stratigraphic code “Qck.” This report utilizes McConnell’s (1905b, 1907) classification, but with the following modifications: the high-level gravel (oldest) is subdivided into the White Channel Gravel (which is further subdivided into a lower White Gravel unit and an upper Yellow Gravel unit) and the Klondike Gravel; the intermediate-level gravel is unsubdivided; and the low-level gravel (youngest) includes gulch, creek and river gravel along the present valley bottoms (Fig. 5).

High-level gravel (Pliocene)

Definition, distribution and thickness

The high-level gravel usually forms prominent, continuous terraces, up to 1 km wide and several kilometres long, 10 to 200 m above present creek and river levels. It is locally subdivided into the White Channel Gravel, characterized by abundant quartz particles, and the overlying Klondike Gravel, which is characterized by chert particles. The White Channel Gravel is now the most

Figure 5. Schematic cross-section of Bonanza Creek showing the general stratigraphy of the study area (modified from McConnell, 1905b, 1907).



important economic unit in the Klondike (it has a large tonnage but a relatively low grade or concentration of gold). It is most common in the Klondike River drainage, and classic exposures occur at Jackson Hill along the Klondike River; at Bunker Hill, Cheechako Hill, Magnet Hill, American Hill, Orofino Hill, Monte Cristo Hill, King Solomon Hill, Boulder Hill, Trail Hill and Lovett Hill along Bonanza Creek; at Gold Hill along Eldorado Creek; at Temperance Hill, Nugget Hill, Pleasure Hill, Preido Hill and Dago Hill along Hunker Creek; and at Treasure Hill and Discovery Hill along Last Chance Creek (a tributary of Hunker Creek). The White Channel Gravel also occurs along the Indian River and Quartz, Little Blanche and possibly Dominion creeks in the Indian River drainage. Gravel discovered on terraces above the Forty Mile River are also included in the classification of high-level gravel. The White Channel Gravel is up to ~46 m thick and is mostly a framework-supported, poorly bedded gravel with minor amounts of interbedded sand and mud. It is locally subdivided along Bonanza and Hunker creeks into a lower White Gravel unit and an upper Yellow Gravel unit. Generally, the White Gravel unit contains more quartz particles than the Yellow Gravel unit, whereas the Yellow unit contains more metamorphic rock particles than the White unit. Classic exposures of the Klondike Gravel occur at the confluence of the Klondike and Yukon rivers; at Jackson Hill along the Klondike River; at Dago Hill and Australia Hill along Hunker Creek; along the Indian River and Australia Creek (a tributary of the Indian River); at Allgold Creek (a tributary of Flat Creek and the Klondike River); and on a terrace near the mouth of Scroggie Creek (a tributary of the Stewart River). It may also occur along the Fortymile River, and according to W.P. LeBarge (pers. com., 2004), adjacent to the abandoned minesite above Clinton Creek and along the Clinton Creek road. The Klondike Gravel is up to ~53 m thick and is mostly a framework-supported, well bedded gravel with interbedded sand and mud.

Texture and clast lithology

The White Channel Gravel (undifferentiated) contains ~56 to 85% gravel-sized particles, with an arithmetic mean of 71.6% gravel, 25.0% sand and 3.4% mud (hw in Fig. 6a,b,c). The particle-size distribution of the gravel is slightly positively skewed (i.e., the distribution has a longer tail to the right, indicating that only a few measurements are distributed over larger percentages than a normal distribution) and slightly platykurtic (i.e., the distribution is flatter than a normal distribution). The White Gravel unit tends to contain less gravel (~76%)

than the Yellow Gravel unit (~84%). The particle shape of the White Channel Gravel (undifferentiated) is mostly subrounded and spherical (Fig. 7), showing the least spread when compared to the other gravel units. The Yellow unit tends to display a slightly wider range in roundness, with subangular-subrounded clasts. The White Channel Gravel (undifferentiated) contains ~10 to 97% quartz particles, with an arithmetic mean of 38.6% quartz, 5.7% igneous rock and 54.7% metamorphic rock particles (Fig. 8). There is an inverse correlation between the percentage of quartz particles and metamorphic rock particles. Also, the White unit contains ~1 to 99% quartz particles, whereas the Yellow unit contains ~40 to 75% quartz particles. All of the particles are locally derived from within the drainage areas, and primarily from the Klondike Assemblage and Nasina Assemblage (i.e., quartz-chlorite schist, quartz-muscovite schist, micaceous quartzite, graphic quartzite, quartz-feldspar augen schist, amphibolite and orthogneiss), with minor amounts from intrusive rocks (i.e., quartz-porphyry dykes and sills). The Klondike Gravel contains ~58 to 91% gravel-sized particles, with an arithmetic mean of 79.3% gravel, 18.5% sand and 2.2% mud (hk in Fig. 6a,b,c). The particle-size distribution of the gravel is slightly negatively skewed (i.e., the distribution has a longer tail to the left, indicating that only a few measurements are distributed over smaller percentages than a normal distribution) and platykurtic. The particle shape shows slightly more spread than the White Channel Gravel, and is mostly rounded and spherical (Fig. 7). The Klondike Gravel contains only ~4 to 20% quartz particles (Fig. 9), with an arithmetic mean of 11.6% quartz, 17.0% igneous rock, 58.0% metamorphic rock, and 13.4% sedimentary rock particles (i.e., chert and conglomerate). There is no correlation between the percentage of quartz particles and metamorphic rock, igneous rock or sedimentary rock particles. Most of these particles, particularly chert and conglomerate, were derived from outside the drainage area, and primarily from Paleozoic sedimentary rocks exposed north of Tintina Fault in the Ogilvie Mountains.

Contacts, age and correlation

The White Channel Gravel sits nonconformably on the White Channel strath and is locally overlain by and interbedded with the Klondike Gravel (Hughes et al., 1972). The White Channel strath is the eroded bedrock surface on which the high-level gravel sits, and it is up to 70 m above the present creek and river levels. The strath is discontinuous, approximately 250 to 800 m wide, and concave upward in cross-sectional profile. It is eroded into

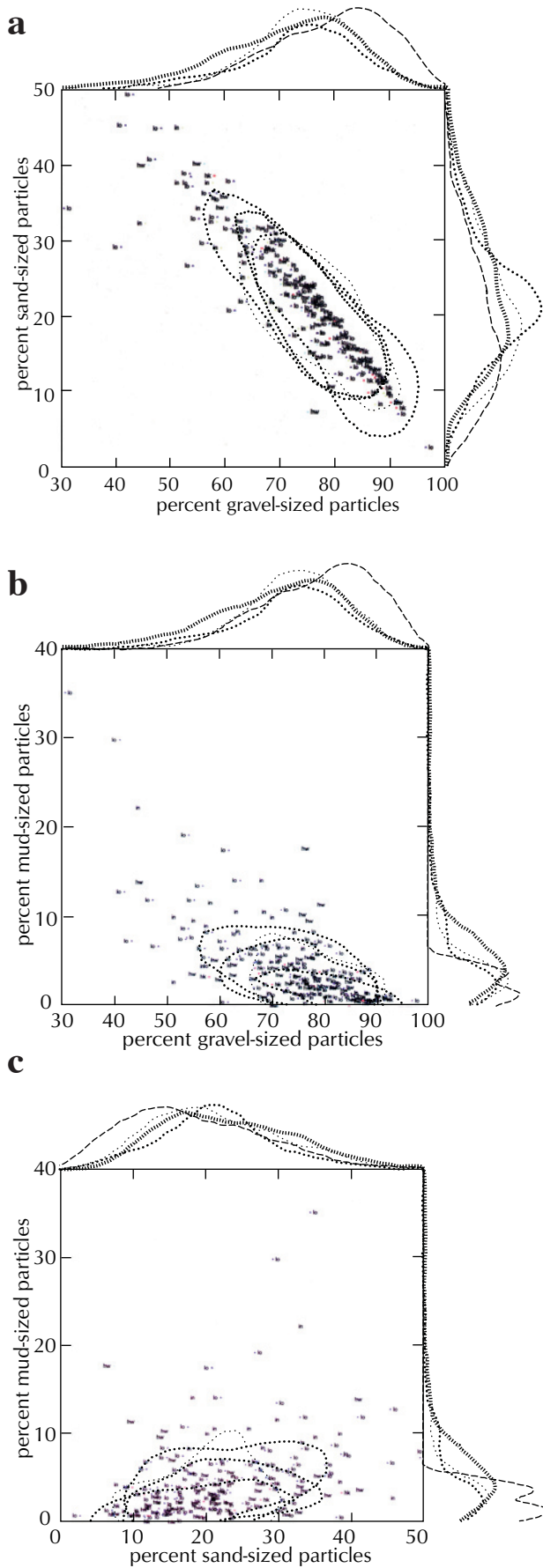
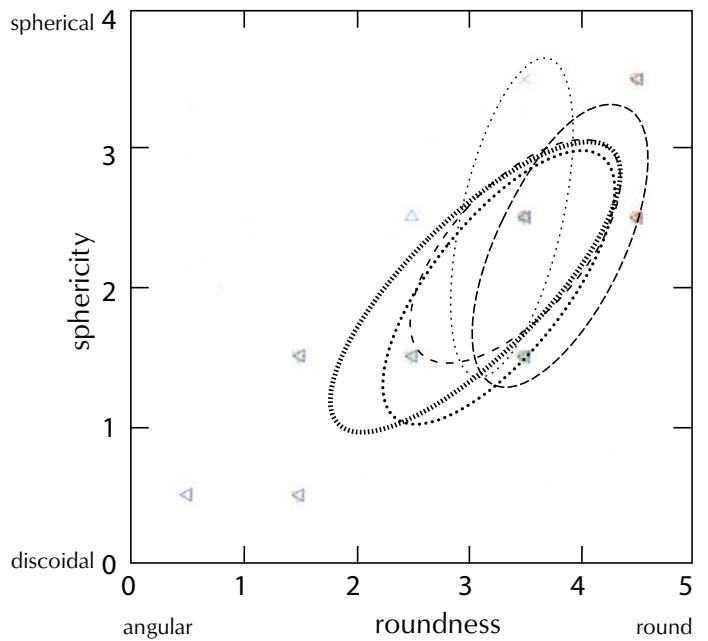


Figure 6.* Scatterplot of particle size analyses of gravel throughout the study area: (a) gravel versus sand; (b) gravel versus mud; (c) sand versus mud. The ovals within the plots correspond to the 95th percentile showing the overall trend of data distribution.

Figure 7.* Scatterplot of particle shape analyses of gravel throughout the study area. The ovals within the plot correspond to the 95th percentile showing the overall trend of data distribution.



Legend for Figures 6 and 7

Key to gravels

- hk --- high-level Klondike gravel
- hw high-level White Channel Gravel (undifferentiated)
- hww - - - high-level White Channel White Gravel unit
- hwy — high-level White Channel Yellow Gravel unit
- in intermediate-level gravel
- lo low-level gravel

*For further details, these figures are provided at larger scale on the CD-ROM.

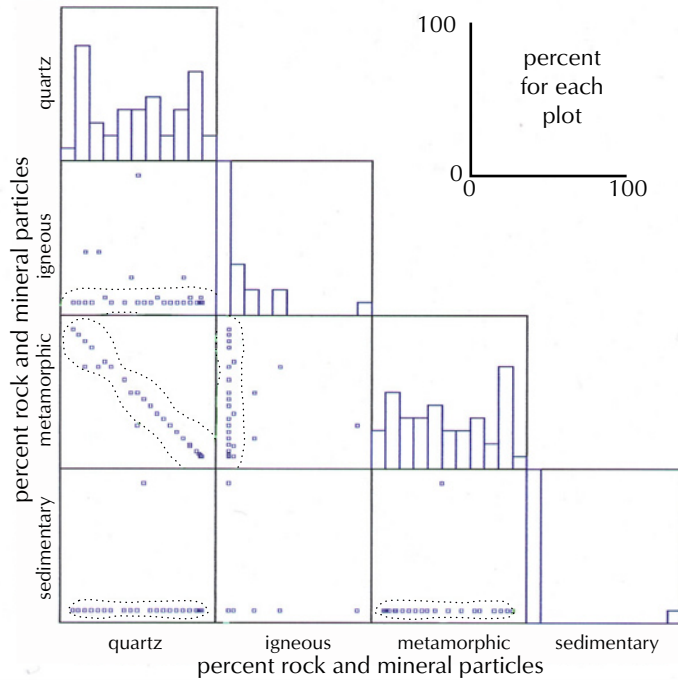


Figure 8.* Multivariate scatterplot of particle composition analyses of high-level White Channel Gravel throughout the study area. The uppermost plot in each column is a histogram showing the relative frequency of each variable in that column.

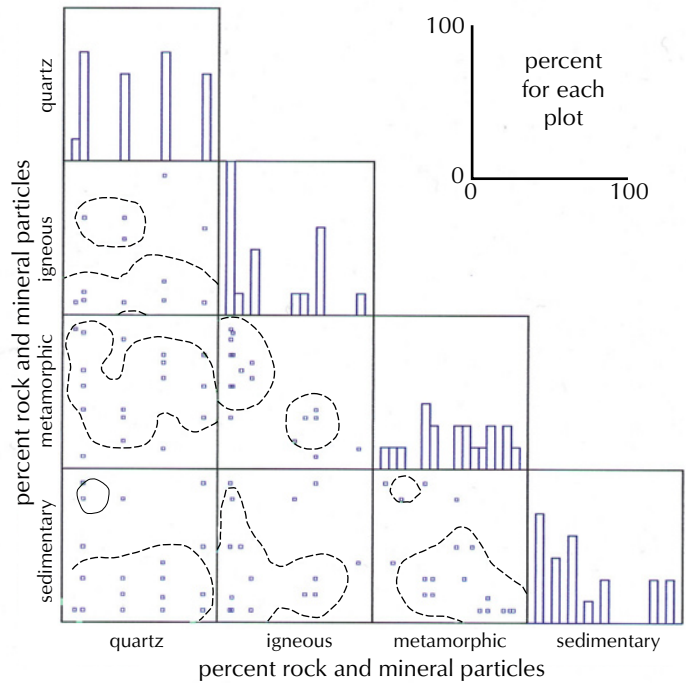


Figure 9.* Multivariate scatterplot of particle composition analyses of high-level Klondike Channel Gravel throughout the study area. The uppermost plot in each column is a histogram showing the relative frequency of each variable in that column.

Legend for Figures 8, 9 and 10

Key to gravels

- hk --- high-level Klondike gravel
- hw high-level White Channel Gravel (undifferentiated)
- hww - - - high-level White Channel White Gravel unit
- hwy — high-level White Channel Yellow Gravel unit
- in intermediate-level gravel
- lo low-level gravel

rocks of the Yukon-Tanana Terrane. Based on McConnell's (1905b, 1907) descriptions and cross-sections, the White Gravel unit is thought to be interbedded with the overlying Yellow Gravel unit. The Yellow unit is overlain by muck or colluvium. The Klondike Gravel rests nonconformably on rocks of the Yukon-Tanana Terrane, and locally overlies and is interbedded with the White Channel Gravel (Hughes et al., 1972).

The White Channel Gravel contains no plant or animal remains, with the exception of fossil palynomorphs (i.e., spores and pollen). These indicate a Pliocene age for the White unit (Morrison, 1985). Kunk (1995) reported hornblende ⁴⁰Ar/³⁹Ar ages that range from 2.64 to 3.01 Ma

from tephra in the White Channel Gravel along Quartz Creek, and Sandhu et al. (2001) obtained a glass-fission-track age of 3.00 ± 0.33 Ma from the Quartz Creek tephra in the Yellow unit in the same area. Hence, the White Channel Gravel is Pliocene in age, with the White Gravel unit probably Early Pliocene (~5 to 3 Ma) and the Yellow Gravel unit probably latest Early Pliocene to earliest Late Pliocene (~3 Ma). The Klondike Gravel was deposited during deglaciation of the initial and most widespread of the pre-Reid glaciations, and is also considered latest Early Pliocene to earliest Late Pliocene (~3 Ma).

McConnell (1905b) thought that white-coloured gravel underlying present creek gravel (i.e., low-level gravel in this report) in Sulphur, Gold Run and Dominion creeks belonged to the White Channel Gravel. However, what appears to be the White Channel Gravel is exposed on a high-level terrace east of Dominion Creeks, specifically between Rob Roy and Bull Frog creeks (Christie, 1996). James S. Christie (pers. comm., 1999) explored this terrace for placer gold and determined from excavated trenches that approximately 11.5 m of gravel is present. Rounded quartz boulders up to 0.8 m long were observed

*For further details, these figures are provided at larger scale on the CD-ROM.

near one of the filled-in trenches, and a grab sample (GL98-29A) of the trench material revealed 97% quartz particles and 3% metamorphic rock particles. The white gravel exposed in the present day creek bottoms of Sulphur, Gold Run and Dominion creeks may be stratigraphically and lithologically similar to the ‘original’ Eldorado Creek gravel that escaped dredging and was being mined in 1999. This gravel, exposed in a placer mining pit just upstream of the confluence of Bonanza and Eldorado creeks, is approximately 1 m thick and consists of a mixture of quartz particles and metamorphic rock particles (W.P. LeBarge, written. comm., 2000). It represents reworked White Channel Gravel, derived from the high-level terraces along Eldorado and Bonanza creeks. Hence, McConnell’s (1905b) white gravel in Sulphur, Gold Run and Dominion creeks is also interpreted as reworked White Channel Gravel and is assigned to the intermediate-level gravel. In addition, Froese et al. (2001) reported that the white gravel in Dominion Creek is associated with magnetically reversed sediments, which they propose may correlate with the Matuyama reversed chron (i.e., older than 780 Ka). Bostock (1964) correlated the White Channel Gravel with gravel in the Clear Creek placer mining area, but this was based only on lithocorrelation; the age of the gravel in the Clear Creek area remains unknown. Tempelman-Kluit (1980, Fig. 3, p. 1193) shows the White Channel Gravel as being widely distributed along Flat Creek and the Stewart, Indian and Yukon rivers. However, most of these deposits belong to the Klondike Gravel. The Klondike Gravel is correlated with the ‘Flat Creek beds’ of McConnell (1905b) and can be traced to the Ogilvie Mountains.

Intermediate-level gravel (Pliocene-Pleistocene)

Definition, distribution and thickness

The intermediate-level gravel mostly forms relatively small (i.e., up to tens of metres wide and a few hundred metres long), irregularly distributed strath terraces that range from 1 to 50 m above present creek and river levels. This unit is second to the White Channel Gravel in terms of economic importance. Although not very common, the intermediate-level gravel is widely distributed throughout the study area, and occurs along Bonanza and Allgold creeks in the Klondike River drainage; along Little Blanche, Montana, Eureka, Dominion and Gold Run creeks in the Indian River drainage; along Tenmile, Matson, Fiftymile, California, Twelvemile, Glacier and Miller creeks in the Sixty Mile

River drainage; and along Kirkman, Thistle, Blackhills and Scroggie creeks in the Stewart River-Yukon River drainages. As discussed in the previous section on high-level gravel, the intermediate-level gravel also occurs as buried gravel below low-level gravel along Eldorado, Sulphur, Gold Run and Dominion creeks. It has not been observed in the Ladue River drainage. The intermediate-level gravel is up to 9 m thick and is mostly a framework-supported, poorly bedded gravel with minor amounts of interbedded sand and mud.

Texture and clast lithology

The intermediate-level gravel contains ~45 to 83% gravel-sized particles, with an arithmetic mean of 73.6% gravel, 22.1% sand and 4.3% mud (“in” in Fig. 6a,b,c). The particle-size distribution of the gravel is slightly negatively skewed and leptokurtic (i.e., the distribution is more peaked than a normal distribution). The particle shape shows slightly greater spread than the upper-level gravel, and is predominantly subrounded and spherical-subdiscoidal (Fig. 7). It contains 0 to 85% quartz particles, with an arithmetic mean of 17.7% quartz, 7.1% igneous rock and 75.2% metamorphic rock particles (Fig. 10).

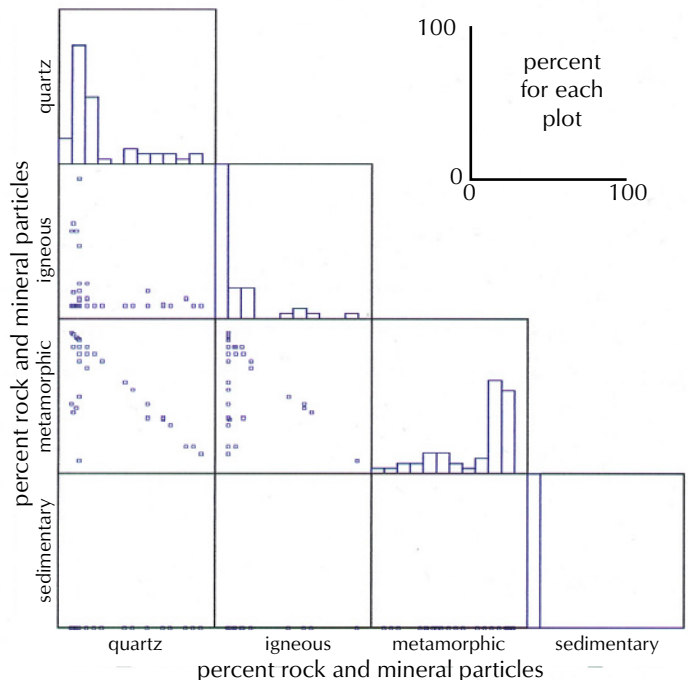


Figure 10.* Multivariate scatterplot of particle composition analyses of intermediate-level gravel throughout the study area. The uppermost plot in each column is a histogram showing the relative frequency of each variable in that column.

*For further details, these figures are provided at larger scale on the CD-ROM.

There is an inverse correlation between the percentage of quartz particles, and metamorphic rock and igneous rock particles.

Contacts, age and correlation

The intermediate-level gravel sits nonconformably on Yukon-Tanana Terrane bedrock and is locally overlain by low-level gravel or muck. Naeser et al. (1982) obtained a glass fission-track age of 1.22 ± 0.49 Ma from the Mosquito Gulch tephra, which occurs in overbank deposits above intermediate-level gravel on a terrace referred to as ‘Archibald’s bench’ along Bonanza Creek. Sandhu et al. (2001) obtained a weighted mean average glass fission-track age of 1.42 ± 0.16 Ma from the same tephra. As mentioned previously in the section on high-level gravel, the white gravel exposed along Sulphur, Gold Run and Dominion creeks is assigned to the intermediate-level unit and is considered by Froese et al. (2001) to be at least 780 Ka, based on reversed magnetization within the gravel. Note that this reversal has not been found elsewhere and it could be a paleomagnetic polarity excursion (Barendregt, 1985). Hence, the intermediate-level gravel is considered latest Late Pliocene to Early Pleistocene in age. McConnell (1905b) suggested that the intermediate-level gravel represents a transition from the high-level gravel to the low-level gravel.

Low-level gravel (Pleistocene-Holocene)

Definition, distribution and thickness

The low-level gravel represents alluvium exposed along present day creeks, gulches and rivers, and it occurs in all the drainages throughout the study area. Historically it was the most important economic unit, because of the high grade and low tonnage, but most of the deposits have been mined three or four times now. The low-level gravel is up to 20 m thick and is mostly a framework-supported, well bedded gravel with interbedded sand and mud.

Texture and clast lithology

The low-level gravel contains ~31 to 97% gravel, with an arithmetic mean of 71.4% gravel, 23.1% sand and 5.5% mud (in Fig. 6a,b,c). The particle size distribution of the gravel-sized particles is slightly negatively skewed and leptokurtic. The particle shape shows the greatest spread compared to the other gravel units, and is mostly subangular-subrounded and spherical-subdiscoidal (Fig. 7). It contains 0 to 80% quartz, with an arithmetic mean of 12.0% quartz, 7.2% igneous rock, 79.3%

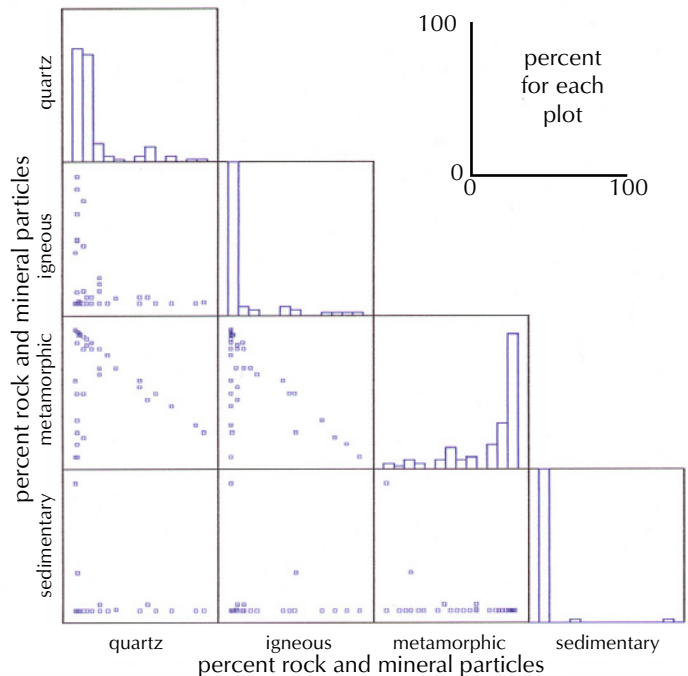


Figure 11.* Multivariate scatterplot of particle composition analyses of low-level gravel throughout the study area. The uppermost plot in each column is a histogram showing the relative frequency of each variable in that column.

metamorphic rock and 1.5% sedimentary rock particles (Fig. 11). There is an inverse correlation between the percentage of quartz particles, and metamorphic rock and igneous rock particles.

Contacts, age and correlation

The low-level gravel sits nonconformably on Yukon-Tanana Terrane bedrock, and locally unconformably on intermediate-level gravel. It is overlain by muck or colluvium. The low-level gravel often contains extant plant and animal remains, and Fraser (1995) reports radiocarbon ages of ~24 to 26 Ka from the overlying muck. Hence, the low-level gravel unit is considered Late Pleistocene to Holocene in age.

SEDIMENTOLOGY

Introduction

A fundamental tool in the description and interpretation of sediment is the concept of ‘lithofacies’. Lithofacies refers to the physical and chemical characteristics of a sedimentary unit or bed (Moore, 1949). They are established by comparing and contrasting the observed texture and sedimentary structures of beds

*For further details, these figures are provided at larger scale on the CD-ROM.

(typically exposed in the pit walls of placer mines), and either combining or splitting the beds into well defined ‘lithofacies types’. This method is subjective and depends on the complexity of the sediment and the scale and purpose of the project. There is no fundamental number of lithofacies that should be determined, and as pointed out by Harms et al. (1982), splitting sedimentary features into too many lithofacies only complicates analysis, whereas lumping features into too few lithofacies results in oversimplification. Lithofacies characteristics are the result of physical and chemical processes that were active at the time the sediment was deposited. Most strata can be subdivided into a number of distinct lithofacies types, and once all of the beds have been assigned to a lithofacies, patterns in the distribution of the lithofacies can then be investigated. This is done by visually inspecting measured sections and panel diagrams and noting which lithofacies tend to be associated together. The vertical association of lithofacies types, or ‘lithofacies assemblages’, forms the basis for interpreting the environment of deposition of the sediment.

Lithofacies types

Eight stratigraphically repeated lithofacies types are recognized in the placer deposits (Table 2). The lithofacies types are assigned a mnemonic code adapted from Miall (1996). In this code system the upper-case letter refers to the predominant texture (i.e., “G” for gravel, “S” for sand

and “F” for mud) and the lower-case letter refers to the dominant sedimentary structure (i.e., “l” for laminated, “m” for massive, “p” for planar cross-beds, etc).

Lithofacies Gh (clast-supported, crudely bedded gravel)

Lithofacies Gh is the most common lithofacies observed in the placer deposits, and represents the most common ‘pay gravel’ mined. It occurs in the high-level, intermediate-level and low-level gravel units throughout the study area. Lithofacies Gh consists of clast-supported, muddy, sandy, slightly bouldery, fine- to coarse-grained pebble and fine cobble gravel, with clasts up to 0.8 m long locally present (Plate 2a,b). Although this lithofacies appears massive, it actually displays crude bedding and cryptic channel and scour fills that form sequences up to 23 m thick. Normal grading may be present near the top of the sequences and crude clast imbrication (i.e., At/Bi)¹ is present. Lithofacies Gh displays flat upper contacts, is locally interbedded with lithofacies Sh, and is overlain by lithofacies Fm,o, rarely by lithofacies Sh and very rarely by lithofacies Fl.

Lithofacies Gmm (matrix-supported, massive gravel)

This lithofacies is very rare and occurs in the high-level Klondike Gravel, and as a transition between lithofacies Gh in the intermediate-level gravel unit in the Sixtymile River area and the low-level gravel unit in the

Table 2. *Lithofacies types (modified from Miall, 1996).*

Code	Lithofacies	Sedimentary structures	Interpretation
Gh	Gravel: clast-supported, crudely bedded	Crude horizontal bedding, imbrication	Stream-flow deposits: longitudinal bars, lag deposits
Gmm	Gravel: matrix-supported, massive	Weak grading	Debris-flow deposits: slumps and till
Gp	Gravel: cross-bedded	Planar cross-beds	Stream-flow deposits: transverse bars
Sh	Sand: fine to coarse, pebbly, crudely bedded	Crude horizontal bedding	Stream-flow deposits: plane-bed flow
Sp	Sand: fine to very coarse, pebbly, cross-bedded	Planar cross-beds, minor ripples	Stream-flow deposits: transverse and linguoid bars
Sl	Sand: very fine to coarse, crudely laminated	Low angle (<15°) lamination	Stream-flow deposits: scour fills
Fl	Mud: mostly silt, minor sand and tephra, laminated	Crude horizontal lamination	Stream-flow deposits: overbank and abandoned channel fill deposits
Fm,o	Mud: mostly silt and organics (“muck”), minor tephra	Crude horizontal lamination	Eolian deposits (loess) and peat growth

¹A is the long axis of a clast and is transverse (t) to the stream flow, and B is the intermediate axis of a clast and is imbricated (i) or dips upstream.

Indian River area. It consists of matrix-supported, muddy, cobble gravel with clasts up to 0.2 m long (Plate 2c,d). Lithofacies Gmm forms beds up to 4 m thick and is overlain by lithofacies Gm.

Lithofacies Gp (cross-bedded gravel)

Lithofacies Gp is rare, but was observed in the Yellow Gravel unit of the White Channel Gravel in the Klondike area, the intermediate-level gravel in the Sixty Mile River area and in low-level gravel in the Indian River area. It consists of planar cross-bedded and rare trough cross-bedded, muddy, sandy, fine- to coarse-grained pebble gravel (Plate 2e,f). Lithofacies Gp occurs as lenses or tabular beds, 0.4-0.5 m thick, within lithofacies Gh.

Lithofacies Sh (crudely bedded sand)

This lithofacies is common and occurs in the high-level, intermediate-level and low-level gravel units throughout the study area. It consists of crudely bedded, slightly pebbly, fine- to coarse-grained sand that forms tabular beds up to 0.5 m thick, although most beds are only 0.2 m thick (Plate 3a,b). Lithofacies Sh is interbedded with lithofacies Gh and Fl, or occurs as fining-upward transitions from lithofacies Gh to lithofacies Fl.

Lithofacies Sp (cross-bedded sand)

This lithofacies is rare and was observed in high-level gravel in the Klondike area and in intermediate-level gravel in the Indian River, Sixty Mile River, and Stewart River-Yukon River areas. It consists of planar cross-bedded, slightly pebbly, medium- to coarse-grained sand and minor current-rippled, medium-grained sand that forms beds 0.1 to 1.0 m thick (Plate 3c,d). Lithofacies Sp forms long, wedge-shaped lenses interbedded with lithofacies Gh.

Lithofacies Sl (crudely laminated sand)

Lithofacies Sl is very rare and was observed in the high-level White Channel Gravel in the Klondike area. It consists of crudely laminated, very fine- to fine-grained sand that forms 0.1-m-thick lenses in lithofacies Gh (Plate 3e,f).

Lithofacies Fl (crudely laminated mud)

Lithofacies is common and occurs in the intermediate-level gravel and low-level gravel units throughout the study area. It consists of crudely laminated silt and very fine-grained sand that forms tabular beds up to 4 m thick and lenses up to 0.2 m thick (Plate 4a,b). Plant detritus and tree stumps are locally abundant. Lithofacies Fl is

interbedded with lithofacies Gh or Sh, and also occurs as fining-upward sequences overlying lithofacies Gh and Sh.

Lithofacies Fm,o (muck)

This lithofacies is abundant and overlies the high-level, intermediate-level and low-level gravel units throughout the study area. It consists of primary and re-transported loess, and in situ peat that forms sequences up to 20 m thick (Plate 4c,d,e,f). Pleistocene bones are locally abundant. Lithofacies Fm,o is normally frozen due to permafrost, and ground ice is locally present. This lithofacies commonly contains coarse-grained (i.e., sand and gravel) colluvium and mass wasting deposits (locally referred to as ‘slide’ or ‘slide rock’).

Lithofacies assemblages

The eight lithofacies types can be grouped into four lithofacies assemblages (Table 3). These are naturally occurring vertical associations of lithofacies types, and provide the basis for interpreting the environment of deposition of the placer deposits.

Gravel assemblage

The gravel assemblage (Fig. 12) is characterized by 80 to 100% gravel (based on the percentage of cumulative thickness of gravel in measured vertical profiles), primarily amalgamated beds of lithofacies Gh, with minor amounts of lithofacies Gp and Sh. It occurs mainly in the White Channel Gravel, but was also observed in the intermediate-level gravel unit. Lithofacies Gh and Gp are interpreted as longitudinal bar, transverse bar and lag deposits, and are similar to Miall’s (1996) “gravel bar

Table 3. *Lithofacies assemblages (modified from Miall, 1996).*

Assemblage	Lithofacies	Interpretation
Gravel	Gh minor Gp and Sh	gravel bars and bedforms (element GB) deposited in shallow, gravel-bed braided rivers
Gravel-sand	Gh and Sh minor Gp, Sp and Fl	gravel bars and bedforms (element GB) and sandy bedforms (element SB) deposited in deep, gravel-bed braided rivers and gravel-bed, wandering rivers
Mud	Fl, minor Sh and Fm,o	overbank fines (element OF) deposited in gravel-bed, wandering rivers
Muck	Fm,o, minor Fl	primary and re-deposited loess, in-situ peat and colluvium

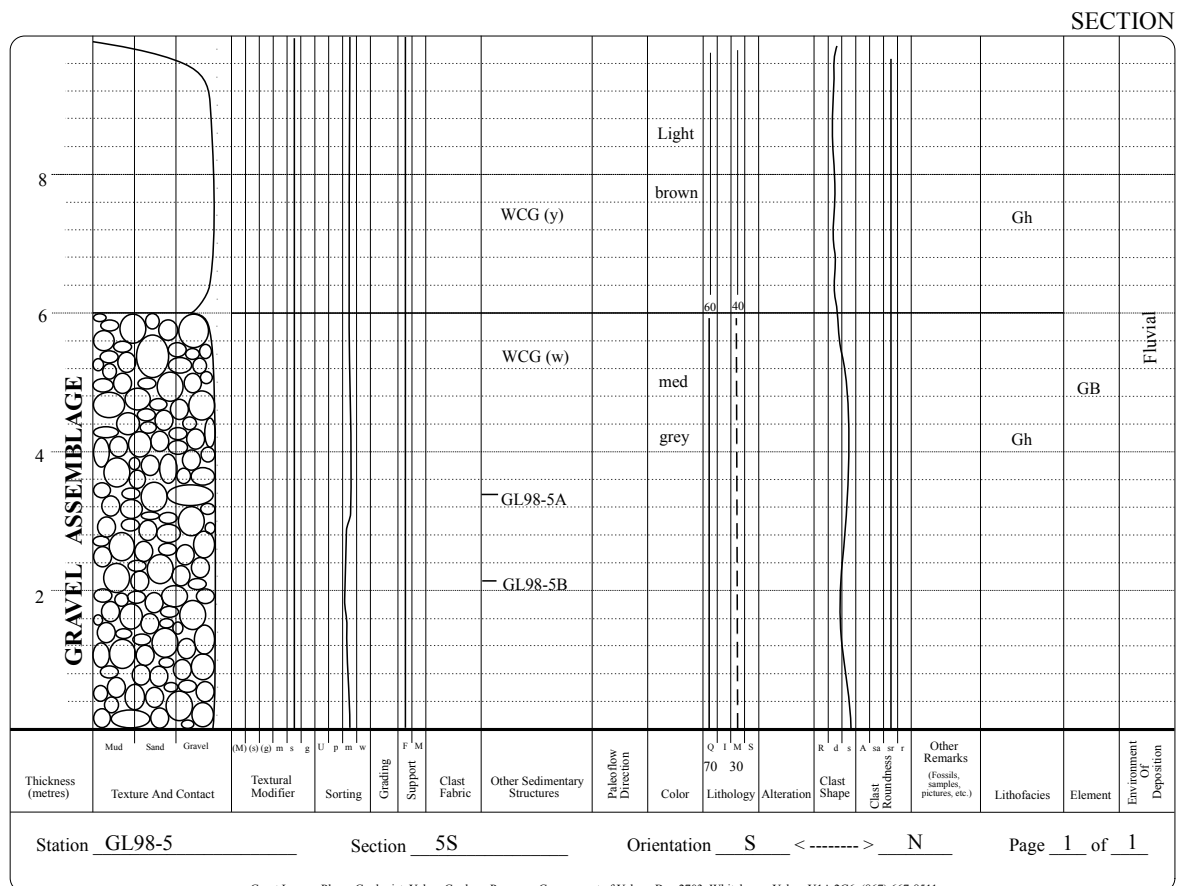
and bedform” architectural element for fluvial deposits (i.e., code GB). Lithofacies Sh is interpreted as minor sand bars, and is similar to Miall’s (1996) ‘sandy bedform’ architectural element for fluvial deposits (i.e., element SB). Thick, multi-story gravel deposits dominated by element GB accumulate on floodplains in shallow, gravel-bed braided rivers (Miall, 1996). According to Miall (1996), this fluvial style consists of a network of unstable, low-sinuosity channels, approximately 1 m in depth and characterized by longitudinal bars and lag deposits, that form by regular flow events in relatively unconfined valleys.

Gravel-sand assemblage

The gravel-sand assemblage (Fig. 13) contains less than 80% gravel (based on the percentage of cumulative thickness of gravel in measured vertical profiles). It is distinguished from the gravel assemblage by an increase in the amount of interbedded sand, and occurs in the Klondike Gravel and the intermediate-level and low-level gravel units. The gravel-sand assemblage is dominated by lithofacies Gh, with lesser amounts of lithofacies Sh, and minor amounts of lithofacies Gp, Sp and Fl. Lithofacies

Gh and Gp are interpreted as longitudinal bar, transverse bar and lag deposits, and are similar to Miall’s (1996) “gravel bar and bedform” architectural element for fluvial deposits (i.e., element GB). Lithofacies Sh and Sp are interpreted as sand bars, and are similar to Miall’s (1996) “sandy bedform” architectural element for fluvial deposits (code SB). Lithofacies Fl is interpreted as minor abandoned channel fill and waning flood deposits, and is similar to Miall’s (1996) “overbank fines” architectural element for fluvial deposits (element FF). Sediments dominated by element GB, with important amounts of element SB, are deposited on floodplains in deep, gravel-bed braided rivers, gravel-bed wandering rivers, and gravel-bed meandering rivers (Miall, 1996). Three-dimensional exposures and very detailed paleocurrent measurements are required to distinguish between these three types of fluvial styles, and a river may change from one fluvial style into another along its course, or it may evolve from one fluvial style into another with time (Miall, 1996). Generally, vertical profiles of sediments deposited by deep, gravel-bed braided rivers display crude fining-upward lithofacies cycles; gravel-bed wandering

Figure 12.
Example of the gravel assemblage (stratigraphic-sedimentologic section for station GL98-5).



Placer geology of the Stewart River and Dawson map areas

Figure 13. Example of the gravel-sand assemblage (stratigraphic-sedimentologic section for station GL00-54).

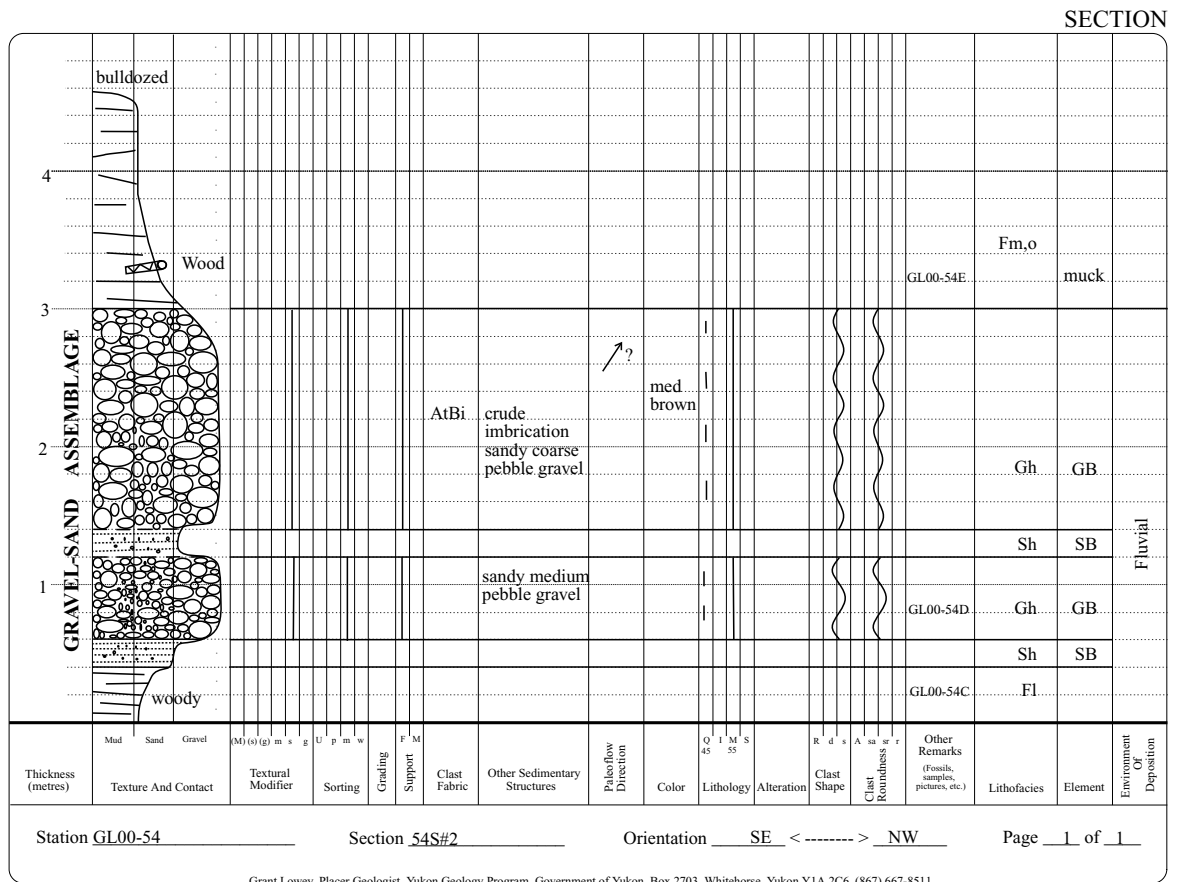
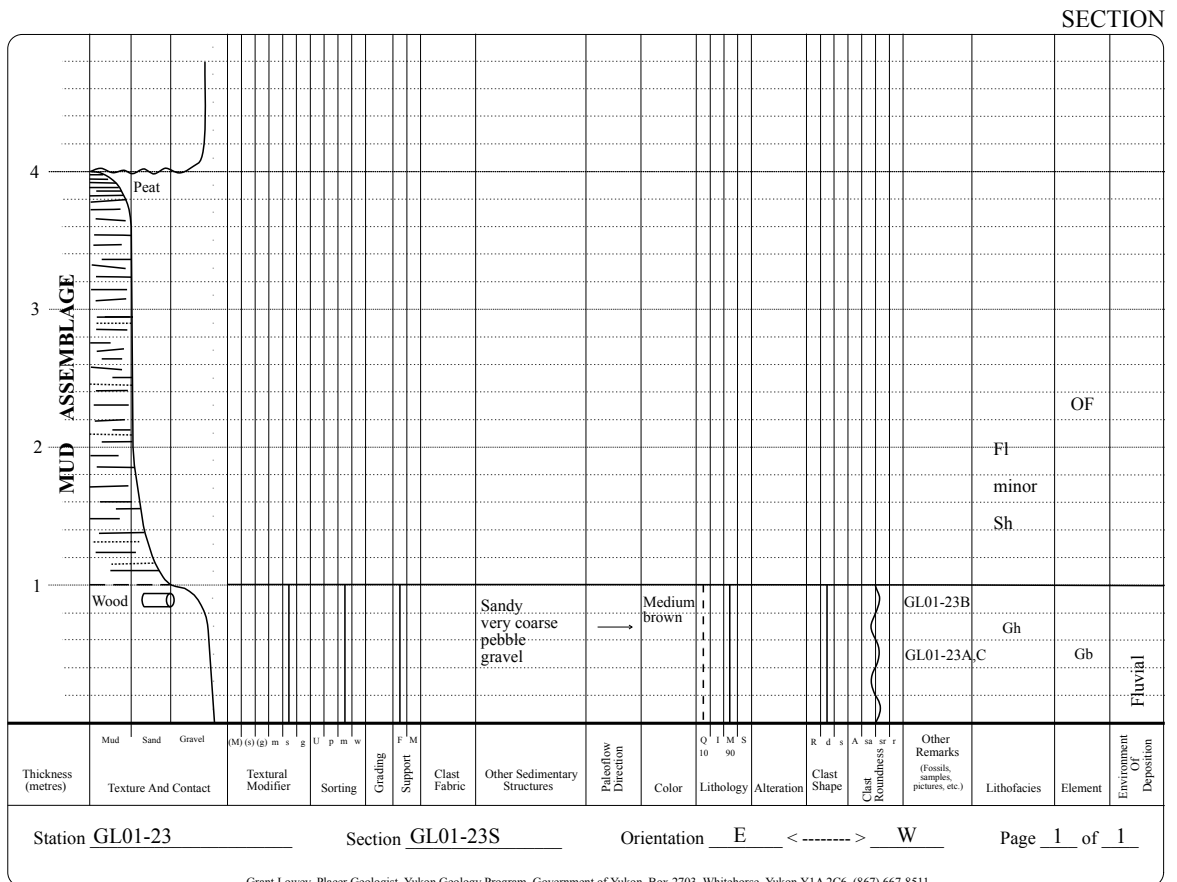


Figure 14. Example of the mud assemblage (stratigraphic-sedimentologic section for station GL01-23).



rivers display better developed cycles; and gravel-bed meandering rivers are characterized by well defined fining-upward cycles (Miall, 1996). None of the vertical profiles in this study display well developed fining-upward cycles, and cycles in the intermediate-level gravel and low-level gravel units are better developed than in the high-level Klondike Gravel.

Mud assemblage

This mud assemblage (Fig. 14) contains less than 5% gravel, consisting predominantly of lithofacies Fl with minor amounts of lithofacies Sh and F_{mo}. It is restricted to the intermediate-level gravel and low-level gravel units. The mud assemblage is interpreted as fine-grained flood deposits and is similar to Miall's "overbank fines" architectural element for fluvial deposits (element FF).

Muck assemblage

This muck assemblage is characterized by lithofacies F_{m,o} with very minor amounts of lithofacies Fl. It locally overlies all of the gravel units and is interpreted as primary and re-deposited loess and in situ peat that is not related to the fluvial deposition of the placer deposits.

Environments of deposition and paleocurrent flow

The White Channel Gravel was deposited by shallow, gravel-bed braided rivers in paleo-Bonanza, paleo-Hunker and paleo-Dominion creeks, and in the paleo-Indian River. Measurements obtained from clast imbrication and cross-bedding indicate that the paleocurrent flow of these streams was parallel to the flow of the present day Bonanza, Hunker and Dominion creeks and Indian River. The Yellow Gravel unit of the White Channel Gravel displays more cross-bedding than the White Gravel unit, and this may indicate a transition in fluvial styles from a gravel-bed braided river to a gravel-bed wandering river, or it may simply be due to the greater preservation of sedimentary structures in the younger Yellow Gravel. The Klondike Gravel is glaciofluvial in origin and was deposited by a deep, gravel-bed braided river in the paleo-Klondike River during deglaciation of the initial and most widespread of the pre-Reid glaciations.

Measurements obtained from clast imbrication and cross-bedding indicate that the paleocurrent was parallel to that of the present Klondike and Indian rivers, but opposite to the present day Yukon River (i.e., the paleo-Klondike River flowed south at one time, joining the paleo-Yukon River). The intermediate-level gravel and low-level gravel were deposited by gravel-bed wandering rivers and creeks. Measurements obtained from clast

imbrication and cross-bedding indicate that the flow direction of the intermediate-level gravel was parallel to the flow of the present day rivers and creeks.

PLACER FORMATION

Origin of gold

Gold recovered from placer deposits in the study area ranges widely in size, appearance and purity from minute flakes capable of floating on water, to fist-sized nuggets (the largest nugget reported weighed 3937.7 g (126.6 crude ounces) and came from the claim '9 below' Upper Discovery on Dominion Creek²); from pristine octahedral crystals to well rounded nuggets; and from a fineness of ~600 to ~900. The origin of placer gold in the study area was briefly reviewed in the section on Lode Deposits, and this topic will be discussed further in the second part of the report describing placer areas according to drainages. The purpose of this section is to examine the origin of coarse 'nugget' gold in placer deposits. The origin of coarse nugget gold in placers is controversial (Boyle, 1979), and placer deposits in the study area are no exception, particularly those in the Klondike and Sixty Mile river areas. Nuggets are considered either detrital in origin, derived directly from the weathering and erosion of auriferous quartz veins, or they are thought to be authigenic in origin, having partly (i.e., smaller detrital gold grains cemented together), or entirely formed by direct precipitation from auriferous water (Boyle, 1979; Eyles, 1995; and references therein).

McConnell (1905a, p. 37A-38A) noted that a 2-m-wide quartz vein near the Lone Star Mine was "studded with grains and nuggets of gold," and he (McConnell, 1905b, p. 105) concluded that there "is little doubt that the Klondike gold, or the greater part of it, at least, is detrital in origin, and has been largely derived from the auriferous quartz veins cutting the older schists." However, McConnell (1905b, p. 106) suggested that a "small percentage may have been precipitated from water carrying gold in solution," citing as evidence a boulder from the Sixty Mile River goldfields, the upper surface of which was partially covered with dendritic gold. In addition, McConnell (1905b) reported that the White Channel Gravel was named for its dominant white or light grey colour, which he attributed to the abundance of quartz clasts and an alteration of the sand-mud matrix that he thought was due to the "leaching of

²<http://www.library.state.ak.us/gold/browseaction.cfm?AID=Wolfe>

iron.” Tempelman-Kluit (1982) referred to the alteration as “bleaching” and thought that it was caused by groundwater. He proposed that the gold was “growing” in the gravel, and that it had precipitated from the mixing of deep, warm, ascending groundwater with shallow, cool, descending groundwater. Dufresne (1987) undertook a detailed study of the alteration and gold, and concluded that both were due to low temperature (i.e., 120 to 130°C), low salinity (i.e., 1 to 2 wt.% NaCl) hydrothermal fluids characteristic of epithermal mineralization. However, Knight et al. (1994, 1999), using major and minor trace element compositions of gold particles from placers and lodes, were able to determine that “most if not all” of the gold was derived from the lodes, and Lowey (2002) reinterpreted the alteration as the result of weathering and particularly diagenesis.

Clay minerals observed in the altered matrix of the White Channel Gravel can originate in at least five ways (i.e., weathering of pre-existing minerals and direct deposition; weathering of pre-existing minerals and mechanical infiltration; recrystallization; authigenesis; and cementation from groundwater; Figure 15):

a) Common bedrock lithologies throughout the goldfields include schist, gneiss and quartzite, which contain abundant muscovite, biotite, chlorite and feldspar (Mortensen, 1996). These minerals alter during weathering to clay minerals such as illite, smectite, vermiculite and kaolinite (Blatt, 1992; Bloom, 1969;

Grim, 1968; Velde, 1985), all of which were probably produced during the long period of weathering required to develop the subdued Miocene landscape postulated by Tempelman-Kluit (1980). During subsequent uplift and erosion, the clays may have been transported and deposited as allogenic clay minerals with other sediments to form the White Channel Gravel. This long period of weathering followed by uplift and erosion may also explain the formation and distribution of tors throughout the goldfields (Easterbrook, 1993). In addition, Johnson and Meade (1990), and Morton and Hallsworth (1999) have shown that further weathering of sediment occurs during periods of alluvial storage on floodplains, which may have resulted in additional clay minerals being produced.

b) The seepage of muddy water through gravel alluvium may result in the deposition of mechanically infiltrated clays (Moraes and De Ros, 1990). Mechanically infiltrated clays tend to be concentrated within the vadose zone (due to the evaporation of infiltrated water), within the water table (due to a decrease in the velocity of percolating water in the phreatic zone) and above impermeable barriers, such as bedrock-gravel contacts (due to the filtering of clay particles above barriers in the phreatic zone; Moraes and De Ros, 1990). During floods, the White Channel Gravel floodplain would have been repeatedly inundated with muddy water that enhanced the formation of

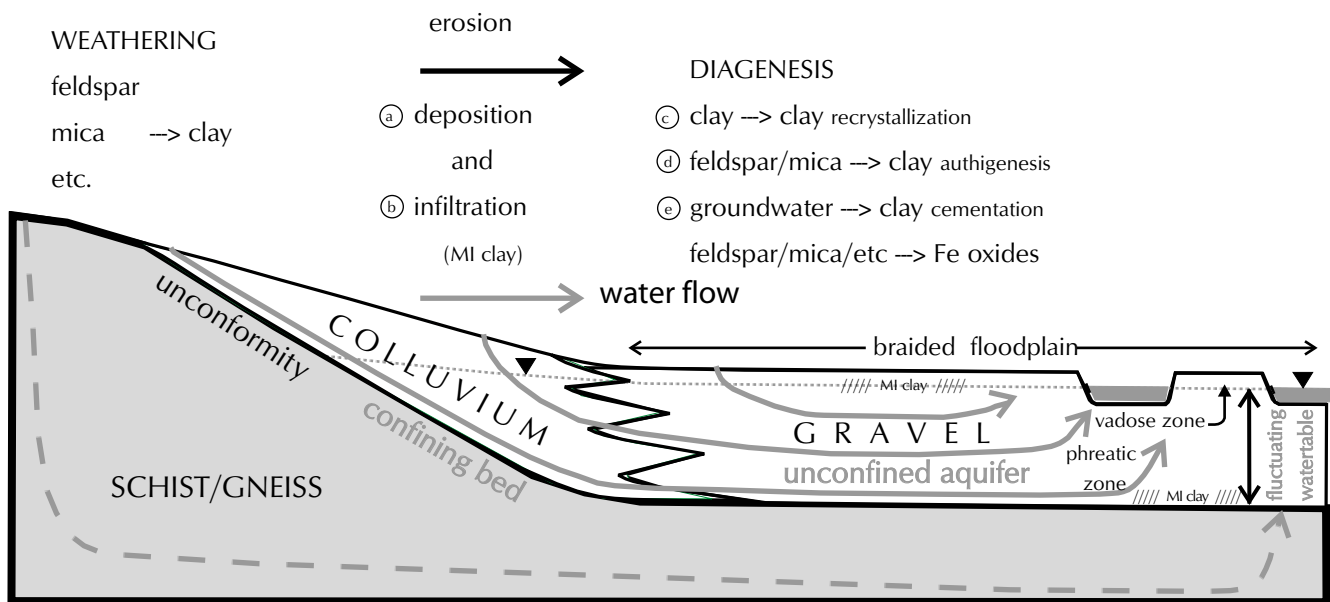


Figure 15. Schematic diagram summarizing the origin of alteration in the White Channel Gravel (MI= mechanically infiltrated, ▼= water table)(see text for explanation).

mechanically infiltrated clays. In addition, the White Channel Gravel represents a water table aquifer, or unconfined aquifer, that is confined to the relatively impermeable bedrock walls of the valley. Hence, the floodplain water table, which is closely associated with the river stage, changes as groundwater flow through the aquifer varies (Fetter, 1988). According to Moraes and De Ros (1990), fluctuations in the water table can result in the formation of poorly horizontal clay-rich zones that may or may not cut across sedimentary structures. These zones, which correspond to former positions of the water table, can be relatively narrow (centimetres) or thick (up to tens of metres), depending on the length of time the water table was maintained at a particular level (Moraes and De Ros, 1990). Dufresne (1987) described clay-rich zones that occur above the gravel-bedrock contact in the White Channel Gravel and transect primary sedimentary structures, but he interpreted these zones as evidence of ascending hydrothermal fluids.

- c) Once deposited, allogenic and mechanically infiltrated clay minerals may recrystallize. This diagenetic process mainly involves a change in size (commonly an increase) or shape of mineral crystals without significant changes in composition (Boggs, 1987).
- d) Other allogenic minerals (such as feldspar, mica and chlorite) deposited with the White Channel Gravel may undergo diagenetic alteration to authigenic clay minerals (kaolinite, illite and smectite), similar to the weathering process described previously. Depending on their abundance, these new minerals may or may not act as a cement in the White Channel Gravel (Boggs, 1987).
- e) New clay minerals (particularly kaolinite) may have precipitated from interstitial pore water and circulating groundwater as diagenetic pore filling cement (Boggs, 1987). Groundwater flow would have been enhanced by the large differences in hydraulic conductivities (i.e., the capacity of sediment to transmit water) between the White Channel Gravel and the underlying bedrock. This may have resulted in a concentration of groundwater flow near the gravel-bedrock contact, which could account also for the formation of the iron oxide cement commonly observed at this contact and which Dufresne (1987) interpreted as evidence for hydrothermal alteration. The iron for the cement was most likely supplied by an intrastratal solution of detrital silicate minerals such as hornblende, chlorite,

biotite, as well as detrital magnetite and pyrite (Tucker, 1981). In addition, iron oxide can be seen precipitating at the bedrock-gravel contact at almost every exposure of the White Channel Gravel and other gravel units throughout the Klondike goldfields.

Also, Cox et al. (2002) found that there is a positive correlation between quartz-pebble conglomerate abundance and age, indicating that diagenetic factors, and not necessarily intense chemical weathering, protracted sediment transport, or sediment recycling, play an important role in quartz-pebble conglomerate formation, such as the White Channel Gravel.

Placer gold from Matson Creek (a tributary of the Sixty Mile River) was interpreted by Wetherley (1983) to have formed by the reprecipitation of gold in soil, the topographic surface of which was slowly lowered by erosion, resulting in the reconcentration of the precipitated gold. Although no studies have been done on the major and minor trace element compositions of gold particles from this area, Dumula and Mortensen (2002) have analysed the composition of placer and lode gold from other drainages in the study area. They concluded that placer gold from Eureka and Black Hills creeks (tributaries of the Indian and Stewart rivers, respectively) was derived from an epithermal source near the headwaters of these drainages; that placers in the Moosehorn Range area were derived from intrusion-related, gold-bearing quartz veins; and that placers in Thistle and Kirkman creeks (tributaries of the Stewart River) were also likely derived from an as-yet-undiscovered intrusion-related gold-quartz veins. Hence, there is no compelling evidence that gold nuggets (or any 'coarse' placer gold) in the study area formed by chemical precipitation.

In a comprehensive review of ophiolite-related gold-quartz veins throughout the North American Cordillera, Ash (2001) noted that coarse native gold is commonly associated with these deposits. For example, a 72.8 kg (2340 troy ounce) piece of gold was produced from the Carson Hill mine in the Mother Lode belt in central California (Ash, 2001). He further noted that most large placer gold deposits in the Canadian Cordillera (such as Barkerville, Atlin and the Klondike), show a close spatial relationship to ophiolite rocks within, and marginal to, terrane-collisional boundaries. As discussed in the section on Bedrock Geology, the Yukon-Tanana Terrane and Slide Mountain Terrane were juxtaposed by regional-scale thrust faulting in Early Mesozoic time (Mortensen, 1996). Ash (2001) suggested that the

Klondike goldfields reside immediately below or in close proximity to terrane-bounding sutures between the Slide Mountain Terrane and Yukon-Tanana Terrane, and he proposed that the main source of coarse placer gold in the Klondike goldfields were gold-quartz veins hosted by the Slide Mountain Terrane ophiolitic rocks (i.e., greenstone and serpentinite), which are now mostly eroded and preserved as isolated klippen above Yukon-Tanana Terrane metasedimentary rocks. This thought provoking hypothesis remains to be tested.

Concentration of gold

Practically all of the placer deposits in the study area are fluvial in origin (the exception is colluvial placers in the headwaters of 7 Pup, a tributary of Bonanza Creek).

Table 4. Occurrence and formation of fluvial placers (modified from Slingerland and Smith, 1986).

Scale of placer accumulation	Observed sites of placer accumulation
Small scale (beds, 10 ⁰ m)	Scoured bases of trough cross-strata sets
	Winnowed tops of gravel bars
	Thin ripple-form accumulation
	Dune crests
	Dune foresets
	Plane-parallel laminae
	Leeward side of obstacles
	Beach berms
Intermediate scale (bars, 10 ² m)	Concave side of channel bends
	Convex banks of channel bends
	Heads of midchannel bars
	Point bars with suction eddies
	Scour holes, especially at tributary confluences
	Inner bedrock channels and false bedrock
	Bedrock riffles
	Constricted channels between banks and backward-migrating bars
Beach swash zones	
Large scale (systems, 10 ⁴ m)	Bands parallel to depositional strike
	Heads of wet alluvial fans
	Points of abrupt valley widening
	Points of exit of highland rivers onto a plain
	Regional unconformities
	Pediment mantles

The process of mechanical concentration of placer gold depends on several basic principles involving specific gravity, grain size, and grain shape as influenced by the velocity of water in the stream (Blatt et al., 1991). According to Blatt et al. (1991), the effect of specific gravity on mineral segregation is more important than the effects of grain size and grain shape because the difference in specific gravity is accentuated in water as compared to air: the ratio of gold (specific gravity = 19) to quartz (specific gravity = 2.6) in water (specific gravity = 1) is $(19-1)/(2.6-1)=11.25$; whereas in air (specific gravity = 0) the ratio is only $19/2.6 = 7.3$. Thus gold is more readily separated from quartz in water than it is settling in air.

A very important concept in fluvial sedimentology is that different depositional processes operate at different physical scales (Miall, 1996). Slingerland (1984) and Slingerland and Smith (1986) recognized a three-fold hierarchy in the occurrence and formation of fluvial placers (Table 4): small (bed) scale (10⁰ m), intermediate (bar) scale (10² m) and large (system) scale (10⁴ m). Recent advances in fluvial geology by Miall (1996) have shown that fluvial deposits can be grouped into 10 classes spanning at least 12 orders of magnitude of time scale (i.e., from lamina, representing only a few seconds of deposition, to the basin-fill complex, representing time spans of millions to tens of millions of years). Combining the work of Slingerland (1984), Slingerland and Smith (1986), and Miall (1996), the concentration of gold in placer deposits in the study area can be understood in terms of a five-fold hierarchy of physical scales (Fig. 16): lithofacies (the smallest size), element, reach, system and sequence (the largest size).

a) The lithofacies scale is up to metres in size (and days in duration) and represents beds classified on the basis of texture and sedimentary structures. Typical lithofacies present are Gh (clast-supported, crudely bedded gravel), Gp (cross-bedded gravel) and Sp (cross-bedded sand). At this scale, the important processes forming placers are suspension sorting (i.e., the free settling of particles in water, during which the minerals with the largest settling velocities are deposited first and those with the smallest settling velocities are deposited last); entrainment sorting (i.e., the carrying or dragging of particles from a granular bed by flowing water, a process that is dependent on particle size, shape and density); transport sorting (i.e., the transport of particles by flowing water, during which oversized and dense particles are transported at a different rate than smaller, less dense particles); shear sorting (i.e., the pushing of particles in a moving granular layer due

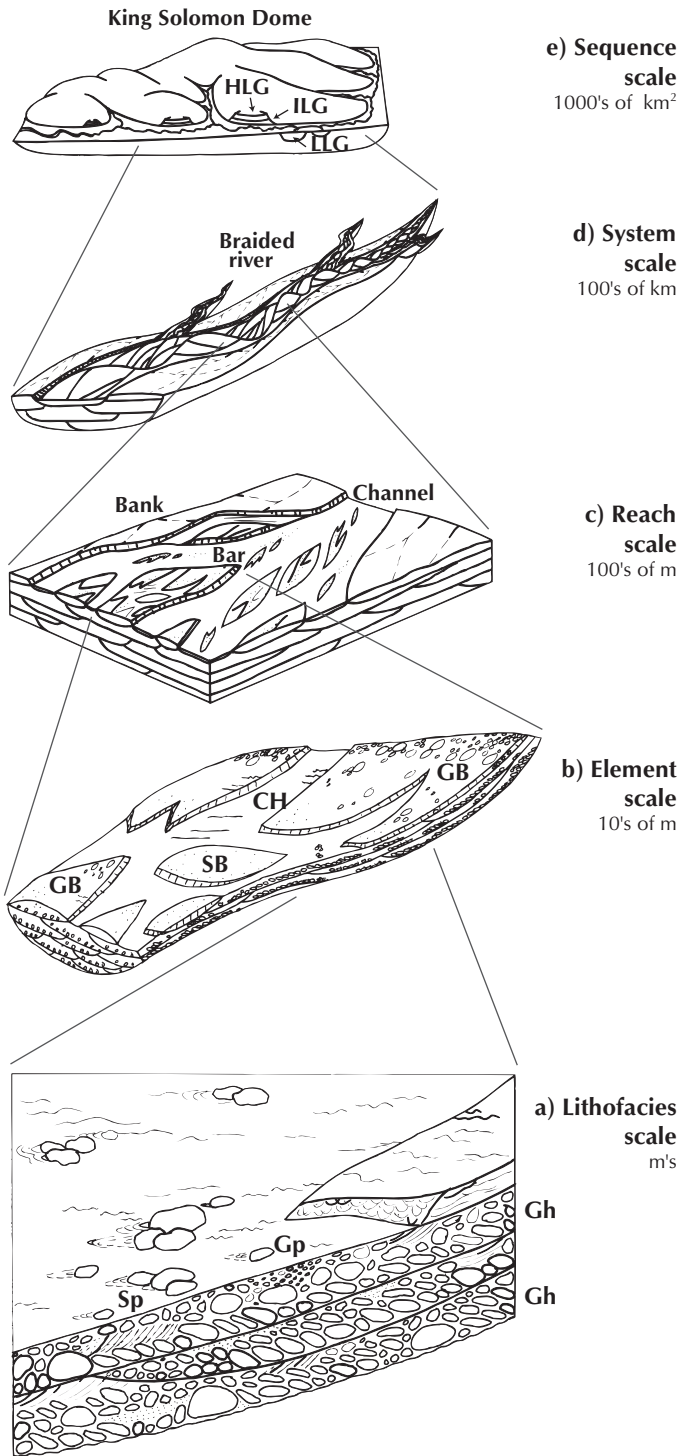


Figure 16. Schematic diagram summarizing the five-fold hierarchy of physical scales related to the concentration of gold in the study area (see text for explanation). HLG = high-level gravel, ILG = intermediate-level gravel, LLG = low-level gravel, GB = gravel bar, SB = sand bar, CH = channel fill deposits, Sp = cross-bedded sand, Gp = cross-bedded gravel, Gh = clast-supported, crudely bedded gravel.

to particle collisions; Slingerland and Smith, 1986); and bed roughness (i.e., the unevenness of the surface of gravel pavement, the uppermost layer of gravel at the bottom of a stream; Day and Fletcher, 1991). Bed roughness is probably the most important process since the surface of newly formed gravel pavement resembles the riffles of a sluice box (Fig. 17). Day and Fletcher (1991) found that a high degree of bed roughness results in high-density minerals being trapped in the voids between gravel particles, and that if the bed roughness is minimal, high-density minerals are less effectively trapped. The degree of entrapment of high-density minerals tends to increase as their density increases, but decreases as their particle size decreases (Day and Fletcher, 1991). Jacob et al. (1999) distinguished between three types of gravel fabrics and their abilities to trap heavy minerals: matrix-supported gravel; framework-supported gravel in which the voids are in-filled simultaneously with deposition of the clasts; and framework-supported gravel in which there are generations of infilling of the voids. Only the later gravel fabric, referred to as a “compound gravel fabric” and generated by the successive addition of sediment into a relatively fixed framework, was found to be economical (Jacob et al., 1999). In addition, Allan and Frostick (1999) discovered that during flood flows, the framework of the uppermost gravel layer lifts and dilates, causing trapped minerals to move further down into gravel voids at deeper levels. Hence at the lithofacies scale, gravel lithofacies, particularly Gh, are preferentially enriched in gold relative to sand lithofacies.

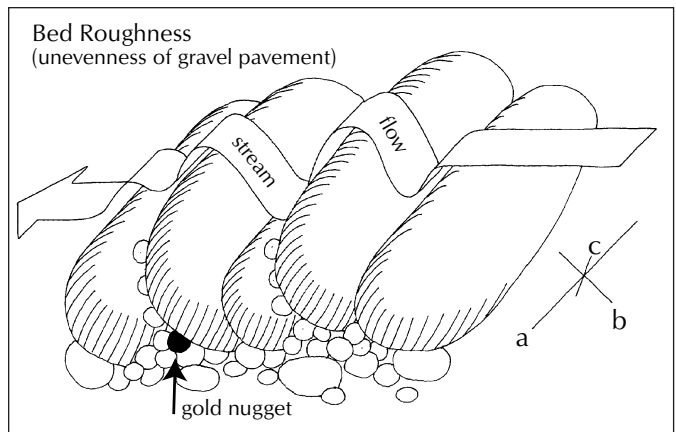


Figure 17. Schematic diagram showing the influence of bed roughness on the concentration of placer gold at the lithofacies scale.

- b) The element scale is tens of metres in size (and years in duration) and represents an amalgamation of lithofacies into fluvial architectural elements (i.e., the ‘building blocks’ of depositional environments). Typical elements are GB (gravel bars), SB (sand bars), and CH (channel fill deposits). At this scale, the important process forming placers is the accumulation of gravel beds (lithofacies Gh) into gravel bars (element GB). Hence, gravel bars become enriched in gold relative to sand bars because gravel bars are made up of the gold-bearing gravel beds. Heavy minerals are also preferentially concentrated at the heads of bars because this is where they first encounter bed roughness (i.e., heavy minerals get trapped here first), bars tend to decrease in particle size downstream (and so bed roughness decreases down-bar), and bars tend to migrate slowly downstream, which results in their progressive enrichment as the bar head is continually eroded (Slingerland, 1984; Jacob et al., 1999). In addition, Jacob et al. (1999) discerned two types of ‘trapsites’. Fixed trapsites, which were found to have higher concentrations of heavy minerals, are generated by relatively fixed turbulent eddies in the stream flow near bedrock (Jacob et al. 1999). They are characterized by very coarse-grained, compound gravel fabrics associated with bedrock scours, bedrock-attached bars, and bedrock highs, and represent initial bar growth (i.e., ‘cluster bedforms’) and lag deposits (Jacob et al., 1999). Mobile trapsites, which were found to have lower concentrations of heavy minerals, are generated by transient eddies in the stream flow and are characterized by finer grained, compound gravel fabrics associated with mature bars (Jacob et al., 1999).
- c) The reach scale is hundreds of metres in size (and tens of years in duration) and represents a continuous length of a stream channel (including the bars, smaller channels and banks). At this scale, the important processes forming placers are stream junctions (Mosley and Schumm, 1977), valley widening (Slingerland, 1984), and the gradient of the stream (Hester, 1970; Slingerland, 1984; Day and Fletcher, 1991). Day and Fletcher (1991) found that steep gradients resulted in the transportation of heavy minerals, whereas gentle gradients resulted in the trapping of heavy minerals, and Hester (1970) determined that concentrations of gold occurred along Dominion Creek where the valley flattens appreciably. Hence, stream gradient, or slope of the stream channel, particularly abrupt decreases in slope, is probably the most important factor determining the formation of placers at the reach scale.
- d) The system scale is hundreds of kilometres in size (and hundreds of years in duration) and represents a sedimentary environment, such as a river or alluvial fan. The braided river environment (characterized by many channels separated by small bars or islands, and coarse-grained alluvium) deposited most of the placers in the study area.
- e) The sequence scale is thousands of square kilometres in size (and thousands of years in duration) and represents mappable stratigraphic units (i.e., formations or members) made up of one or more sedimentary environments. Three out of the four gravel units recognized in the study area formed economical placers: the high-level White Channel Gravel, the intermediate-level gravel and the low-level gravel. At this scale, placer formation is the result of long-term interactions among time-averaged flow variables in the river system, the availability of heavy minerals, and various ‘forcing mechanisms’ (Schumm, 1977; Slingerland and Smith, 1986).

Evolution of placers

The term ‘forcing mechanism’ refers to processes that cause the ‘Earth system’ to change: internal (autogenic) processes include tectonics, volcanism and biological evolution, and external (allogenic) processes include orbital changes (climate) and extraterrestrial impacts³. Out of the three fundamental forcing mechanisms affecting fluvial systems (i.e., tectonics, climate and sea-level change), only tectonics and climate are important because the study area is considered too far inland to have been affected by changes in sea-level. Tectonics and climatic change may result in changes in base level and accumulation space in fluvial systems, which are preserved as cycles of aggradation and incision (Blum and Törnqvist, 2000). Base level refers to the lower limit to which a stream erodes its base (i.e., the ‘geomorphic’ concept of base level), and accumulation space refers to the space made available for potential sediment accumulation (Blum and Törnqvist, 2000).

Tempelman-Kluit (1980) suggested that most of west-central Yukon (including the study area) was a “mature surface of low relief” that was uplifted in Late Miocene or Pliocene time, but he did not propose a mechanism for the uplift. As stated previously, the uplifted area,

³<http://www.clas.ufl.edu/users/emartin/GLY3074F01/assignments/bestforcing.htm>

referred to physiographically as the Klondike Plateau, is mostly underlain by Paleozoic, medium- to high-grade, polydeformed metasedimentary and meta-igneous rocks belonging to the Yukon-Tanana Terrane and minor amounts of altered mafic rocks belonging to the Slide Mountain Terrane, indicating that not only has there been widespread uplift, but there has been deep erosion as well. According to England and Molnar (1990), erosion of this magnitude is largely or completely compensated isostatically; the isostatic response is regional, affecting an area of 10 000 km² or more; and in an area undergoing isostatically compensated exhumation, bedrock moves upward while the mean surface elevation falls by ~10 to 20% of the amount of erosion (e.g., if 1000 m of bedrock have been removed by erosion, the mean surface elevation has decreased by only 100 to 200 m). Furthermore, England and Molnar (1990) note that isostatically compensated exhumation, when acting alone, reduces the crustal thickness: the crust is thinner beneath Dawson (~35 km) than Whitehorse (~39 km; Lowe and Cassidy, 1995). The uplift is interpreted to have been long-term and continuous (as opposed to ‘suddenly’ happening in Late Miocene or Pliocene time), and may be ongoing.

Accompanying the uplift was chemical weathering, which at first was probably intense, but the degree of chemical weathering decreased with time as the climate got periodically colder due to the repeated glaciation of the Yukon. McConnell (1907) concluded that, based on the predominance of quartz clasts, the White Channel Gravel is a residual deposit built up slowly over a long period of time and during which the softer bedrock was weathered and removed by erosion; Lowey (2002) reinterpreted the altered matrix of the White Channel Gravel as the result of weathering and diagenesis, during which a thick saprolite layer or highly weathered bedrock zone developed (referred to as an ‘alterite’ by soil scientists, Delvigne, 1998). McConnell (1905b, p. 83) also noted that the matrix is characterized by “small, clear, little-worn and often sharply angular grains of quartz.” Similar occurrences of angular quartz grains (and quartz-rich sand and gravel deposits, referred to as ‘white-sand’), form under humid tropical and sub-tropical conditions. Thomas (1994, p. 301) describes a deposit in Sierra Leone in which the “gravels are mainly unrolled vein quartz liberated during the chemical decay of the rocks... Dissolution of quartz also takes place. Quartz grains not only become etched, but are also subject to disintegration along incipient stress-release fractures... This process leads to the formation of quartz shards and similar angular products of disintegration.”

The abundance of kaolinite in the White Gravel unit of the White Channel Gravel may also indicate that it formed in a more temperate and humid climate (Lowey, 2002), although probably not sub-tropical.

Climatic change also influenced the deposition and erosion of the various gravel units. According to Vandenburghe (1993) and Weissmann et al. (2002), glacial advance results in rising base levels, increasing accumulation space, and aggradation, due to low vegetation, high sediment supply and high peak discharges; glacial recession results in the highest base levels, the greatest accumulation space, and the thickest deposition of alluvium; the end of glaciation results in falling base levels, decreasing accumulation space, and incision, due to the delay of vegetation, significant reduction in glacial runoff and sediment loads, and flashy seasonal floods without appreciable sediment loads; and interglaciation results in the lowest base levels, the smallest accumulation space, and the reworking of alluvium.

The combined effects of uplift and climatic change on base level and accumulation space are summarized in Figure 18 and are shown schematically in Figure 19. The following sequence of events is thought to have occurred in the evolution of placers in the study area:

- a) Emplacement of auriferous quartz veins began approximately 140 Ma ago in the Klondike area and later in other areas (e.g., Sixty Mile River area, Moosehorn Range, etc.).
- b) Intense chemical weathering culminated ~5 Ma ago. During erosion and the formation of the White Channel strath, stream power was much greater than the resisting power of bedrock, and the strath is interpreted as a tectonic terrace representing Type 1 dynamic equilibrium (cf., Bull, 1991), during which the rate of downcutting equaled the rate of uplift.
- c) Onset of the initial and most widespread of the pre-Reid glaciations resulted in a rising base level and increasing accumulation space. During deposition of the White Channel Gravel, stream power was less than resisting power, and sediment supply exceeded the transport capacity of the stream. The high-level gravel is interpreted as a depositional ‘climatic’ terrace representing a reversal in the downcutting (cf., Bull, 1991), during which the White Channel strath was buried.
- d) Glacial recession resulted in the highest base level and the greatest accumulation space. During deposition

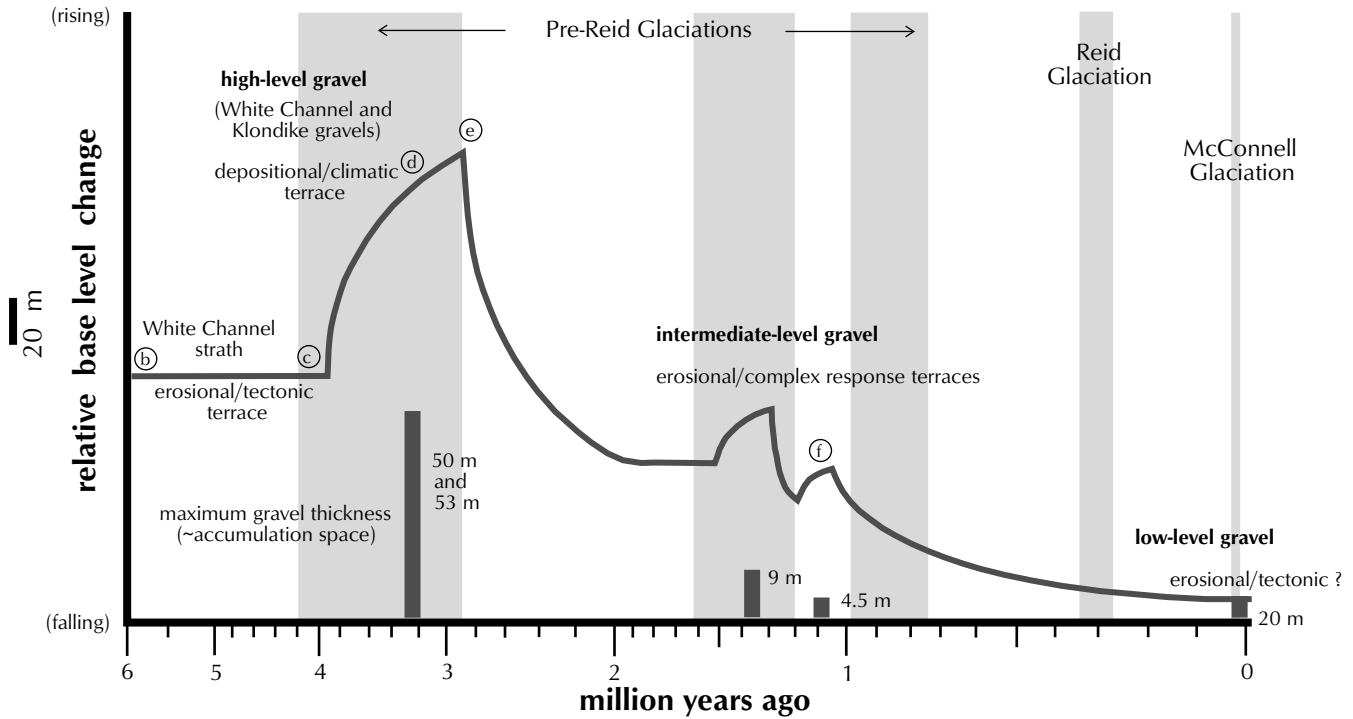


Figure 18. Schematic diagram summarizing the influence of uplift and glaciation in the formation of goldfields throughout the study area (see text for explanation).

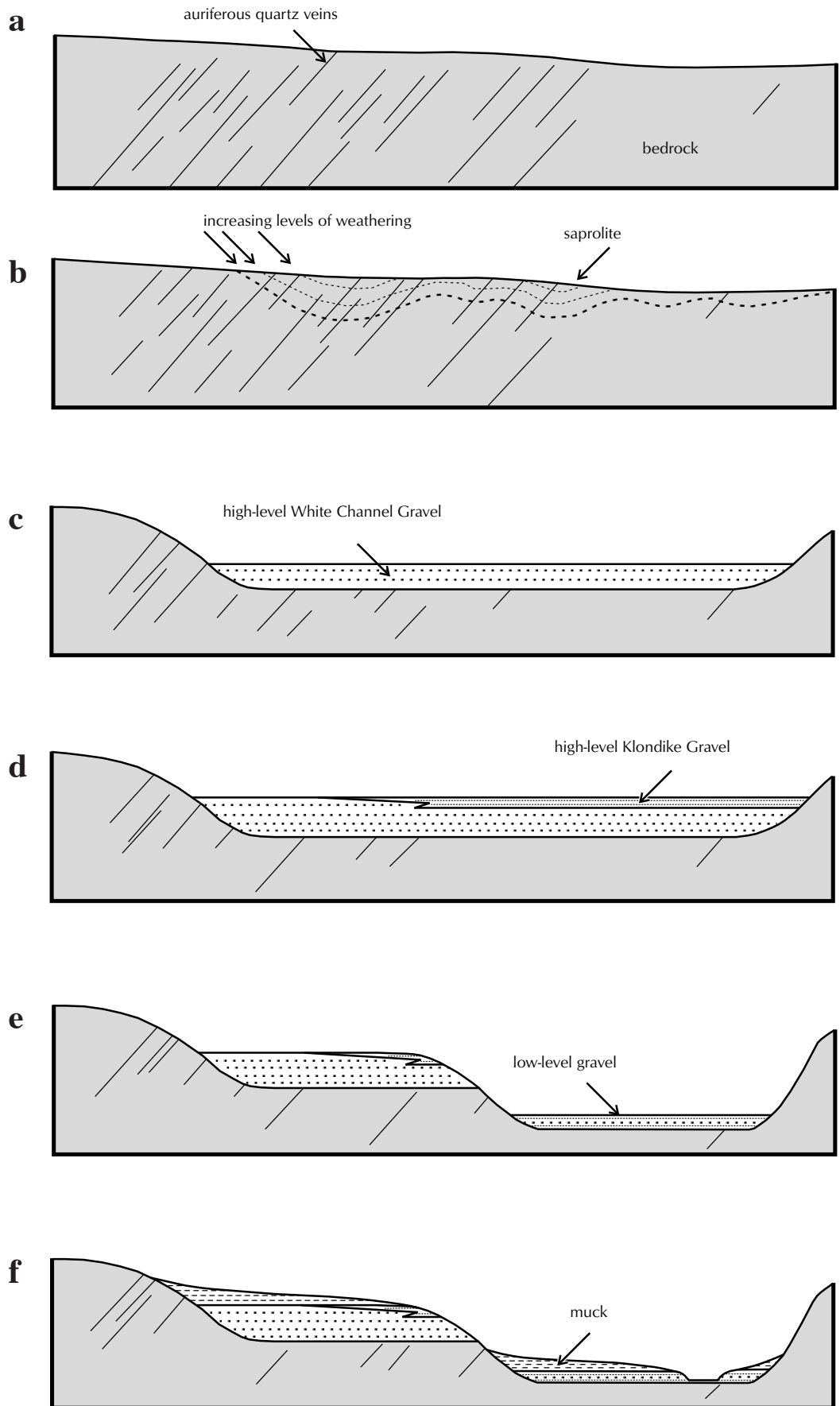
of the Klondike Gravel, stream power was less than resisting power, and sediment supply exceeded the transport capacity of the stream. Hence, the high-level gravel is interpreted as a depositional ‘climatic’ terrace representing a reversal in the downcutting (cf., Bull, 1991), during which the White Channel Gravel was buried.

- e) End of initial pre-Reid glaciation resulted in a falling base level and decreasing accumulation space. Incision of the White Channel Gravel and Klondike Gravel occurred.
- f) Interglaciation, and subsequent glaciations and deglaciations resulted in the lowest base levels and the least accumulation space and the reworking of gravel. During the deposition of the intermediate-level gravel, stream power was greater than resisting power, and sediment supply was less than the transport capacity of the stream. The intermediate-level gravel is interpreted as erosional ‘complex response’ terraces representing static equilibrium (cf., Bull, 1991), during which there were pauses in valley-floor degradation, which are attributed to the subsequent and less extensive pre-Reid glaciations. During deposition of the low-level gravel, stream power appears to have been greater

than resisting power, and the sediment supply was less than the transport capacity of the streams. The low-level gravel deposits represent a return to valley-floor degradation and possibly Type 1 dynamic equilibrium conditions, which may be related to the Reid or McConnell glaciations.

Hence, the dominant forcing mechanisms controlling the formation of the placer deposits were uplift due to isostatically compensated exhumation, and climatic change related to the repeated glaciation of the Yukon. Uplift resulted in degradation and incision of bedrock and an overall decrease of about 70 m in the base level of the evolving placers; this was punctuated by local increases in base level, due to climatic change caused by the repeated glaciation of the Yukon that resulted in aggradational events and the deposition of the various gravel units. The overall decrease in base level from high-level, to intermediate-level and finally to low-level gravel was accompanied by a decrease in accumulation space (as indicated by a decrease in gravel thickness), which resulted in a relative increase in the concentration of the placer gold. That is, gold derived from the auriferous quartz veins was initially deposited with the high-level White Channel Gravel when base level was higher, but the

Figure 19. Schematic diagram summarizing the evolution of placers throughout the study area (see text for explanation).



Placer geology of the Stewart River and Dawson map areas

accumulation space was greater, and so the placer gold concentration or grade was less in these high-level gravels (Fig. 20). The White Channel Gravel was then incised and reworked and the placer gold was redeposited with the intermediate-level gravel (not shown in Figure 20) and then the low-level gravel when base level was lower,

but the accumulation space was less, and so the placer gold concentration or grade was greater in these low-level gravels. In effect, the gold moved vertically and remained behind while the excess gravel — due to the shrinking accumulation space — was transported out of the study area.

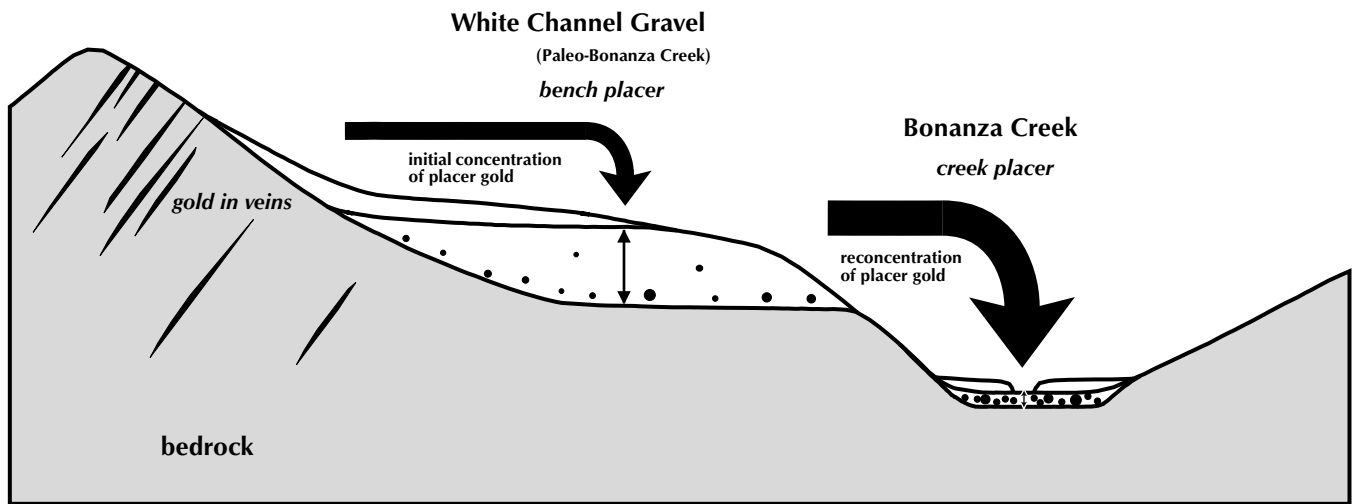


Figure 20. Schematic diagram summarizing the importance of decreasing base level and accumulation space in the reconcentration of gold throughout the study area (see text for explanation).

PLACER MINING AREAS

INTRODUCTION

This section describes the geology of active, inactive and abandoned placer mines throughout the study area and is organized according to drainages: Klondike River drainage, Indian River drainage, Sixty Mile River drainage including the Fortymile River area, Stewart River-Yukon River drainages, and the Ladue River drainage. Note that some operators of placer mines may have moved to different locations within a drainage, or to an entirely new drainage, or even shut down since the fieldwork for this project was undertaken.

KLONDIKE RIVER DRAINAGE

Location and description of area

The Klondike River drainage covers approximately 900 km² and is located immediately south of Dawson City, Yukon (Fig. 2). It includes approximately one-half of the world famous Klondike goldfields, of which the main gold-bearing streams include the Klondike River and its tributaries: Bonanza, Hunker and Bear creeks. The main gold-bearing streams, tributaries to Bonanza Creek, include Eldorado Creek and Irish Gulch. The main gold-bearing streams, tributaries to Hunker Creek, include Last Chance, Hester and Gold Bottom creeks. Allgold Creek, a tributary of Flat Creek (which is a tributary of the Klondike River), is another important gold-bearing stream in the Klondike River drainage.

Placer activity and gold production

Placer deposits in the Klondike River drainage have been mined for over 100 years (Plate 5a,b) and McConnell (1905, 1907) provides a history of the discovery of placer gold and initial mining activities. The Klondike River drainage had 47 active placer operations in 1997, with 3 along the Klondike River, 1 along Bear Creek, 18 along Bonanza Creek and its tributaries, and 25 along Hunker Creek and its tributaries (Mining Inspection Division, 1998).

Between 1978 and 2001, the Klondike River drainage produced 20.38% (375,775 oz; 11 687 900 g) of the total placer gold in the Yukon, with Hunker Creek ranked 3rd (214,813 oz; 6 681 440 g), Bonanza Creek ranked 5th (123,099 oz; 3 828 810 g), Eldorado Creek ranked 16th (37,833 oz; 1 176 700 g), the Klondike

River ranked 27th (17,991 oz; 559 580 g), Bear Creek ranked 28th (17,058 oz; 530 560 g), Gold Bottom Creek ranked 29th (16,610 oz; 516 630 g), Allgold ranked 37th (8767 oz; 272 700 g) and Upper Bonanza Creek ranked 44th (5011 oz; 155 900 g) in terms of production (W.P. LeBarge, pers. comm., 2002).

General description of deposits

Appendix 7 provides detailed descriptions of all deposits examined throughout the Klondike River drainage (i.e., location data, stratigraphic-sedimentologic section and panel diagram). This section on general deposit descriptions provides a summary of that information and the next section provides detailed descriptions of selected placer mines.

Distribution

The high-level White Channel Gravel (Plate 5c,d, 6a,b) occurs as prominent, high-level terraces along the Klondike River, and Bonanza and Hunker creeks, and their tributaries: along the left limit of the Klondike River (i.e., in a downstream direction Australia Hill, Jackson Gulch and Lovett Hill); along the left limit of Eldorado Creek, the main tributary to Bonanza Creek (i.e., in a downstream direction French Hill and Gold Hill); along the right limit of Bonanza Creek upstream from Eldorado Creek (i.e., Bunker Hill); along the left limit of Bonanza Creek downstream from Eldorado Creek (i.e., in a downstream direction Adams Hill, Magnet Hill, American Hill, Orofino Hill, Monte Cristo Hill, King Solomon Hill and Boulder Hill); along the right limit near the mouth of Bonanza Creek (i.e., in a downstream direction Ophir Hill, Cripple Hill, Trail Hill and Lovett Hill); along the left limit of Hunker Creek (i.e., in a downstream direction Delhi Hill, Temperance Hill, Nugget Hill, Paradise Hill, Preido Hill and Dago Hill); along the left limit of Last Chance Creek, a tributary of Hunker Creek (i.e., in a downstream direction Treasure Hill and Discovery Hill); and along the right limit near the mouth of Hunker Creek (i.e., Australia Hill, Map 1). Although McConnell (1905b) indicated that the White Channel Gravel also occurs along the left limit of All Gold Creek (a tributary of Flat Creek), no exposures of the White Channel Gravel could be found. The high-level Klondike Gravel (Plate 5e,f) occurs as high-level terraces along the left limit of the Klondike River (i.e., in a downstream direction Australia Hill,

Placer geology of the Stewart River and Dawson map areas

Jackson Gulch, Lovett Hill and the Klondike Bench), and along the left limit of All Gold Creek.

The intermediate-level gravel (Plate 6c,d) occurs as irregular, intermediate-level terraces along the left limit of Bonanza Creek (just downstream from Mosquito Gulch) and the right limit of Bonanza Creek, at Trail Hill, and according to W.P. LeBarge (pers. com., 2004), on Hunker Creek below Dago Hill. It was also observed on a bedrock terrace approximately 5 m above Allgold Creek. The low-level gravel (Plate 6e,f) represents present day river, creek and gulch deposits throughout the Klondike River drainage.

Thickness

The White Channel Gravel is up to 46 m thick and increases overall in thickness in a downstream direction along Bonanza and Hunker creeks. Measured sections of the high-level White Channel Gravel range from 7 to 15 m thick, with 3 to 6 m of the White Gravel (where present) and 2 to 4 m of the Yellow Gravel (where present). The Klondike Gravel is up to 53 m thick and generally decreases in thickness in a downstream direction along the Klondike River. Measured sections range from 2 to 27 m thick. The intermediate-level gravel is up to 4 m thick and measured sections range from 0.5 to 4 m thick. The low-level gravel is up to 10 m thick and measured sections range from 0.2 to 10 m thick. A greater thickness of gravel occurs in the Klondike River and Yukon River (up to 10 m thick) compared to creek and gulch gravel (up to 5 m thick).

Texture (grain size/roundness/sphericity)

The high-level gravel ranges from sandy muddy gravel to gravel, with muddy sandy to sandy gravel as the most common textures (Fig. 21). The intermediate-level gravel includes muddy sandy gravel and sandy gravel, whereas the low-level gravel ranges from sandy muddy gravel to sandy gravel, with muddy sandy gravel as the most common texture. All three levels of gravel show similarities in roundness (i.e., subangular to rounded particles) and sphericity (i.e., subdiscoidal to subprismoidal particles), although the high-level White Gravel unit of the White Channel Gravel displays the lowest spread in particle shape and the low-level gravel displays the greatest spread (Fig. 22).

Clast lithology

Quartz, igneous and metamorphic rock particles are present in all three levels of gravel, but sedimentary rock particles are present only in the Klondike Gravel and the

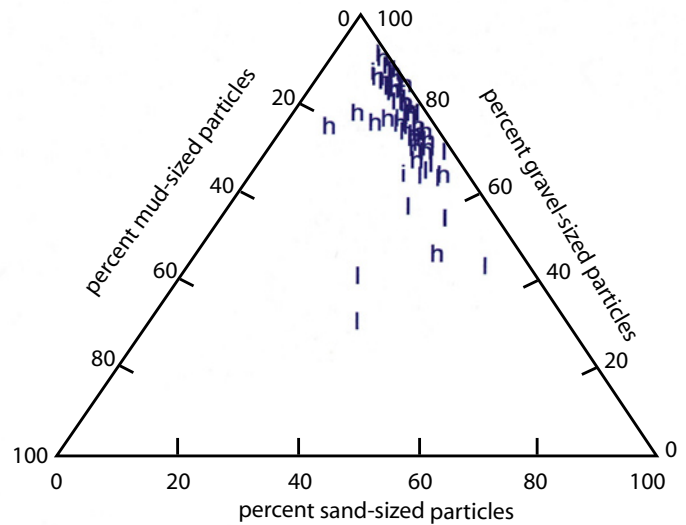


Figure 21.* Ternary diagram of particle size analysis of gravel throughout the Klondike River drainage. h = high-level gravel, i = intermediate-level gravel, l = low-level gravel.

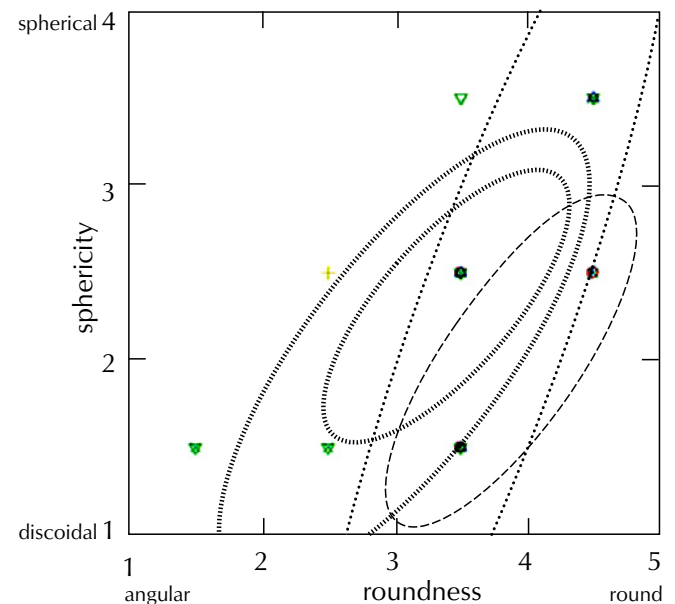


Figure 22.* Scatterplot of particle shape analysis of gravel throughout the Klondike River drainage.

Legend for Figures 22 and 23

Key to gravels

- hk --- high-level Klondike gravel
- hw high-level White Channel Gravel (undifferentiated)
- hww - - - high-level White Channel White Gravel unit
- hwy — high-level White Channel Yellow Gravel unit
- in intermediate-level gravel
- lo low-level gravel

*For further details, these figures are provided at larger scale on the CD-ROM.

intermediate-level and low-level gravel units (Fig. 23). Generally, the following trends are recognized in the different levels of gravel: for the high-level White Channel Gravel, as the percentage of quartz particles increases, the percentage of igneous rock particles increases, but the percentage of metamorphic rock particles decreases; for the high-level Klondike Gravel, as the percentage of quartz particles increases, the percentage of igneous and sedimentary rock particles increases, but the percentage of metamorphic rock particles decreases; for the intermediate-level gravel, as the percentage of quartz particles increases, the percentage of igneous rock particles increases, but the percentage of metamorphic rock particles decreases; and for the low-level gravel, as the percentage of quartz particles increases, the percentage of igneous rock particles and metamorphic rock particles increases.

Age

The section on general stratigraphy, sedimentology and placer formation discusses in detail the age of the various levels of gravel. The high-level White Channel Gravel is considered Early Pliocene to earliest Late Pliocene (~5 to 3 Ma) and the high-level Klondike Gravel is considered earliest Late Pliocene (~3 Ma); the intermediate-level

gravel is thought to be Late Pliocene to Early Pleistocene (~3 to 1.8 Ma); and the low-level gravel is Late Pleistocene to Holocene (~1.8 to 0 Ma).

Environment of deposition/paleoflow direction

Practically all of the placers are fluvial in origin and were deposited in streams that flowed in the same direction as the present day streams in which the placer deposits occur. The only exception is placers on 7 Pup, a tributary of upper Bonanza Creek, which are colluvial in origin.

Heavy minerals

All three levels of gravel contain similar heavy mineral concentrate assemblages that are dominated by magnetite, hematite and minerals locally derived from metamorphic and igneous rocks (i.e., hornblende, garnet, enstatite, kyanite, actinolite, chlorite, sphene, spinel and zircon; Appendix 5). Perhaps the most comprehensive study of heavy minerals in the Klondike was by Gleeson (1970) who identified 48 minerals and concluded that most of these were derived from local bedrock sources (with the exception of the Klondike Gravels which were partly derived from the Ogilvie Mountains). Ray (1962) also undertook a study of heavy minerals in this area and reported that no "anomalous associations" were found.

Gold characteristics

Placer gold recovered from the high-level Klondike Bench is mostly fine grained (i.e., less than 2 mm), with a fineness of 810. McConnell (1905) states that placer gold in the high-level White Channel Gravel is lighter in colour, coarser grained, has a lower fineness and is more angular than gold in adjacent streams. Generally, gold recovered from the White Channel Gravel along Bonanza Creek varies from fine to coarse grained (i.e., 1 to 4 mm), with a fineness ranging from 750 to 864: at American Hill, the gold is bright and mostly fine grained (i.e., 2 mm) with a few angular, rough nuggets and a fineness of 864; at Cripple Hill, the gold is dull and has a fineness of 795; at Magnet Hill, the gold has a fineness of 670; at Bunker Hill, on upper Bonanza, the gold is fine grained (i.e., less than 2mm) with a fineness of 800; and at French Hill, on Eldorado Creek, the gold is coarse grained (i.e., greater than 2 mm) with a fineness ranging from 631 to 750. Generally, placer gold recovered from the high-level White Channel Gravel along Hunker Creek varies from fine to coarse, with a fineness ranging from 735 to 860: at Australia Hill, the gold is flat and smooth with no nuggets and a fineness of 780; at Dago Hill, the gold is flat, round,

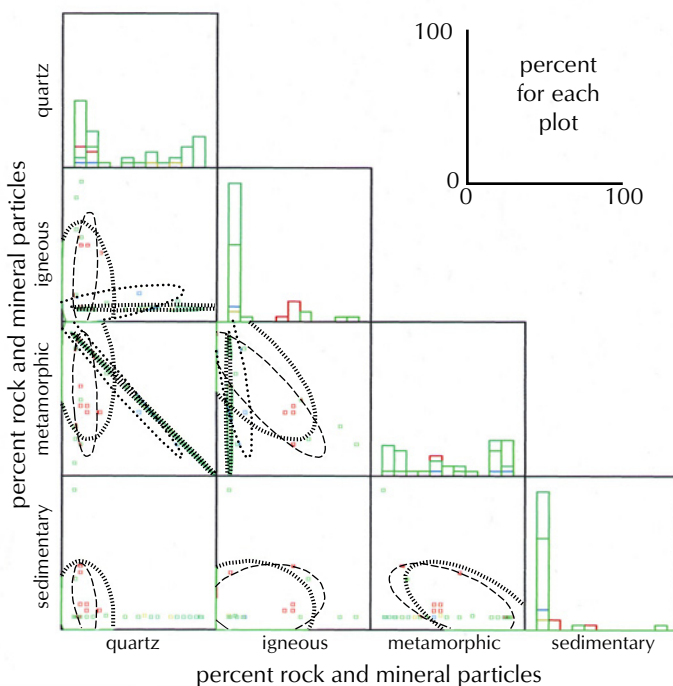


Figure 23.* Multivariate scatterplot of particle composition analysis of gravel throughout the Klondike River drainage.

*For further details, these figures are provided at larger scale on the CD-ROM.

rough, crystalline or wire with a fineness ranging from 798 to 859; and at Pleasure Hill, the gold is bright yellow, round and rough, with a fineness of 810.

No gold characteristics are available for the intermediate-level gravel. Placer gold recovered from low-level gravel along Allgold Creek has a fineness ranging from 858 to 860. McConnell (1905) noted that gold from Bonanza Creek is coarse grained, rough and flat in the upper part of the stream, but becomes smaller grained in the lower part of the stream. Generally, gold from Bonanza Creek has a range of fineness: 739 to 798 (lower), 781 (middle), 809-827 (upper). According to McConnell (1905, p. 91), "Eldorado creek has proved the richest creek in the Klondike district and one of the greatest placer creeks ever discovered," and the gold is very coarse grained, angular and mostly unworn; gold recovered from Irish Gulch on Eldorado Creek has a fineness range of 624 to 742. Gold from Hunker Creek also tends to decrease in grain size downstream (McConnell, 1905), and has a fineness range of 701 to 726 (lower), 725 to 820 (middle), and 798 to 859 (upper); along Last Chance Creek it has a fineness range of 683 to 832; and along Gold Bottom Creek it has a fineness range of 780 to 800. Placer gold from low-level gravel along Bear Creek has a fineness range of 644 to 746.

Description of selected placer mines

Pleasure Hill (Hunker Creek) • Tamarack Inc. (Appendix 7, GL99-23)

The White Channel Gravel is being mined by Tamarack Inc. on a high-level terrace named Pleasure Hill (Plate 7a), located on the left limit of Hunker Creek above Last Chance Creek. The gravel represents a floodplain deposit of paleo-Hunker Creek and consists of approximately 4.8 m of White Gravel (the pay gravel) overlain by approximately 3 m of Yellow Gravel, resting on chlorite schist. 'Reefs' and 'domes' occur in the bedrock, and gold is concentrated near these structures, but apparently the weathered bedrock contains no gold in paying quantities. The gold is brightly coloured, round to rough, with some nuggets, and a fineness ranging from 810 to 840.

Klondike (Lousetown) Bench (Klondike River) • Don Sanberg (Appendix 7, GL99-22)

Gravel (Klondike Gravel?) is being mined on a high-level terrace named the Klondike Bench (Plate 7b), located at the confluence of the Klondike River and Yukon River.

An exposure in a mining pit consists of 1 m of planar cross-bedded sand (displaying a southward paleoflow direction), overlain by 3.5 m of poorly bedded brown gravel, which is overlain by muck. The gravel represents a floodplain deposit of the paleo-Klondike River. Gold recovered from the gravel is mostly fine grained (90% less than 1 mm) with a fineness of 810.

Bonanza Creek • Leo Twordik, Kohlman Exploration and Mining (Appendix 7, GL01-45)

Intermediate-level gravel is being mined on a bedrock terrace located on the left limit of Bonanza Creek below Mosquito Gulch (Plate 7c). The terrace is approximately 10 m above the present day Bonanza Creek. It is incised into marble, capped by 2 m of muddy, sandy, fine cobble gravel (a mixture of slide rock and gravel deposited on the floodplain of paleo-Bonanza Creek), and overlain by muck. Numerous ice-filled old shafts and adits are present, as well as the remains of an underground railroad track. The gold is mostly fine grained (i.e., less than 1 mm) with a few small flakes. It has a fineness of 780.

Irish Gulch (Eldorado Creek) • Ron and Bern Johnson, Beron Placers Company Ltd. (Appendix 7, GL99-58)

Low-level gulch gravel is being mined by Beron Placers in Irish Gulch, a tributary of Eldorado Creek (which is a tributary of Bonanza Creek; Plate 7d). The pay gravel is approximately 0.5 m thick, light brown and rests on chlorite schist that slopes north. The gravel is overlain by 5 m of muck that contains massive ground ice and an old ice-filled adit. Placer gold recovered from this mine is rounded and smooth and has a fineness of 750.

Hunker Creek • Doug Busat, T.D. Oilfield Services Ltd. (Appendix 7, GL01-26)

T.D. Oilfield Services Ltd. is mining low-level river and creek gravel at the mouth of Hunker Creek (see Plate 6e). The pay gravel is approximately 3 m thick and consists of light grey, sandy, fine to coarse cobble gravel. It rests on pyritic graphite schist and is overlain by 6.5 m of interbedded sand and slightly muddy, sandy, fine- to medium-pebble gravel. In this area, the bedrock is wavy and uneven, quartz boulders are present, and old shafts and workings are numerous. The placer gold is dull, primarily flat and smooth with no nuggets, and has a fineness ranging from 760 to 780. Mercury contamination from old mining is present.

5 Pup, Last Chance Creek (Hunker Creek) • Lee Olynk (Appendix 7, GL00-30)

Approximately 1 m of mixed creek gravel and colluvium overlies siltstone in 5 Pup, a tributary of Last Chance Creek (which is a tributary of Hunker Creek). The low-level gravel is overlain by approximately 4 m of muck. The placer gold has a fineness ranging from 683 to 832.

Last Chance Creek (Hunker Creek) • Paul and Guy Favron, Favron (Appendix 7, GL01-23)

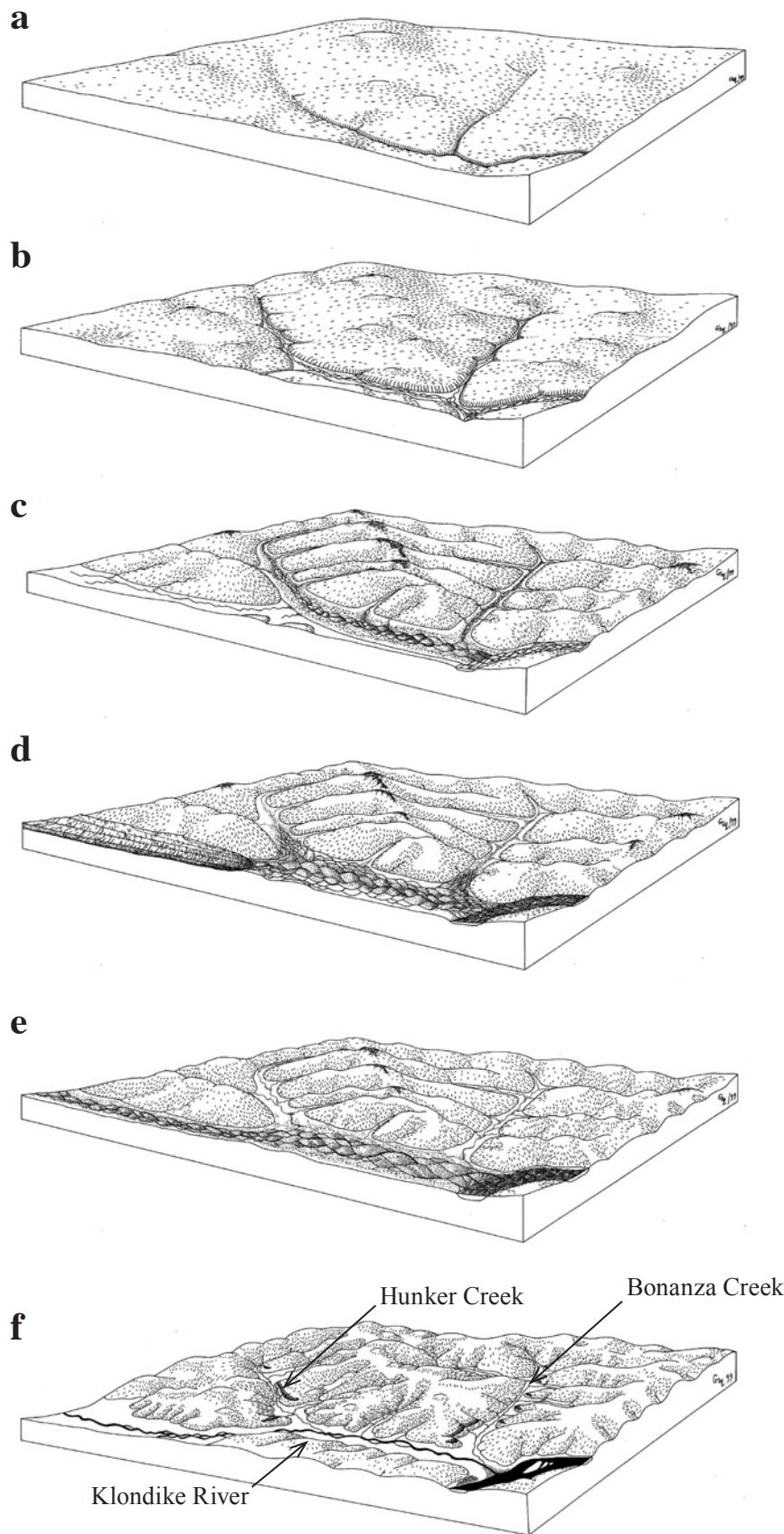
Low-level creek gravel is being mined by Favron near the mouth of Last Chance Creek (Plate 7e). The pay gravel sits on conglomerate, is approximately 1 m thick, consists of sandy very coarse-pebble gravel and is overlain by 4 m of muck and then tailings. The placer gold has a fineness ranging from 683 to 832.

Mint Gulch (Hunker Creek) • Heisey Ventures, Inc. (Appendix 7, GL01-27)

Heisey Ventures Inc. is mining low-level gulch gravel on a low bedrock bench at Mint Gulch (Plate 7f). The pay gravel rests on chlorite schist and graphite schist, is approximately 1 m thick, and consists of muddy, sandy, coarse-pebble gravel overlain by muck and slide rock. The placer gold contains a few coarse nuggets (up to 4.5 oz; 140 g).

Victoria Gulch (upper Bonanza Creek) • Jerry Bryde (Appendix 7, GL00-31)

Jerry Bryde is mining 0.5 m of colluvium and weathered, decomposed muscovite schist and minor diabase near the headwaters of 7 Pup on upper Bonanza (and just below the historic Lone Star Mine). Quartz boulders with gold attached are present, and the placer gold is mostly fine grained (less than 1 mm) and commonly crystalline, with a fineness ranging from 800 to 860.



Formation of placers

The formation of placer deposits in the Klondike River drainage is summarized in Figure 24:

- a) Approximately 10 Ma ago, the Klondike was a subdued Miocene landscape undergoing intense chemical weathering, resulting in the formation of a thick saprolite layer, the disintegration of auriferous quartz veins, and the initiation of paleo-Bonanza Creek (middle) and paleo-Hunker Creek (left) drainages;
- b) Approximately 5 Ma ago, the saprolite layer was eroded, resulting in the initial deposition of the White Channel Gravel (White Gravel unit) and the concentration of placer gold in paleo-Bonanza and paleo-Hunker creeks;
- c) Approximately 3 Ma ago, deposition of the Yellow Gravel unit of the White Channel Gravel occurred and the concentration of placer gold in paleo-Bonanza and paleo-Hunker creeks continued;
- d) Approximately 2.9 Ma ago, a pre-Reid glacier advanced down the paleo-Klondike River valley, resulting in the demise of the sedimentation of the White Channel Gravel;
- e) Approximately 2.8 Ma ago, the glacier retreated during the pre-Reid interglacial, resulting in the deposition of the Klondike Gravel;
- f) The Klondike area today shows incision of Bonanza and Hunker creek valleys. Formation of the high-level White Channel Gravel terraces has resulted in the reconcentration of placer gold in the creeks.

Figure 24. Formation of placers in the Klondike River drainage (view looking south): (a) ~10 Ma ago; (b) ~5 Ma ago; (c) ~3 Ma ago; (d) ~2.9 Ma ago; (e) ~2.8 Ma ago; (f) present.

INDIAN RIVER DRAINAGE

Location and description of area

The Indian River drainage covers approximately 1300 km² and is located south of the Klondike River drainage (Fig. 2). It contains the other half of the world-famous Klondike goldfields. Its main gold-bearing streams include the Indian River and Quartz, Montana, Eureka and Dominion creeks. The main gold-bearing stream tributary to Quartz Creek is Little Blanche Creek. Eureka Creek, and the main gold-bearing streams tributary to Dominion Creek include Sulphur and Gold Run creeks.

Placer activity and gold production

Placer deposits in the Indian River drainage have also been mined for over 100 years (Plate 8a,b); McConnell (1905, 1907) provides a history of the discovery of placer gold and initial mining activities in this area. The Indian River drainage had 32 active placer operations in 1997, with 5 along the Indian River, 4 along Quartz Creek and its tributaries, 3 along Eureka Creek, 11 along Dominion Creek, 7 along Sulphur Creek and 2 along Gold Run Creek (Mining Inspection Division, 1998).

Between 1978 and 2001, the Indian River drainage produced 38.04% (647,925 oz; 20 152 700 g) of the total placer gold in the Yukon, with Dominion Creek ranked 1st (303,457 oz; 9 438 580 g), the Indian River ranked 2nd (223,732 oz; 6 958 850 g), Gold Run Creek ranked 6th (187,885 oz; 5 843 880 g), Sulphur Creek ranked 7th (110,324 oz; 3 431 460 g), Quartz Creek ranked 10th (64,297 oz; 1 999 900 g) and Eureka Creek ranked 11th (59,027 oz; 1 835 946 g) in production (W.P. LeBarge, pers. comm., 2002).

General description of deposits

Appendix 8 provides detailed descriptions of all deposits examined throughout the Indian River drainage (i.e., location data, stratigraphic-sedimentologic section and panel diagram). This section on general deposit descriptions provides a summary of that information and the next section provides detailed descriptions of selected placer mines.

Distribution

The high-level White Channel Gravel and overlying Klondike Gravel (Plate 8c,d,e,f; 9a,b) occurs on bedrock terraces along the right limit of the Indian River just upstream from Quartz Creek. It also occurs as terraces along the right and left limits of Little Blanche Creek, the

right limit of Quartz Creek and possibly, the left limit of Dominion Creek just upstream from Rob Roy Creek.

The intermediate-level gravel (Plate 9c,d) was observed on the left limit of the lower part of Montana Creek, the left limit of its tributary Stowe Creek, and on the left and right limits of Eureka Creek. It also probably occurs in Dominion Creek (i.e., from the Indian River bridge to Gold Run creeks) and Sulphur Creek. The low-level gravel (Plate 9e,f) represents the present day river, creek and gulch deposits throughout the Indian River drainage.

Thickness

The White Channel Gravel is up to 23 m thick and increases overall in thickness in a downstream direction along the Indian River towards Quartz Creek. Measured sections range from 3 to 23 m thick. The Klondike Gravel is up to 10 m thick and generally decreases in thickness in a downstream direction along the Indian River. Measured sections range from 1 to 10 m thick. The intermediate-level gravel is up to 4 m thick and measured sections range from 0.6 to 4 m thick. The low-level gravel ranges from 0.5 to 4 m thick.

Texture (grain size/roundness/sphericity)

The high-level gravel ranges from muddy, sandy gravel to gravel, with slightly sandy gravel as the most common texture (Fig. 25). The intermediate-level gravel ranges from muddy sandy gravel to slightly sandy gravel, with sandy gravel and slightly sandy gravel as the most common textures. The low-level gravel ranges from muddy sandy gravel to slightly sandy gravel, with muddy sandy gravel as the most common texture. All three levels of gravel show similarities in roundness (i.e., subangular to subrounded particles) and sphericity (i.e., subdiscoidal to spherical particles), although the high-level Klondike Gravel displays slightly better roundness (i.e., rounded particles) and sphericity (i.e., subprismoidal particles; Fig. 26).

Clast lithology

Quartz, igneous and metamorphic rock particles are present in all three levels of gravel, but sedimentary rock particles are present only in the high-level and low-level gravel units (Fig. 27). Generally, the following trends are recognized in the different levels of gravel: for the high-level White Channel Gravel, as the percentage of quartz particles increases, the percentage of igneous rock particles remains approximately constant, but the percentage of metamorphic rock particles decreases;

Legend for Figures 26 and 27

Key to gravels

- hk --- high-level Klondike gravel
- hw high-level White Channel Gravel (undifferentiated)
- hww - - - high-level White Channel White Gravel unit
- hwy — high-level White Channel Yellow Gravel unit
- in intermediate-level gravel
- lo low-level gravel

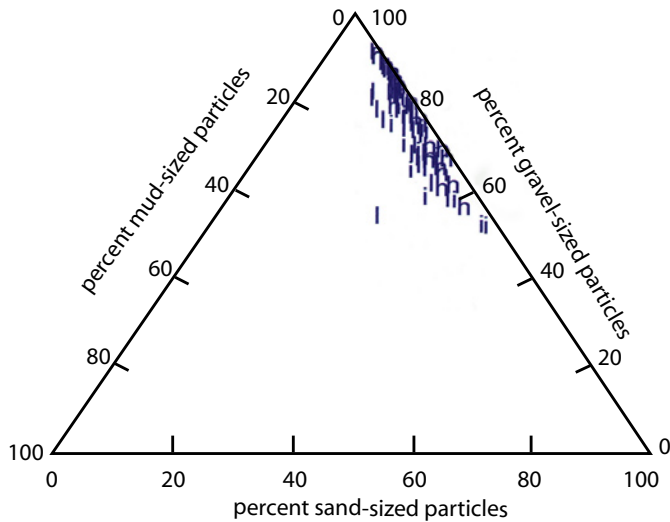


Figure 25.* Ternary diagram of particle size analysis of gravel throughout the Indian River drainage; h = high-level gravel (undifferentiated), i = intermediate-level gravel, l = low-level gravel.

for the high-level Klondike Gravel, as the percentage of quartz particles increases, the percentage of igneous, metamorphic and sedimentary rock particles is relatively constant; for the intermediate-level gravel, as the percentage of quartz particles increases, the percentage of igneous rock particles remains relatively constant, but the percentage of metamorphic rock particles decreases; and for the low-level gravel, as the percentage of quartz particles increase, the percentage of igneous and sedimentary rock particles remains relatively constant, but the percentage of metamorphic rock particles increases.

Age

The section on general stratigraphy, sedimentology and placer formation discusses in detail the age of the various levels of gravel. Usually the high-level White Channel Gravel is considered Early Pliocene to earliest Late Pliocene (~5 to 3 Ma) and the high-level Klondike

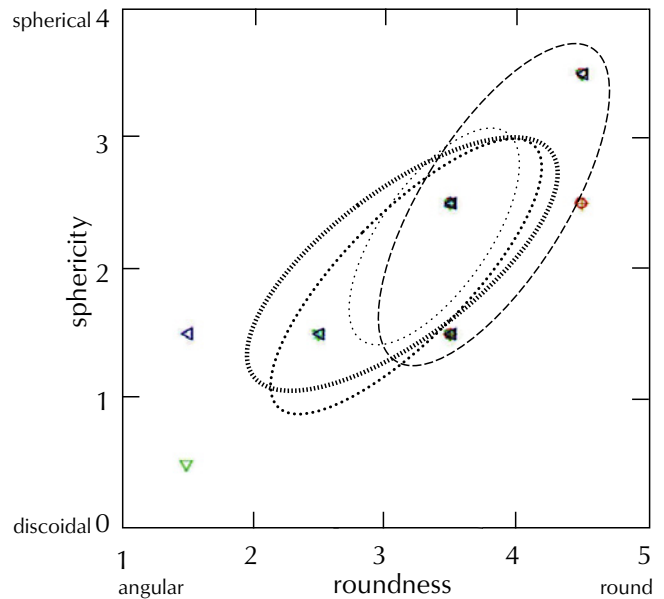


Figure 26.* Scatterplot of particle shape analysis of gravel throughout the Indian River drainage.

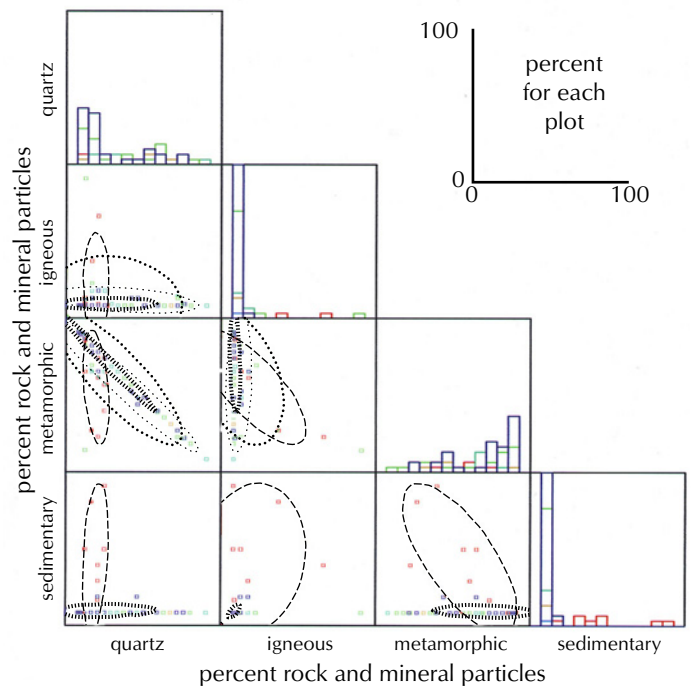


Figure 27.* Multivariate scatterplot of particle composition analysis of gravel throughout the Indian River drainage.

Gravel is considered earliest Late Pliocene (~3 Ma); the intermediate-level gravel is thought to be Late Pliocene to Early Pleistocene (~3 to 1.8 Ma); and the low-level gravel is Late Pleistocene to Holocene (~1.8 to 0 Ma).

*For further details, these figures are provided at larger scale on the CD-ROM.

Environment of deposition/Paleoflow direction

All of the placers are fluvial in origin and were deposited in streams that flowed in the same direction as the present day streams in which the placer deposits occur.

Heavy minerals

All three levels of gravel contain similar heavy mineral concentrate assemblages that are dominated by magnetite, hematite and minerals locally derived from metamorphic and igneous rocks (i.e., hornblende, garnet, enstatite, kyanite, actinolite, chlorite, sphene, spinel and zircon; Appendix 5). Mostly subangular quartz and rock fragments were recovered. Gleeson's 1970 study of heavy minerals in the Klondike reported 48 minerals, most of which were derived from local bedrock sources. Christie (1996) described a heavy mineral concentrate assemblage from Dominion Creek that included garnet, kyanite, pyrite and small amounts of magnetite and zircon.

Gold characteristics

Placer gold recovered from high-level White Channel Gravel terraces along Quartz Creek is mostly fine grained (i.e., less than 1 mm), flat and smooth, with some small, round angular nuggets. Gold recovered from the confluence of Quartz Creek and Little Blanche Creek is coarse and chunky, with a fineness ranging from 740 to 780.

Placer gold recovered from intermediate-level gravel on Montana Creek has a fineness of 770. On Eureka Creek the gold is brassy, orange and flaky, and coarse with quartz. It has a fineness ranging from 677 to 745. Placer gold recovered from intermediate-level gravel on Gold Run Creek is generally rounded, smooth and chunky, but some is flat, angular, rough or wiry, and there are a few nuggets; fineness ranges from 830 to 860. Placer gold recovered from intermediate-level gravel on lower Dominion Creek varies from rough to smooth, flattened to angular, and crystalline, to wiry or spongy, and has a fineness ranging from 845 to 865; whereas on middle Dominion Creek it is mostly fine grained (i.e., less than 1 mm) and flaky, with some spongy gold and attached quartz, and has a fineness ranging from 817 to 849. Placer gold recovered from intermediate-level gravel on Sulphur Creek is very fine grained and has a fineness ranging from 790 to 832.

Generally, placer gold recovered from low-level gravel along the Indian River has a fineness ranging from 780 to 843. Specifically, along the lower part of the Indian River it is smooth, flattened and round, and has a fineness

of 830; along the middle part of the Indian River (just below Quartz Creek), it is fine grained and has a fineness of 790; and along the upper part of the Indian River it is flaky. Placer gold recovered from low-level gravel along Quartz Creek has a fineness ranging from 732 to 800, and on Little Blanche Creek it has a fineness ranging from 650 to 710. Placer gold recovered from low-level gravel along Eureka Creek is mostly fine grained and has a fineness ranging from 677 to 745; on Montana Creek it has a fineness of 770. McConnell (1905) notes that placer gold from Dominion Creek shows a general decrease in grain size downstream, and has a fineness range from 790 to 840 (lower), to 817 to 849 (middle), to 667 to 745 (lower). Placer gold recovered from low-level gravel along Sulphur Creek has a fineness ranging from 790 to 832; on Gold Run Creek it has a fineness ranging from 830 to 878; and on Caribou Creek it has a fineness ranging from 816 to 840.

Description of selected placer mines*Quartz Creek • Kevin Tatlow, Tatlow Placer Mines Ltd. (Appendix 8, GL98-26)*

Tatlow Placer Mines Ltd. is mining high-level White Channel Gravel on a right limit bench on Quartz Creek, just below Little Blanche Creek (Plate 10a). An exposure in a mining pit consists of 15 m of White Gravel overlain by 5 m of Yellow Gravel. The gravel represents a floodplain deposit of paleo-Quartz Creek. Gold recovered from the gravel is coarse and chunky and has a fineness of 780.

Montana Creek • Don MacDonald (Appendix 8, GL00-33)

Intermediate-level gravel is being mined on a low-level bedrock terrace on the left limit of Montana Creek (Plate 10b). The terrace is approximately 4 m above present day Montana Creek. It is incised into orthogneiss and is capped by 2.5 m of slightly cobbly, sandy, very coarse pebble gravel, which is overlain by muck. The gravel represents a floodplain deposit of paleo-Montana Creek. Gold recovered from the gravel is brassy and flaky with attached quartz. It has a fineness of 770.

Eureka Creek (middle) • Wayne Tatlow, Sky Dawn Mining (Appendix 8, GL98-37)

Intermediate-level gravel is also being mined on a low-level bedrock terrace on the left limit of Eureka Creek (Plate 10c). The terrace is approximately 3 m above the present day Eureka Creek and is incised into quartz-

muscovite schist and graphite. The gravel is up to 2 m thick and is overlain by muck. It represents a floodplain deposit of paleo-Eureka Creek. Gold recovered from the gravel is mostly coarse, brassy to orange and has a fineness range of 677 to 745.

Dominion Creek (lower) • Jim Christie, Gimlex Gold Mines (Appendix 8, GL97-21,22 and GL98-39)

Gimlex Gold Mines is mining intermediate-level gravel in lower Dominion Creek. The gravel consists of 3.5 m of grey pebble gravel (interpreted as reworked White Channel Gravel) overlain by 1 m of brown granule gravel with interbedded sand lenses (i.e., Dominion Creek gravel). Placer gold recovered from the grey gravel is mostly smooth and flattened, with some wire and crystalline gold. The fineness is 860.

Dominion Creek (lower) • Norm Ross, Ross Mining Limited (Appendix 8, GL98-40)

Ross Mining Limited is also mining intermediate-level gravel in Dominion Creek, just upstream from Gimlex Gold Mines (Plate 10d). The gravel consists of 4 m of grey gravel (also interpreted as reworked White Channel Gravel) overlain by 3 m of brown granule gravel with interbedded sand lenses (i.e., Dominion Creek Gravel). The placer gold is mostly smooth and flattened, with some angular, rough and spongy gold, and has a fineness ranging from 845 to 865.

Dominion Creek (middle) • Art Sailer, Ace Placers (Appendix 8, GL98-46)

Intermediate-level gravel is being mined by Ace Placers near Jensen Creek. The gravel consists of 1 m of reworked White Channel Gravel resting on schist and overlain by 1 m of Dominion Creek gravel, which is overlain by 2-3 m of muck. The placer gold is mostly fine grained, flat and flaky, with some nuggets and attached quartz. It has a fineness ranging from 817 to 849.

Sulphur Creek • Lance Gibson, Lucky Lady Placers (Appendix 8, GL98-42)

Intermediate-level gravel is being mined by Lucky Lady Placers on Sulphur Creek (Plate 10e). The gravel consists of 1.5 m of reworked White Channel Gravel resting on quartz schist and muscovite schist and overlain by 1 m of Sulphur Creek gravel, which is overlain by 3 to 4 m of muck.

Indian River (lower) • Barry Graham (Appendix 8, GL98-21)

Barry Graham is mining low-level gravel along the left limit of the lower part of the Indian River floodplain. The gravel is up to 2 m thick and is overlain by overbank fines. Placer gold recovered from the gravel is smooth, flattened and round, with a fineness of 830.

Indian River (middle) • Dennis Foy (Appendix 8, GL98-12)

Dennis Foy is mining low-level gravel along the middle part of the Indian River, just upstream from Ophir Creek. Up to 2 m of gravel rests on rubbly shale. The gold is mostly fine grained and has a fineness of 800.

Indian River (upper) • Stuart Schmidt, Schmidt Mining (Appendix 8, GL98-35)

Low-level gravel from the Indian River floodplain is also being mined by Schmidt Mining, opposite Eureka Creek (Plate 10f). The gravel is up to 1 m thick, rests on blocky granitic gneiss and is overlain by overbank fines. The placer gold is flaky with a fineness of 820.

Dominion Creek (middle) • Miles Johnson, Maverick Gold Mines (Appendix 8, GL98-44)

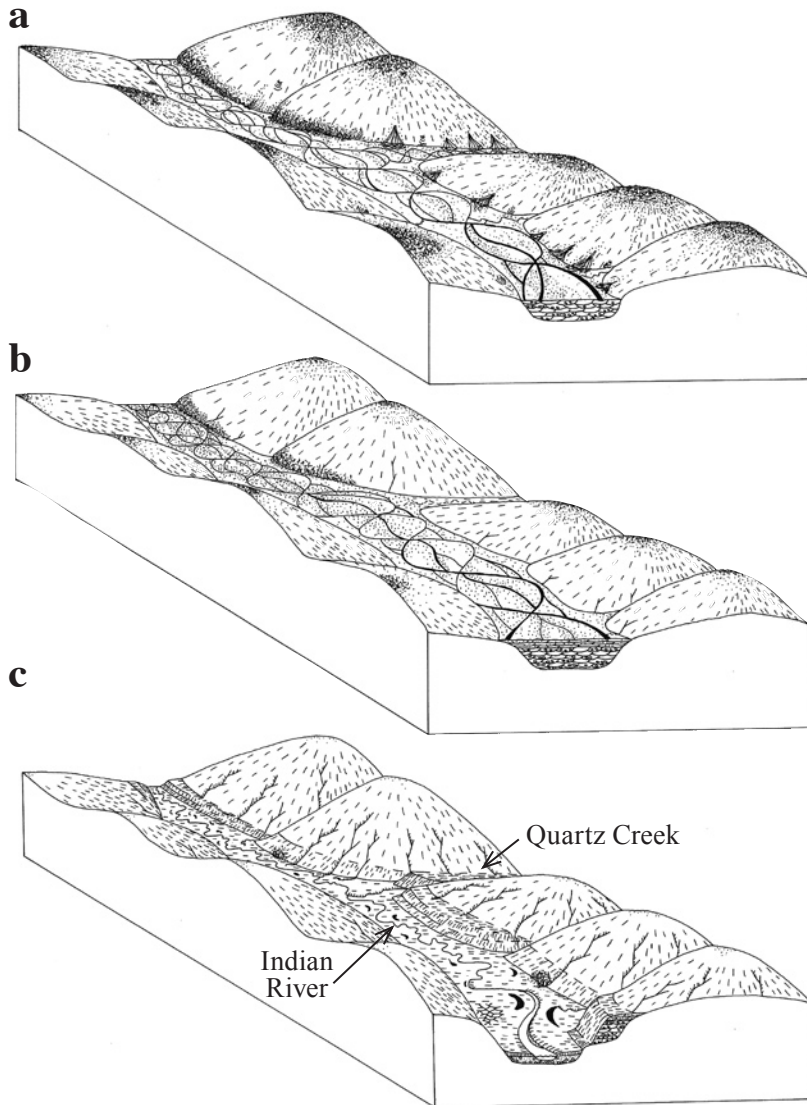
Low-level Dominion Creek gravel is being mined by Maverick Gold Mines just downstream from Jensen Creek. The gravel is up to 2 m thick, rests on biotite-muscovite schist with garnet porphyroblasts, and is overlain by 2 m of overbank fines and muck. Placer gold recovered from the gravel has a fineness ranging from 817 to 849.

Dominion Creek (middle) • Paul and Guy Favron, Favron (Appendix 8, GL00-35)

Favron is mining low-level Dominion Creek gravel near Portland Creek. Approximately 2 m of sandy fine cobble gravel and minor interbedded sand is overlain by 3 to 4 m of muck and overbank fines. The gravel rests on orthogneiss. The gold is flat, smooth or rough, and has a fineness of 820.

Caribou Creek, Jim Stuart (Appendix 8, GL98-48)

Low-level gravel is being mined by Jim Stuart along the upper part of Caribou Creek. Approximately 1 m of pay gravel resting on schist is overlain by 2 to 3 m of overbank fines and muck. The placer gold has a fineness ranging from 816 to 840.



Formation of placers

The formation of placer deposits in the Indian River drainage is summarized in Figure 28:

- a) Approximately 3 Ma ago, deposition of the White Channel Gravel (unsubdivided) took place along the paleo-Indian River (centre) and paleo-Quartz Creek (right), and placer gold was concentrated in the streams;
- b) Approximately 2.8 Ma ago, following the pre-Reid glaciation, deposition of the Klondike Gravel occurred;
- c) The Indian River area today shows incision of the Indian River and Quartz Creek valleys. Formation of the high-level White Channel Gravel terraces has resulted in the re-concentration of placer gold in the river and creek.

Figure 28. Formation of placers in the Indian River drainage (view looking west): (a) ~3 Ma ago; (b) ~2.8 Ma ago; (c) present.

SIXTY MILE RIVER DRAINAGE

Location and description of area

The Sixty Mile River drainage covers approximately 800 km² and is located west of the Klondike River and Indian River drainages (Fig. 2). It includes the historic Fortymile and Sixty Mile goldfields, and the main gold-bearing streams are the Sixty Mile and Fortymile rivers. The main gold-bearing streams tributary to the Sixty Mile River include Bedrock, Miller, Glacier, Little Gold and Big Gold creeks. Matson Creek and Ten Mile Creek, tributaries to the Sixty Mile River, are other important gold-bearing streams in the drainage.

Placer activity and gold production

Placer deposits in the Sixty Mile River drainage have also been mined for over 100 years (Plate 11a,b) and Cockfield (1921) provides a history of the discovery of placer gold and initial mining activities. The Sixty Mile River drainage had 23 active placer operations in 1997, with 4 along the Sixty Mile River, 1 along Bedrock Creek, 4 along Miller Creek, 7 along Glacier Creek, 1 along Little Gold Creek, 1 along Big Gold Creek, 3 along Matson Creek, and 2 along the Fortymile River and its tributaries (Mining Inspection Division, 1998).

Between 1978 and 2001, the Sixty Mile River drainage produced 13.32% (228,215 oz; 7 098 290 g) of the total placer gold in the Yukon, with the Sixty Mile River ranked 4th (187,885 oz; 5 843 880 g), Miller Creek ranked 13th (49,494 oz; 1 539 400 g), Tenmile Creek ranked 18th (29,077 oz; 904 400 g), Matson Creek ranked 25th (21,845 oz; 679 460 g), Glacier Creek ranked 31st (15,818 oz; 492 000 g), Little Gold Creek ranked 45th (4,857 oz; 151 100 g), Bedrock Creek ranked 49th (3,796 oz; 118 100 g) and the Forty Mile River ranked 50th (3,052 oz; 94 930 g) in production (W.P. LeBarge, pers. comm., 2002).

General description of deposits

Appendix 9 provides detailed descriptions of all deposits examined throughout the Sixty Mile River drainage (i.e., location data, stratigraphic-sedimentologic section and panel diagram). This section on general deposit descriptions provides a summary of that information and the next section provides detailed descriptions of selected placer mines.

Distribution

High-level gravel (Plate 12a,b) was observed only in the Fortymile River area. Gravel thought to be equivalent to the White Channel Gravel and Klondike Gravel occurs on bedrock terraces high above the river and along the Clinton Creek road. The intermediate-level gravel (Plate 11c,d, 12c,d) forms terraces along the left limit of Glacier Creek (where it overlies a paleo-channel cut in bedrock) and the left limit of Miller Creek in the Sixty Mile River area. It may also occur along the left limit of the Sixty Mile River just upstream from California Creek, where poorly exposed gravel was observed on a terrace above the river. In addition, intermediate-level gravel was found along the right limit of Fifty Mile Creek, the left limit of Ten Mile Creek, and gravel on a poorly exposed terrace on the left limit of Twelve Mile Creek may also be at an intermediate level. The low-level gravel (Plate 11e, f, 12 e, f) represents present-day river, creek and gulch deposits throughout the Indian River drainage.

Thickness

The high-level gravel is approximately 1 m thick. The intermediate-level gravel ranges from 1 to 12 m in thickness, and the low-level gravel is 1 to 8 m thick.

Texture (grain size/roundness/sphericity)

Muddy sandy gravel is the most common texture in all three levels of gravel (Fig. 29), although the high-level gravel includes sandy muddy gravel and gravel; the intermediate-level gravel includes muddy sandy gravel and slightly sandy gravel; and the low-level gravel ranges from muddy sandy gravel to slightly sandy gravel. The intermediate-level and low-level gravel show similarities in roundness (i.e., subangular to subrounded particles) and sphericity (i.e., subdiscoidal to spherical particles; Fig. 30). There is insufficient particle shape data for the high-level gravel.

Clast lithology

Quartz and igneous rock particles are present in all three levels of gravel, and metamorphic and sedimentary rock particles are present in all three levels of gravel with the exception of the high-level Klondike Gravel (Fig. 31). Generally, the following trends are recognized in the intermediate-level and low-level gravel: as the percentage of quartz particles increases, the percentage of igneous rock particles decreases, but the percentage of metamorphic rock particles increases. There is insufficient particle composition data for the high-level gravel.

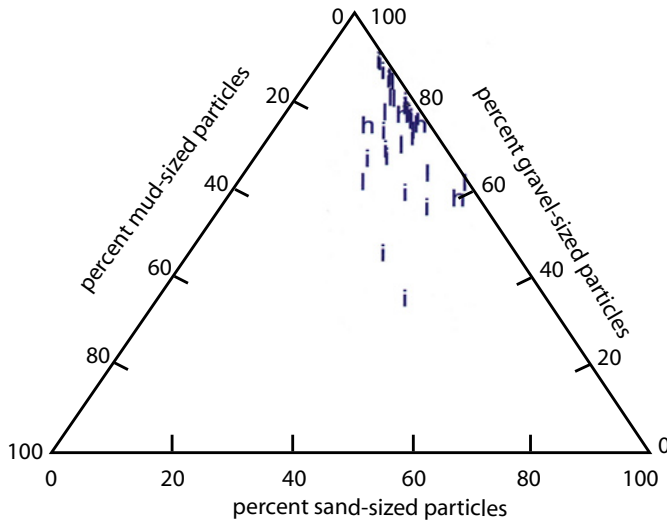


Figure 29.* Ternary diagram of particle size analysis of gravel throughout the Sixty Mile River drainage; h = high-level gravel (undifferentiated), i = intermediate-level gravel, l = low-level gravel.

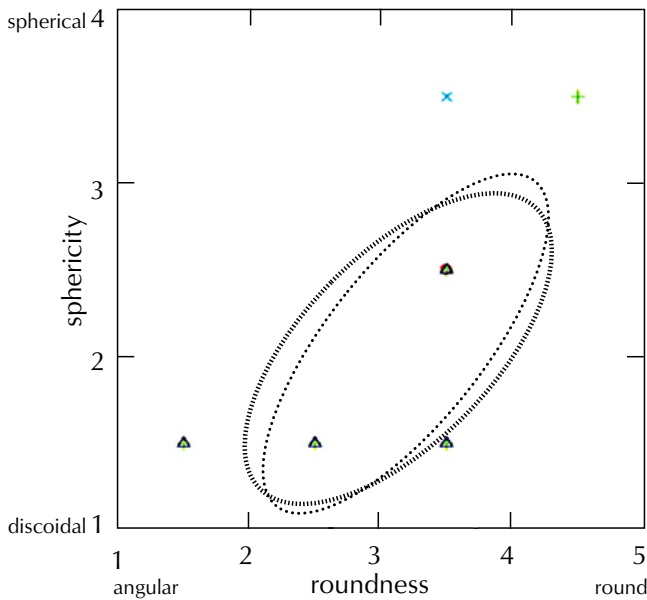


Figure 30.* Scatterplot of particle shape analysis of gravel throughout the Sixty Mile River drainage.

Legend for Figures 30 and 31

Key to gravels

- hk --- high-level Klondike gravel
- hw high-level White Channel Gravel (undifferentiated)
- hww - - - high-level White Channel White Gravel unit
- hwy — high-level White Channel Yellow Gravel unit
- in intermediate-level gravel
- lo low-level gravel

*For further details, these figures are provided at larger scale on the CD-ROM.

Age

The section on general stratigraphy, sedimentology and placer formation discusses in detail the age of the various levels of gravel. Gravel thought to be equivalent to the high-level White Channel Gravel is considered Early Pliocene to earliest Late Pliocene (~5 to 3 Ma) and gravel thought to be equivalent to the high-level Klondike Gravel is considered earliest Late Pliocene (~3 Ma). The intermediate-level gravel is thought to be Late Pliocene to Early Pleistocene (~3 to 1.8 Ma), and the low-level gravel is Late Pleistocene to Holocene (~1.8 to 0 Ma).

Environment of deposition/paleoflow direction

All of the placers are fluvial in origin and were deposited in streams that flowed in the same direction as the present day streams in which the placer deposits occur.

Heavy minerals

All three levels of gravel contain similar heavy mineral concentrate assemblages that are dominated by magnetite, hematite and minerals locally derived from metamorphic and igneous rocks (i.e., garnet, hornblende, enstatite, kyanite, actinolite, chlorite, sphene and zircon; Appendix 5).

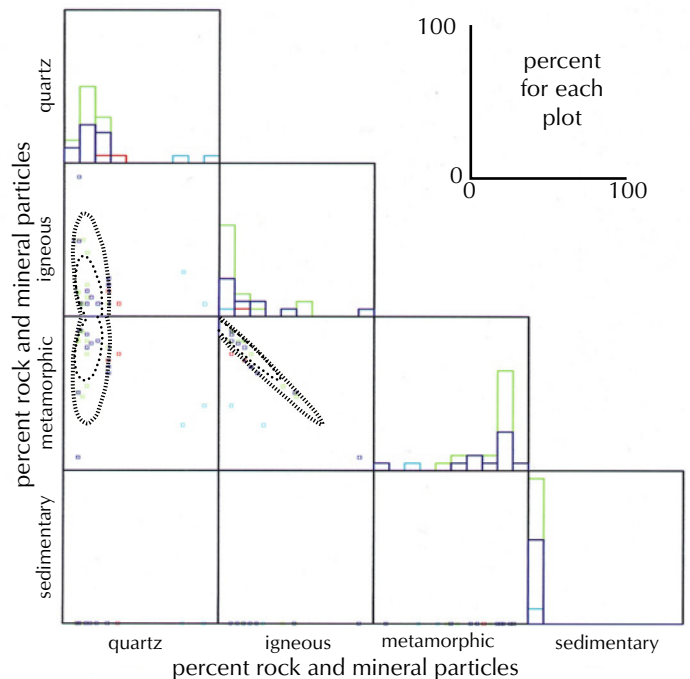


Figure 31.* Multivariate scatterplot of particle composition analysis of gravel throughout Sixty Mile River drainage.

Gold characteristics

No gold characteristics are available for the high-level gravel. Placer gold recovered from intermediate-level gravel on Glacier Creek is coarse grained (i.e., greater than 2 mm), chunky, and has a fineness ranging from 820 to 830. On Matson Creek, it is also coarse (up to 3 cm), and has a fineness ranging from 776 to 893. Placer gold recovered from intermediate-level gravel on Miller Creek is fine- to coarse-grained, occasionally has quartz attached, and has a fineness ranging from 830 to 850.

Placer gold recovered from low-level gravel in the Sixty Mile River is bright, flaky, rough and porous, and has a fineness ranging from 810 to 845. Placer gold from Little Gold and Big Gold creeks has a fineness ranging from 847 to 854; from Glacier Creek, it ranges from 830 to 860; from Miller Creek, it ranges from 827 to 857 and from Bedrock Creek, it is 820. Placer gold recovered from Matson Creek has a fineness ranging from 776 to 893 and from Ten Mile Creek, it is 830 to 845. Placer gold recovered from the Fortymile River has a fineness ranging from 814 to 845.

Description of selected placer mines

Fortymile River • Bill Claxton and Leslie Chapman, Fortymile Placers (Appendix 9, GL01-25)

High-level gravel thought to be equivalent to the White Channel Gravel is the focus of a placer prospect by Fortymile Placers. The gravel, exposed along the right-hand side of the Clinton Creek Road just before descending into the Fortymile River valley, is up to 1 m thick and consists of muddy sandy coarse-pebble gravel overlain by 1 to 2 m of colluvium (Plate 13a). The gravel was deposited in a flood plain of the paleo-Fortymile River.

Glacier Creek • Mike McDougall (Appendix 9, GL99-19)

Mike McDougall is mining intermediate-level gravel on a left limit terrace along Glacier Creek (Plate 13b). The pay gravel is 3.5 m thick and consists of sandy coarse-pebble gravel resting on graphite schist with quartzite, overlain by 1 m of muck and colluvium. It was deposited on the floodplain of paleo-Glacier Creek. Placer gold recovered from the gravel is coarse grained and chunky, and has a fineness of 830.

Matson Creek • Bert Savage, Matson Creek Gold Corp. (Appendix 9, GL99-25)

Intermediate-level gravel is being mined by Matson Creek Gold Corp. from a right limit intermediate-level terrace about 10 m above the present creek (Plate 13c). The pay gravel consists of 1.5 m of muddy sandy boulder gravel, which is overlain by 2 m of sandy coarse pebble gravel and 3 to 4 m of overbank fines and muck. It was deposited on the floodplain of paleo-Matson Creek. The placer gold is coarse grained (with nuggets up to 3 cm) and has a fineness ranging from 776 to 893.

Sixty Mile River (middle) • Greg Hakonson, Eldorado Placers (Appendix 9, GL99-17)

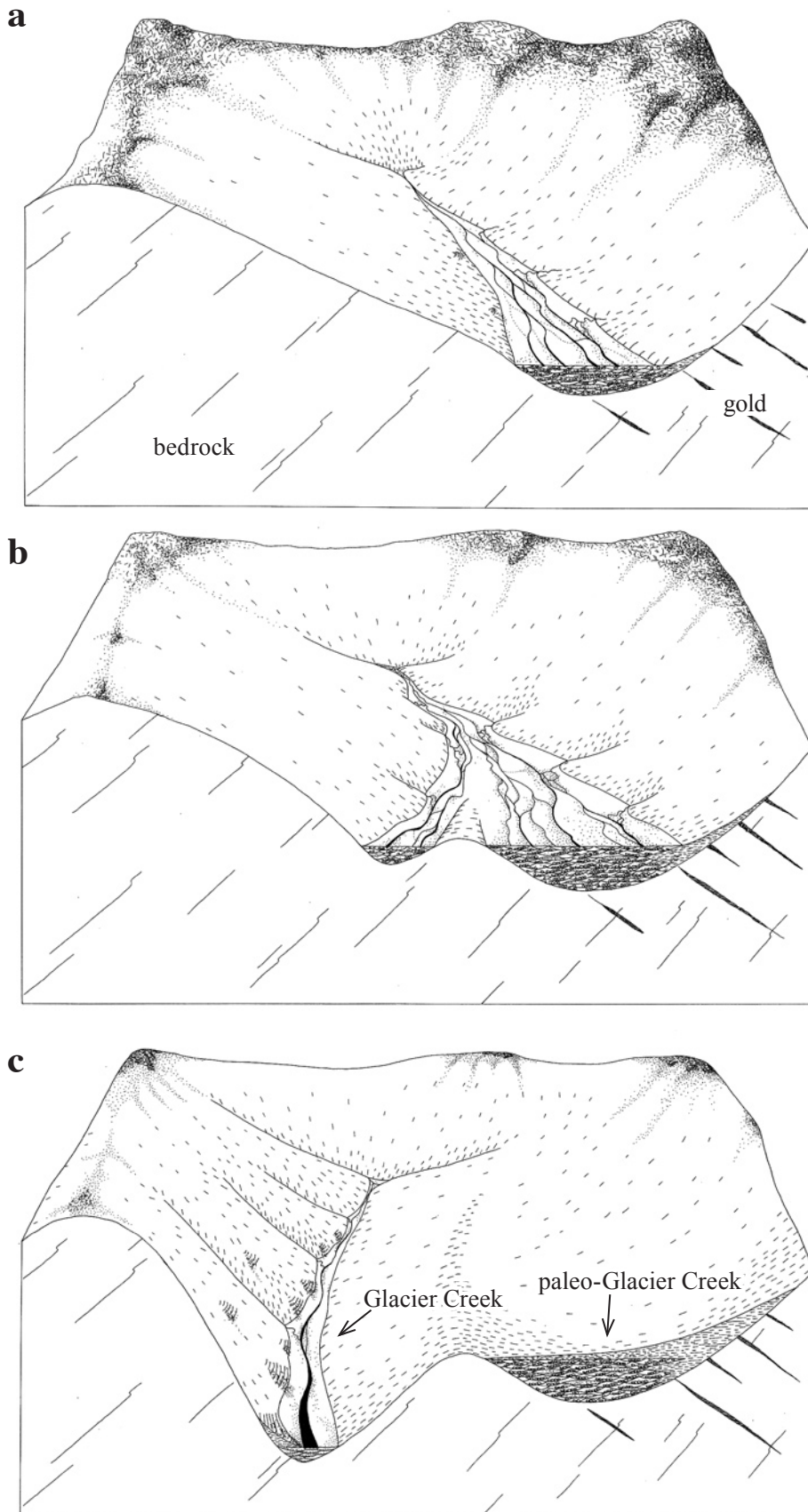
Eldorado Placers Ltd. is mining low-level gravel from the left limit floodplain of the Sixty Mile River, just below Five Mile Creek (Plate 13d). The pay gravel consists of 3 m of muddy sandy cobble gravel that rests on chlorite schist, and is overlain by 2 to 3 m of overbank fines and muck. The placer gold has a fineness ranging from 810 to 840.

Sixty Mile River (upper) • Walter Yaremcio (Appendix 9, GL99-28)

Walter Yaremcio is mining low-level gravel from the left limit floodplain of the Sixty Mile River, just above Bedrock Creek (Plate 13e). The pay gravel consists of 4 m of muddy sandy cobble gravel that rests on quartz-muscovite-biotite schist to gneiss, and is overlain by 1 to 2 m of overbank fines. Placer gold recovered from the gravel is bright and coarse grained, with some larger flaky gold, and has a fineness of 830.

Fortymile River • Bill Claxton and Leslie Chapman, Fortymile Placers (Appendix 9, GL99-62)

Low-level gravel from the left limit floodplain of the Fortymile River, just above Martin Creek, is being mined by Fortymile Placers (Plate 13f). The pay gravel consists of 2 m of muddy sandy cobble gravel that is overlain by 1 to 2 m of overbank fines.

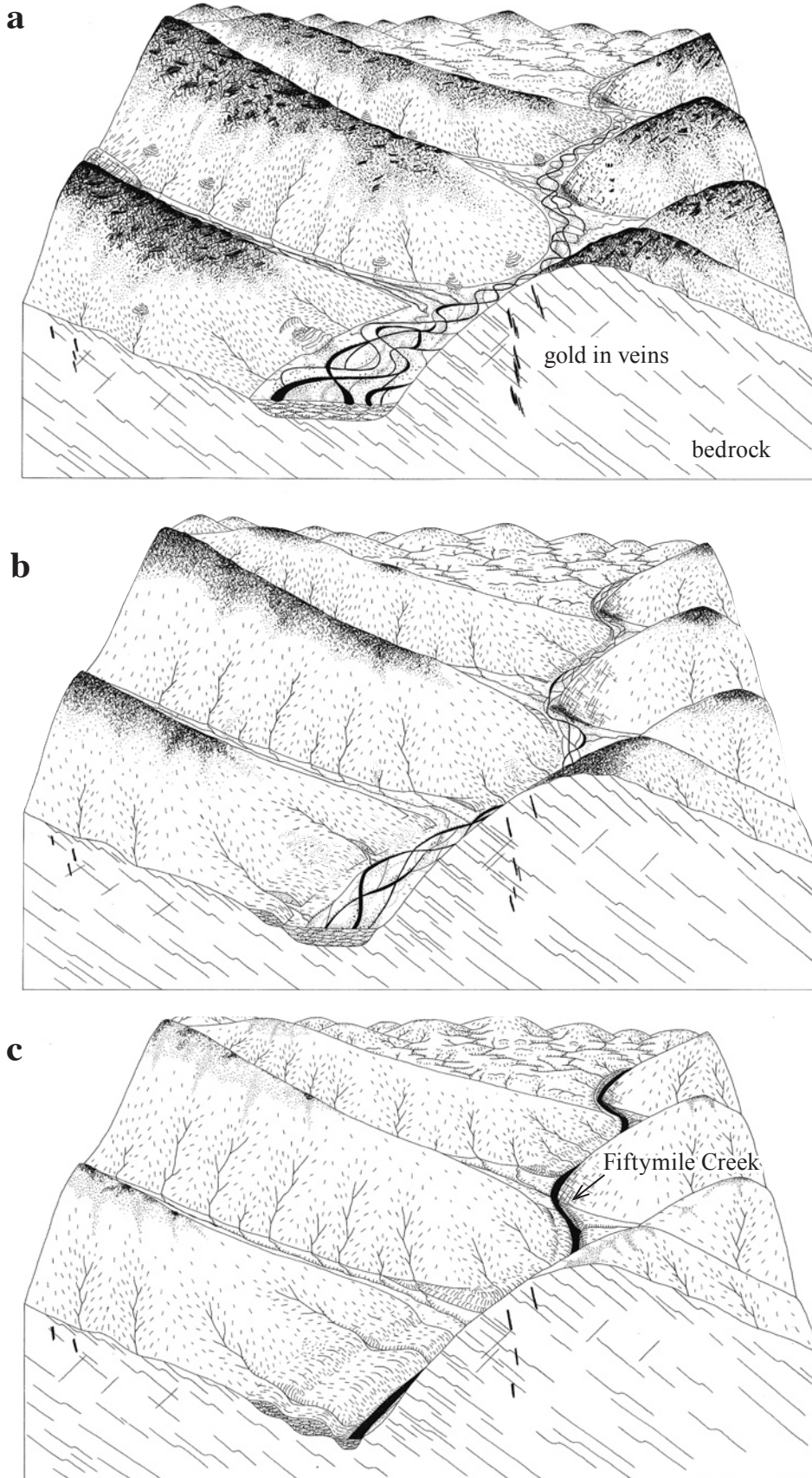


Formation of placers

The formation of placer deposits in the Sixty Mile River drainage is best exemplified by the formation of placers in the Glacier Creek area (see Fig. 32):

- a) Approximately 2 Ma ago, deposition of intermediate-level gravel occurred along paleo-Glacier Creek and placer gold was concentrated in the stream;
- b) Approximately 1 Ma ago, paleo-Glacier Creek was diverted to the south, resulting in abandonment of the existing paleo-Glacier Creek valley and formation of a new valley;
- c) Formation of intermediate-level terraces has resulted in the reconcentration of placer gold in the creeks and river. Note also buried paleo-Glacier Creek valley.

Figure 32. Formation of placers in the Sixty Mile River drainage (view looking south): (a) ~2 Ma ago; (b) ~1 Ma ago; (c) present.



Formation of placers

A new and potentially important placer prospect is the Fifty Mile Creek drainage (also a tributary of the Sixty Mile River; see Fig. 33):

- a) Approximately 2 Ma ago, deposition of intermediate-level gravel occurred along paleo-Fifty Mile Creek and possibly the concentration of placer gold;
- b) Approximately 1 Ma ago, incision of the paleo-Fifty Mile Creek valley occurred, resulting in the formation of the intermediate-level terrace, and the possible reconcentration of placer gold in the new floodplain of paleo-Fifty Mile Creek;
- c) Fifty Mile Creek today shows continued incision of the valley. Formation of low-level terraces has resulted in the reconcentration of placer gold in the creek and its tributaries.

Figure 33. Formation of placers in the Fifty Mile Creek drainage (view looking west): (a) ~2 Ma ago; (b) ~1 Ma ago; (c) present.

STEWART RIVER-YUKON RIVER DRAINAGES

Location and description of area

The Stewart River-Yukon River drainages covers approximately 1200 km² and is located south of the Indian River drainage (Fig. 2). The main gold-bearing streams include Henderson, Maisy May, Blackhills, Scroggie, Barker, Frisco, Thistle, Kirkman and Excelsior creeks. The main gold-bearing streams tributary to Thistle Creek include Blueberry and Lulu creeks.

Placer activity and gold production

Placer deposits in the Stewart River-Yukon River drainages have been mined for nearly 100 years (Plate 14a,b,c,d,e,f); Cairnes (1917) provides a history of the discovery of placer gold and initial mining activities. The Stewart River-Yukon River drainages had 12 active placer operations in 1997, with 2 along Black Hills Creek, 3 along Henderson Creek, 1 along Scroggie Creek, 1 along Kirkman Creek, 4 along Thistle Creek and 1 along Frisco Creek (Mining Inspection Division, 1998).

Between 1978 and 2001, the Stewart River-Yukon River drainages produced 11.23% of the placer gold in the Yukon, with Black Hills Creek ranked 8th (86,765 oz; 2 698 700 g), Scroggie Creek ranked 12th (54,137 oz; 1 683 900 g), Ballarat Creek ranked 13th (16,078 oz; 500 080 g), Henderson Creek ranked 14th (41,520 oz; 1 291 400 g) and Maisy May Creek ranked 21st (25,430 oz; 790 960 g) and in production (W.P. LeBarge, pers. comm., 2002).

General description of deposits

Appendix 10 provides detailed descriptions of all deposits examined throughout the Stewart River-Yukon River drainages (i.e., location data, stratigraphic-sedimentologic section and panel diagram). This section on general deposit descriptions provides a summary of that information and the next section provides detailed descriptions of selected placer mines.

Distribution

High-level gravel (Plate 15a,b) occurs on what is thought to be a paleo-Yukon River terrace, located on the left limit of the Yukon River downstream from Garner Creek. High-level gravel also occurs on a left limit terrace located near the mouth of Scroggie Creek. The terrace on Scroggie Creek is approximately 15 m above present creek levels and the gravel is considered equivalent to

the glaciofluvial Klondike Gravel. The intermediate-level gravel (Plate 15c,d) forms terraces on the left limit of Blackhills, Barker, Scroggie and Thistle creeks, and the right limit of Kirkman Creek. The low-level gravel (Plate 15e,f) represents present-day river, creek and gulch deposits throughout the Stewart River-Yukon River drainages.

Thickness

The high-level Klondike Gravel is up to 8 m thick. The intermediate-level gravel is up to 26 m in thickness, and the low-level gravel ranges from 1.2 to 8 m in thickness.

Texture (grain size/roundness/sphericity)

There is insufficient particle size and shape data for the high-level gravel. The intermediate-level and low-level gravel range from muddy sandy gravel to slightly sandy gravel, with sandy gravel as the most common texture in the intermediate-level gravel, and muddy sandy gravel as the most common texture in the low-level gravel (Fig. 34). Both levels of gravel show similarities in roundness (i.e., subangular to subrounded particles) and sphericity (i.e., subdiscoidal to spherical particles; Fig. 35).

Clast lithology

Quartz, igneous, metamorphic and sedimentary rock particles are present in the intermediate-level and low-level gravel (Fig. 36). Generally, the following trends are recognized in both levels of gravel: as the percentage of quartz particles increases, the percentage of igneous rock particles slightly increases, but the percentage of metamorphic and sedimentary rock particles remains relatively constant.

Age

The section on general stratigraphy, sedimentology and placer formation discusses in detail the age of the various levels of gravel. Gravel equivalent to the high-level Klondike Gravel is considered earliest Late Pliocene (~3 Ma); the intermediate-level gravel is thought to be Late Pliocene to Early Pleistocene (~3 to 1.8 Ma); and the low-level gravel is Late Pleistocene to Holocene (~1.8 to 0 Ma).

Environment of deposition/Paleoflow direction

All of the placers are fluvial in origin and were deposited in streams that flowed in the same direction as the present-day streams in which the placer deposits occur.

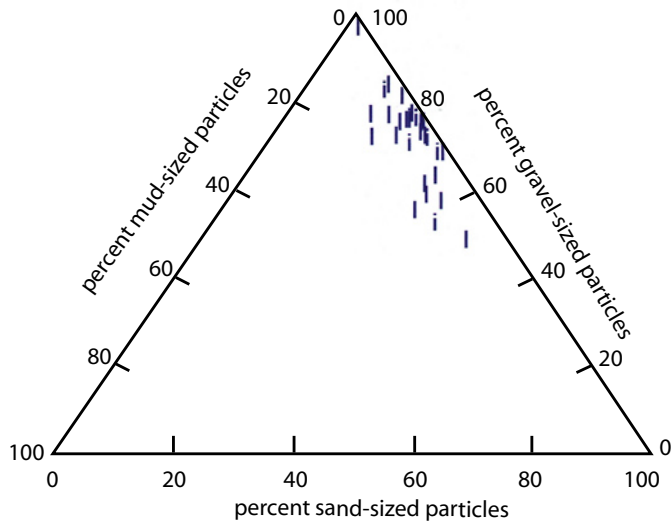


Figure 34.* Ternary diagram of particle size analysis of gravel throughout the Stewart and Yukon River drainages; h = high-level gravel (undifferentiated), i = intermediate-level gravel, l = low-level gravel.

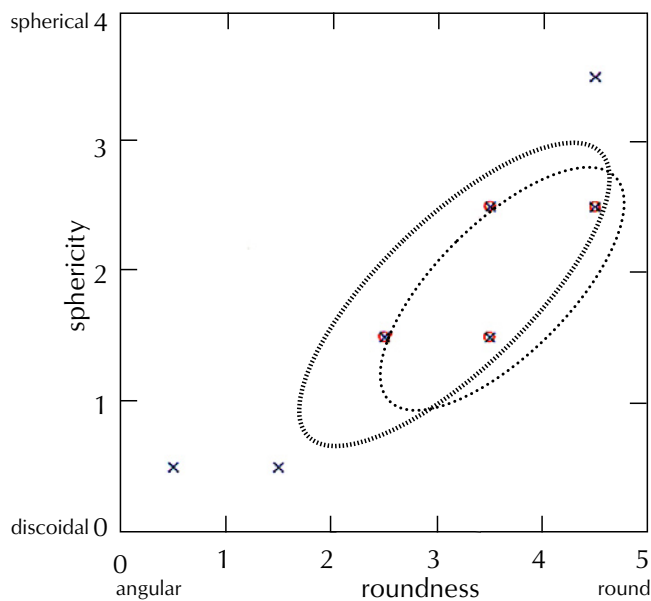


Figure 35.* Scatter plot of particle shape analysis of gravel throughout the Stewart and Yukon River drainages.

Legend for Figures 35 and 36

Key to gravels

- hk --- high-level Klondike gravel
- hw high-level White Channel Gravel (undifferentiated)
- hww - - - high-level White Channel White Gravel unit
- hwy — high-level White Channel Yellow Gravel unit
- in intermediate-level gravel
- lo low-level gravel

*For further details, these figures are provided at larger scale on the CD-ROM.

Heavy minerals

All three levels of gravel contain similar heavy mineral concentrate assemblages that are dominated by magnetite, hematite and minerals locally derived from metamorphic and igneous rocks (i.e., garnet, enstatite, epidote, chloritoid, hornblende, garnet, sphene, kyanite and zircon; Appendix 5).

Gold characteristics

No gold characteristics are available for the high-level gravel. Placer gold recovered from intermediate-level gravel from Black Hills is fine grained and flat, with a fineness of 840; from Barker Creek, it has a fineness ranging from 895 to 905; and from Kirkman Creek, it has a fineness ranging from 860 to 896.

Placer gold recovered from low-level gravel along Henderson Creek is bright, flat and smooth, with a fineness ranging from 720 to 760; along Maisy May it has a fineness ranging from 780 to 782. Placer gold recovered from low-level gravel along the middle part of Black Hills Creek has a fineness of 840, whereas along the upper part of Black Hills Creek, the gold is angular, chunky and rough, with some wire gold and small nuggets. It has a fineness ranging from 700 to 718. Gold from Childs Gulch (a tributary of Black Hills Creek) is angular with a

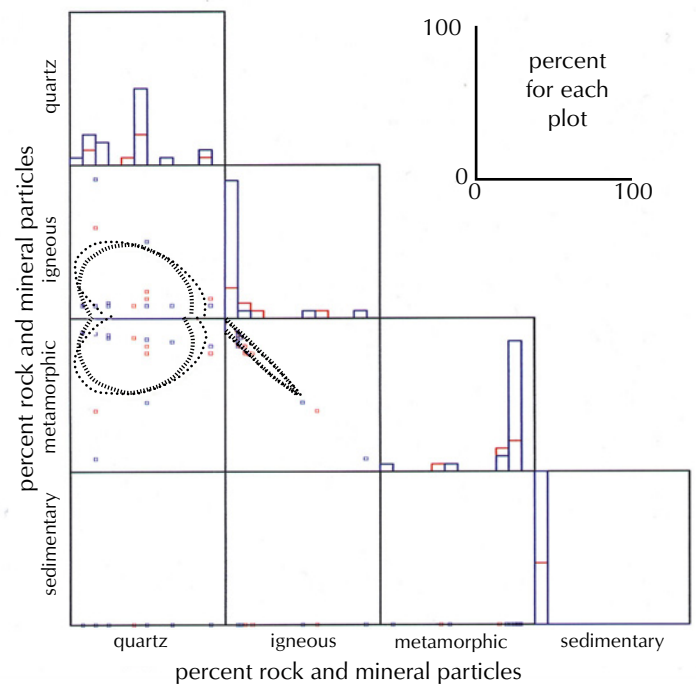


Figure 36.* Multivariate scatterplot of particle composition analysis of gravel throughout the Stewart and Yukon River drainages.

fineness of 750. Placer gold from Scroggie Creek is bright, round and chunky, with a fineness ranging from 895 to 905; from Kirkman Creek, it is mostly fine grained, round, pounded and thin, with a fineness ranging from 860 to 896. Placer gold recovered from low-level gravel along the lower part of Thistle Creek consists of nuggets up to 1 cm.

Description of selected placer mines

Scroggie Creek • Abandoned (Appendix 10, GL00-17)

An attempt to mine high-level Klondike Gravel was undertaken on a high-level, left limit terrace located near the mouth of Scroggie Creek (Plate 16a). The terrace, approximately 15 m above present creek level, consists of 8 m of sandy fine-cobble gravel that was deposited as glaciofluvial outwash during the end of the pre-Reid glaciation.

Black Hills Creek (middle) • Joel White (Appendix 10, GL00-10, 11)

Joel White mined intermediate-level gravel from a left limit terrace located near the middle part of Black Hills Creek (Plate 16b). The terrace is approximately 10 m above the present day creek level and is incised into muscovite schist to quartzite. It is capped with 2.5 m of sandy fine-cobble gravel that was deposited on the floodplain of paleo-Black Hills Creek, which is overlain by overbank fines and muck. Placer gold recovered from the gravel is coarse grained, with numerous nuggets, and has a fineness of 840.

Thistle Creek (Elis Bench) • Stuart Schmidt, Schmidt Mining (Appendix 10, GL00-48)

Schmidt Mining is mining intermediate-level gravel on Elis Bench, an intermediate-level terrace located on the left limit of Thistle Creek (Plate 16c). The terrace is approximately 10 m above the present creek level and is incised into muscovite schist and graphitic quartzite. It is capped by 5 m of sandy fine-cobble gravel that was deposited on the paleo-Thistle Creek floodplain, which is overlain by 3 to 4 m of muck. Placer gold recovered from the gravel is coarse and not as round as in the creek.

Black Hills Creek (mid-lower) • Joel White (Appendix 10, GL00-9)

Joel White is mining low-level gravel from the lower to middle part of the Black Hills Creek (Plate 16d). The pay gravel is 1.8 m thick and consists of slightly cobbly sandy, very coarse-pebble gravel resting on biotite-muscovite

schist and quartzite, overlain by overbank fines. The placer gold has a fineness of 840.

Black Hills Creek (upper) • Paydirt Holdings Ltd. (Appendix 10, GL00-12)

Low-level gravel is also being mined in the upper part of Black Hills Creek. Approximately 1 m of sandy, very coarse-pebble gravel resting on muscovite schist, marble and quartzite is overlain by 2 to 3 m of overbank fines and muck. The placer gold is angular and chunky, with some wire gold and small nuggets, and has a fineness ranging from 700 to 718.

Scroggie Creek (upper) • Bear Creek Placers. (Appendix 10, GL00-18)

Bear Creek Placers is mining low-level gravel along the middle part of Scroggie Creek (Plate 16e). The pay gravel is 2 m thick and consists of sandy, very coarse-pebble gravel resting on marble and amphibolite, overlain by 1 m of overbank fines and muck. Placer gold recovered from the gravel is bright, round and chunky, with a fineness of 900.

Thistle Creek (lower) • Stuart Schmidt, Schmidt Mining (Appendix 10, GL01-22)

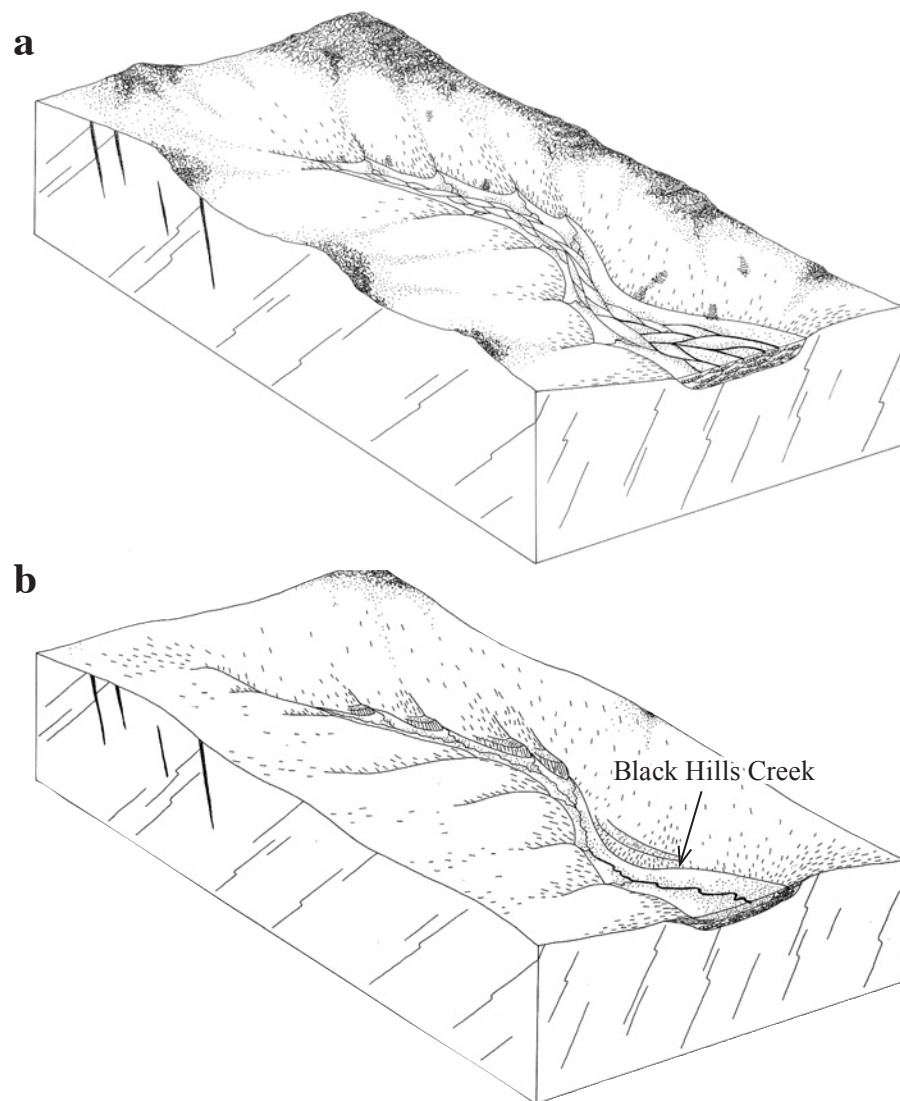
Low-level gravel is being mined by Schmidt Mining along the lower part of Thistle Creek (Plate 16f). The gravel is up to 8 m thick and consists of sandy fine-cobble gravel resting on gneiss and quartzite, overlain by 2 to 3 m of overbank fines and muck. Nuggets up to 1 cm have been recovered from the gravel.

Thistle Creek (upper) • Jay Fellers (Appendix 10, GL00-45)

Jay Fellers is mining low-level gravel along the upper part of Thistle Creek. The gravel is 1.2 m thick and consists of sandy fine-cobble gravel resting on rubbly schist and amphibolite, overlain by 2 to 3 m of overbank fines and muck.

Lulu Creek (Thistle Creek) • Merrit Sager (Appendix 10, GL00-51)

Low-level gravel is being mined by Merrit Sager along Lulu Creek, a tributary of Thistle Creek. Approximately 0.8 m of bouldery sandy coarse-cobble gravel resting on gneiss is overlain by 2 to 3 m of overbank fines and muck.



Formation of placers

The formation of placer deposits in the Stewart River-Yukon River drainages is best illustrated by the formation of placers in the Black Hills Creek area (Fig. 37):

- a) Approximately 2 Ma ago, intermediate-level gravel was deposited on the floodplain of paleo-Black Hills Creek and gold was concentrated in the stream;
- b) Black Hills Creek today shows the incision of Black Hills Creek. Formation of intermediate-level terraces resulted in the reconcentration of placer gold in the creek.

Figure 37. Formation of placers in the Stewart River-Yukon River drainages (view looking north): (a) ~2 Ma ago; (b) present.

LADUE RIVER DRAINAGE

Location and description of area

The Ladue River drainage covers approximately 200 km² and is located south of the Sixty Mile River drainage (Fig. 2). The main gold-bearing streams are located in the Moosehorn Range and include Great Bear, Kenyon, Scottie and Swamp creeks.

Placer activity and gold production

Placer deposits in the Moosehorn Range area have been mined since the late 1970s (Plate 17a,b); Morin (1977) provides a history of the discovery of placer gold and initial mining activities. The Moosehorn area had three placer operations active in 1997: one along Roo Pup, one along Kate Creek and one along an unnamed tributary of Scottie Creek (Mining Inspection Division, 1998).

Between 1978 and 2001, the Ladue River drainage produced 2.23% (38,241 oz; 1 189 400 g) of the total placer gold in the Yukon, with Swamp Creek ranked 24th (21,980 oz; 683 660 g), Scottie Creek ranked 36th (9,028 oz; 280 800 g) and Great Bear Creek ranked 38th (7,233 oz; 225 000 g) in production (W.P. LeBarge, pers. comm., 2002).

General description of deposits

Appendix 11 provides detailed descriptions of all deposits examined throughout the Ladue River drainage (i.e., location data, stratigraphic-sedimentologic section and panel diagram). This section on general deposit descriptions provides a summary of that information and the next section provides detailed descriptions of selected placer mines.

Distribution

Low-level gravel (Plate 17c,d,e,f) occurs on Roo Pup and Kate Creek, both tributaries of Great Bear Creek, as well as on an unnamed tributary of Scottie Creek.

Thickness

The low-level gravel ranges from 2 to 9 m in thickness.

Texture (grain size/roundness/sphericity)

The low-level gravel ranges from muddy sandy gravel to sandy gravel, with muddy sandy gravel as the most common texture (Fig. 38). Particle roundness ranges from angular to rounded, and particle sphericity ranges from discoidal to spherical (Fig. 39).

Clast lithology

Quartz, igneous, metamorphic and sedimentary rock particles are all present. Generally, as the percentage of quartz particles increase, the percentage of igneous rock particles increases, the percentage of metamorphic rock particles decreases, and the percentage of sedimentary rock particles remains relatively constant (Fig. 40).

Age

The section on general stratigraphy, sedimentology and placer formation discusses in detail the age of the various levels of gravel. Generally, the low-level gravel is Late Pleistocene to Holocene (i.e., ~1.8 to 0 Ma).

Environment of deposition/paleoflow direction

The placers are dominantly fluvial in origin and were deposited in streams that flowed in the same direction as the present day streams in which the placer deposits occur. Colluvial processes were important in the formation of placers on Roo Pup, a tributary of Kate Creek.

Heavy minerals

The low-level gravel contains a heavy mineral concentrate assemblage that is dominated by magnetite, hematite and minerals locally derived from igneous and metamorphic rocks (i.e., hornblende, chloritoid, epidote, enstatite, actinolite, biotite and zircon; Appendix 5).

Gold characteristics

Placer gold recovered from creeks draining the Moosehorn Range has a range of fineness: 750 on Kenyon Creek, 800 on Swamp Creek and 820 on Kate Creek. Placer gold recovered from low-level gravel along Kenyon Creek is coarse grained and rounded, with nuggets common; gold from Roo Pup is frothy and hackly, with a fineness of 820.

Description of selected placer mines

Kate Creek (Lessaux Creek) • Ian and Kate Warrick (Appendix 11, GL99-43)

Ian and Kate Warrick are mining low-level gravel along the left limit of Kate Creek, a tributary of Lessaux Creek (see Plate 17e). Approximately 5 m of muddy sandy pebble-to cobble-gravel resting on granodiorite is overlain by 1 m of colluvium and muck. The gold has a fineness of 820.

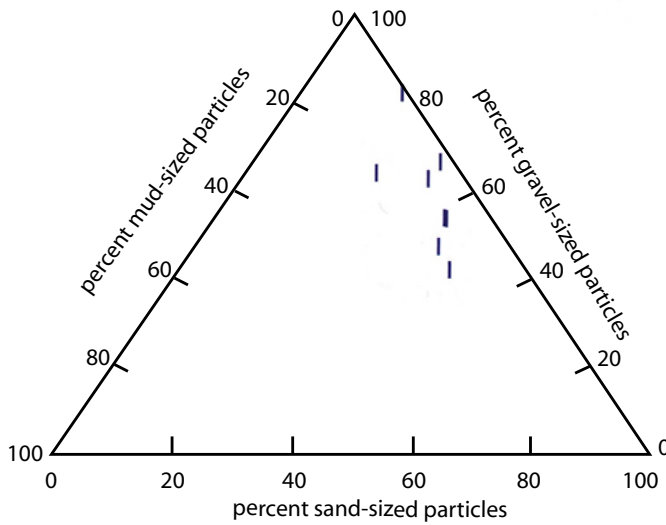


Figure 38.* Ternary diagram of particle size analysis of gravel throughout the Ladue River drainage; l = low-level gravel.

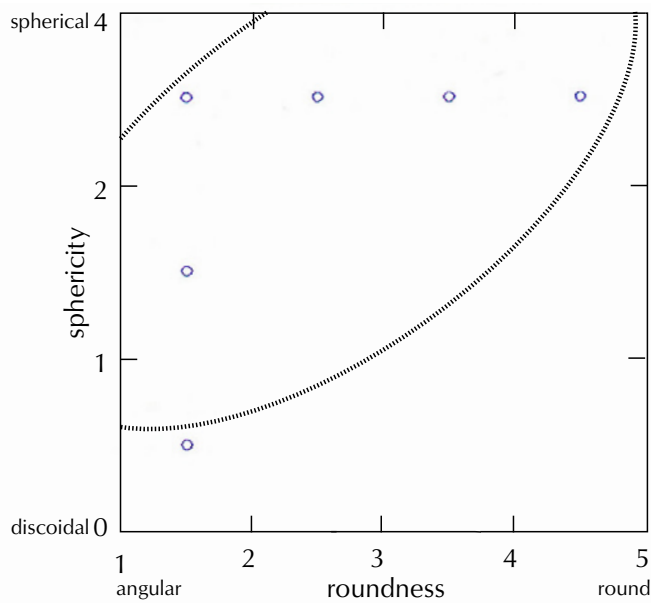


Figure 39.* Scatterplot of particle shape analysis of gravel throughout the Ladue River drainage (low-level gravel).

Legend for Figures 39 and 40

Key to gravels

- hk --- high-level Klondike gravel
- hw high-level White Channel Gravel (undifferentiated)
- hww - - - high-level White Channel White Gravel unit
- hwy — high-level White Channel Yellow Gravel unit
- in intermediate-level gravel
- lo low-level gravel

Roo Pup (Lessaux Creek) • Ian and Kate Warrick (Appendix 11, GL99-42)

Low-level gravel and colluvium is also being mined by Ian and Kate Warrick along the left limit and hillside of Roo Pup (see Plate 17c). Approximately 9 m of sandy, medium- to very coarse-boulder gravel resting on granodiorite is overlain by 1 m of muck. Placer gold recovered from the gravel is frothy and hackly and has a fineness of 820.

Unnamed tributary of Scottie Creek • Glen Hartley (Appendix 11, GL99-45)

Glen Hartley is mining low-level gravel along the headwaters of an unnamed tributary of Scottie Creek (see Plate 13f). Approximately 2 m of muddy cobble gravel resting on rubbly granodiorite and diorite is overlain by 1 m of overbank fines and muck. The placer gold is fine grained and rough and has a fineness of 820.

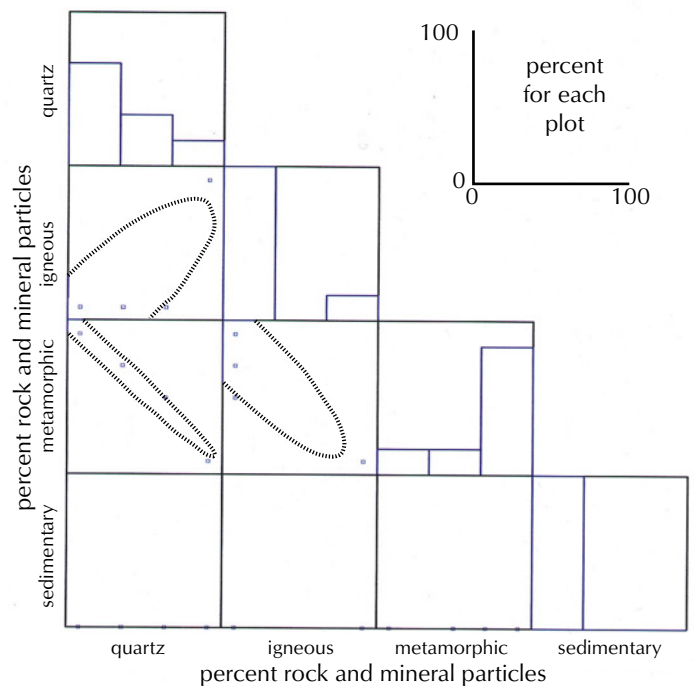
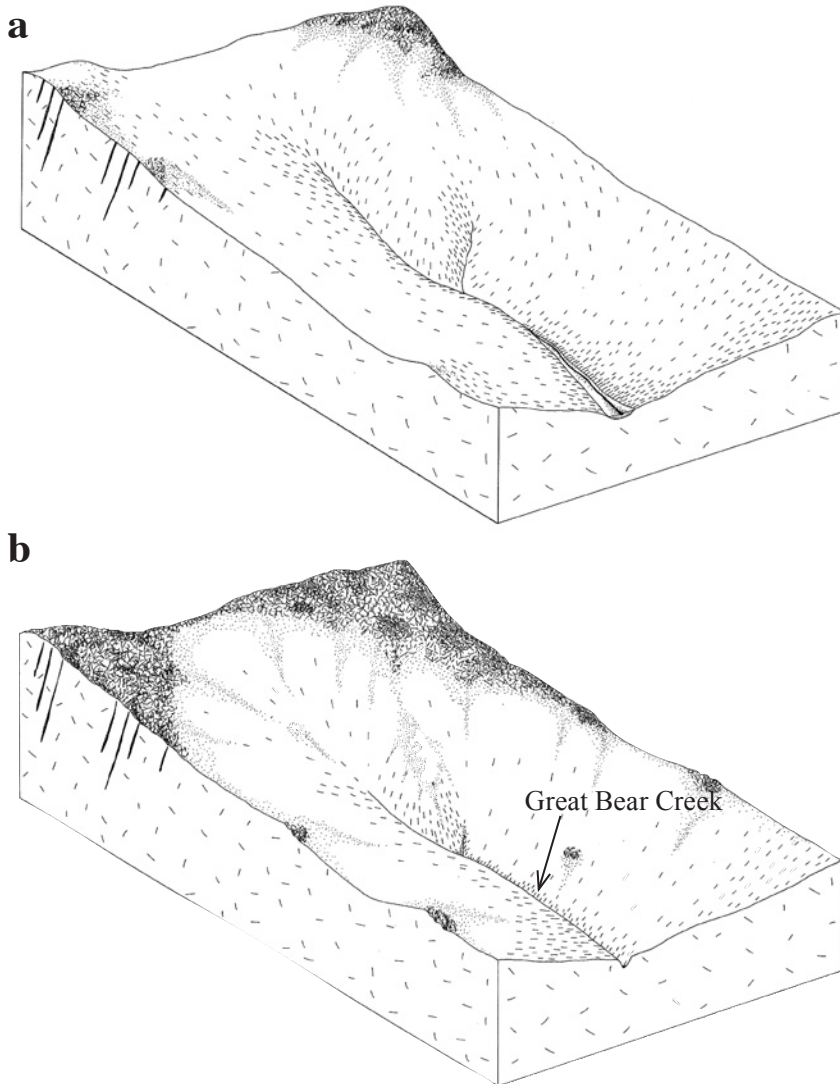


Figure 40.* Multivariate scatterplot of particle composition analysis of gravel throughout the Ladue River drainage.

*For further details, these figures are provided at larger scale on the CD-ROM.



Formation of placers

The formation of placer deposits in the Moosehorn Range area is summarized in Figure 41:

- a) Approximately 1 Ma ago Moosehorn Range was undergoing weathering and erosion, which resulted in the release of gold from auriferous quartz veins and the formation of Great Bear Creek drainage and deposition of auriferous gravel;
- b) Moosehorn Range today shows continued erosion of auriferous quartz veins and the concentration of placer gold along Great Bear Creek and its tributaries.

Figure 41. Formation of placers in the Ladue River drainage (view looking west): (a) ~1 Ma ago; (b) present.

RESOURCE APPRAISAL

INTRODUCTION

A resource appraisal attempts to estimate the value (identified resources) or potential (undiscovered resources) of a naturally occurring material in the earth's crust. Five categories of resource appraisal are commonly used (Harris, 1984): economic, quantity-quality, geological, geostatistical and compound. Every method of appraisal faces limitations of data and theory, and according to Harris (1984), there is "no elegant nor ultimately definitive method for estimating unknown resources." Jefferson and Schmitt (1992, p. 10) caution that "final once-and-for-all assessments of mineral resource potential cannot be made. Areas should be reassessed periodically as new data become available, as new concepts of the factors that influence the concentration of minerals are developed, as new uses and extractive technologies are devised, as the local and world economics change, and as local to national political needs change."

McConnell's (1907) report on gold values in the high-level gravels of the Klondike goldfields was the first attempt at a resource appraisal in the study area. He calculated the volume of White Channel Gravel remaining throughout the Klondike and estimated its monetary value based on the average grade of the gravels. Sinclair et al. (1981) undertook an assessment of mineral (and fuel) resource potential of the entire Yukon, including the potential for placer gold. Their assessment was based on 'qualitative judgments' of the potential for undiscovered deposits within specific geological areas. The qualitative judgments for placer deposits included (Sinclair et al., 1981): 1) the presence of gold-bearing source rocks; 2) the degree of deep weathering the source rocks underwent and the amount of incision due to drainage; 3) the absence of extensive glaciation; and 4) the presence of placer gold occurrences. Using this methodology, Sinclair et al. (1981) assigned a 'very high potential' for placer gold deposits for all of the study area southwest of Tintina Fault (and for most of west-central Yukon), whereas the remaining portion of the study area (northeast of the fault) was assigned a 'moderate' to 'very low' potential for placer gold deposits.

METHODOLOGY

The type of resource appraisal used in this report is a geologic appraisal, specifically a 'deposit model by analogy' approach (Geological Survey of Canada, 1980), and is based on the method of Harrison et al. (1986). It attempts to define, based on data available, areas having various levels of favourability for placer gold (but not to pinpoint any possible undiscovered placer). The appraisal begins by describing an "occurrence model" for placer gold deposits, from which "diagnostic characteristics" (alluvial geology, stream sediment geochemistry, lode mineral occurrences, and placer mineral occurrences) are identified. The diagnostic characteristics are assigned a "favourability score," and streams within the map are evaluated using the diagnostic characteristics. This results in a "sum" of the favourability scores for each stream evaluated. The sum of the favourability scores and the number of kinds of diagnostic characteristics used can be plotted on a matrix (referred to as a confidence-favourability diagram) that shows increasing levels of confidence (i.e., the number of diagnostic characteristics) and favourability (i.e., the sum of favourability scores). From this diagram, a measure of probability of occurrence of placer gold can be established. Hence, the appraisal process is neither mysterious nor hypothetical, but rather, is based on available data and 'experienced judgments'.

Occurrence model

A placer occurrence model is an ore deposit model that embodies the descriptive characteristics of the deposit and the larger ore-bearing geological environment (Hodgson, 1993). Known placers in the study area occur in gravel at a variety of topographic levels. These include prominent, high-level terraces up to 100 m above present day stream levels, discontinuous intermediate-level terraces ranging from nearly the height of high-level terraces to just above present day stream levels, and present day stream alluvium. The gravel is typically framework-supported; poorly bedded; slightly muddy sandy pebble to cobble gravel (i.e., lithofacies Gh); <1 m to >20 m thick; and is dominated by vein quartz particles and/or metamorphic rock particles. It was deposited in a fluvial environment (i.e., gravel braided rivers to gravel wandering rivers) and it ranges from Pliocene to Holocene in age. Undiscovered placers in the study area are assumed to occur in similar gravel deposits.

Diagnostic characteristics

Geologists have observed that within generally defined geological environments, certain geological associations are reasonable indicators of ‘favorable ground’ for the occurrence of mineral deposits (Harris, 1984). Characteristics considered diagnostic for predicting the occurrence of undiscovered placers include the presence and type of gravel, and some indication that gold is present in a drainage system. The presence of gold can be based on the occurrence of soil and silt geochemical anomalies for gold, the occurrence of known gold placer deposits, and the occurrence of auriferous lodes.

Favourability scores

The different kinds of diagnostic characteristics can be weighted according to their relative importance. That is, the presence (or absence) of gravel and gold in a drainage can be assigned relative values or scores. The enormous variety of surficial deposits in the study area (and not all are gravel) were simplified into seven major categories (Table 5). Each category was assigned a relative score, ranging from +3 (very favourable for the occurrence of placer gold) to -3 (very unfavourable for the occurrence of placer gold; Fig. 42). Geochemical anomalies, obtained from Friske et al. (1986, 1991) based on the 98th percentile for reported, regional geochemical gold values in the study area, were assigned relative scores ranging from +2 (>20 ppm gold) to 0 (no gold). Placer gold occurrences were assigned relative scores ranging from +2 (placer from which gold has been produced) to 0 (no known placer occurrence), and lode gold occurrences, obtained from the Yukon MINFILE (1997), were assigned relative scores ranging from +2 (lode from which gold has been produced) to 0 (no known lode gold occurrence). Note that the alluvial geology is given the highest relative ranking (a maximum of +3), rather than the occurrence of geochemical gold anomalies (a maximum of +2), the occurrence of placer gold (a maximum of +2) or the occurrence of gold lodes (a maximum of +2), because the purpose of the appraisal is to determine the potential for undiscovered placers. All streams for which data are available were evaluated using the favourability characteristics and assigned scores, resulting in a sum of favourability scores for each stream.

Confidence-favourability diagram

The various combinations of the sum of favourability scores and the number of kinds of diagnostic characteristics used in the evaluation can be plotted on a

matrix referred to as a confidence-favourability diagram (Fig. 43). The diagram shows the level of confidence in an appraisal (i.e., the number of kinds of diagnostic data used) increasing from right to left along the horizontal axis, versus the level of favourability in an appraisal (i.e., the sum of favourability scores) increasing from bottom to top along the vertical axis.

Probability of occurrence of placer gold

The confidence in an appraisal for a given stream increases directly with the number of kinds of diagnostic characteristics available for that stream, whereas the favourability of that stream is a function of the sum of the favourability scores for each kind of diagnostic characteristics used in the appraisal (Harrison et al., 1986). Hence, various combinations of confidence and favourability can be designated as ‘diagnostic’, ‘suggestive’ and ‘unfavourable’, which can be further modified as ‘highly’, ‘moderately’ and ‘slightly’, to indicate the relative probability of occurrence of placer gold. Note that these probabilities reflect the uncertainty inherent in appraising a stream for undiscovered placers. Also, the placer occurrence model cannot be fully described in terms of the diagnostic characteristics: although a particular segment of a stream may have gravel that is ranked very favourable for the occurrence of placer gold and placer gold occurs elsewhere in the drainage, these characteristics do not guarantee that placer gold will be found at that particular segment of the stream. As a result, none of the combinations of confidence and favourability are considered either highly diagnostic (“h”) or moderately diagnostic (“m”) for the occurrence of placer gold in the study area. The highest appraisal given to a stream is slightly diagnostic (“L”), which is in itself a strong indication for the occurrence of placer gold.

PLACER POTENTIAL

Results of the appraisal are presented in the resource appraisal map for placer gold in the Stewart River (115N&O) and part of the Dawson (116B&C) map areas, Yukon (scale 1:250 000; Map 2, in pocket). Interpretation of the probabilities assigned to the various combinations of confidence and favourability should be based on inspection of the scores for the diagnostic characteristics. For example, in the confidence-favourability diagram (Fig. 43), a probability of ‘m’ (moderately suggestive) indicates a sum of the favourability scores of 4 to 5. This score may result from high scores in only two types of diagnostic characteristics, from modest scores in all

Table 5. Correlation of units used in resource appraisal with surficial geology units.

Resource appraisal units	Surficial geology units		
Pleistocene-Holocene gravelly fluvial deposits commonly forming narrow zones within stream valleys	Ap	Holocene	Floodplain sediments (Holocene)
	Ax	Holocene	Alluvial sediments complex (Holocene)
Pliocene White Channel Gravel deposits commonly forming mid- to high-level terraces	At ^T	Pliocene and Late Miocene	High-level terrace sediments (includes White Channel Gravel and equivalent)
Pliocene(?) gravelly fluvial deposits similar to the White Channel Gravel deposits	At ^{PR}	Late Pliocene/ Early Pleistocene	Alluvial terrace sediments
	At ^T	Pliocene and Late Miocene	High-level terrace sediments (includes White Channel Gravel and equivalent)
	Py	Paleo-Yukon River terrace	
Pleistocene-Holocene gravelly deposits forming alluvial fans, pediments, etc.	Af	Holocene	Alluvial fan sediments
	At	Holocene and modern	Alluvial terrace
	At ^P	Pleistocene	Alluvial terrace sediments
	Af ^P	Pleistocene	Alluvial fan sediments
	CAx ^P	Pleistocene	Alluvial complex sediments
Pliocene-Holocene deposits consisting primarily of sand, mud and/or coal	O	Holocene	Bog, fen and swamp deposits
	Eb ^P	Pleistocene	Eolian blanket
	CEa ^P	Pleistocene	Eolian/colluvial apron (muck)
	D ^{PR}	Late Pliocene/ Early Pleistocene	Drift
	De ^{PR}	Late Pliocene/ Early Pleistocene	Fluvial incised drift
Pliocene-Pleistocene glaciofluvial, glaciolacustrine and till deposits	FGt	Pre-Reid	Glaciofluvial terrace
	Gt ^M	Late Pleistocene	Glaciofluvial terrace sediments
	Gt ^R	Middle Pleistocene	Glaciofluvial terrace sediments
	Lu ^{PR}	Late Pliocene/ Early Pleistocene	Glaciolacustrine undivided
	Gt ^{PR}	Late Pliocene/ Early Pleistocene	Glaciofluvial terrace sediments
	Tb ^{PR}	Late Pliocene/ Early Pleistocene	Till blanket
	Tv ^{PR}	Late Pliocene/ Early Pleistocene	Till veneer
Bedrock outcrops (including thin colluvial blanket and veneer), and mass wasting deposits	Cv-b	Holocene and Pleistocene	Colluvial blanket and veneer sediments
	Cb	Holocene and Pleistocene	Colluvial blanket sediments
	Cv	Holocene and Pleistocene	Colluvial veneer sediments
	Ca	Holocene and Pleistocene	Colluvial apron sediments
	Cf	Holocene and Pleistocene	Colluvial fan sediments
	Cl	Holocene and Pleistocene	Landslide sediments
	Cx	Holocene and Pleistocene	Colluvial complex sediments
	CP	Holocene and Pleistocene	Pediment slope sediments
	DI ^{PR}	Late Pliocene/ Early Pleistocene	Drift modified by landsliding
	V ^T	Late Pliocene	Basalt
	P ^T	Pliocene and Late Miocene	Pediment and bajada sediments
	R	Pre-Late Tertiary	Bedrock
	Rw		Weathered bedrock

RESOURCE APPRAISAL FORM FOR PLACER GOLD	
Creek/River _____	Date _____
Favourability Score	<p style="text-align: center;">Diagnostic Data</p> <p>GEOLOGICAL CHARACTERISTICS</p> <p>+3 Pleistocene-Holocene gravelly fluvial deposits commonly forming narrow zones within stream valleys.</p> <p>+2 Pliocene White Channel Gravel deposits commonly forming mid- to high-level terraces.</p> <p>+1 Pliocene(?) gravelly fluvial deposits similar to the White Channel Gravel deposits.</p> <p>0 Pleistocene-Holocene gravelly deposits forming alluvial fans, pediments, etc.</p> <p>-1 Pliocene-Holocene deposits consisting primarily of sand, mud and/or coal.</p> <p>-2 Pliocene-Pleistocene glaciofluvial, glaciolacustrine and till deposits.</p> <p>-3 Bedrock outcrops and mass wasting (landslide) deposits.</p>
	<p>GEOCHEMICAL ANOMALIES</p> <p>+2 Gold greater than or equal to 21 ppb in stream sediment samples.</p> <p>+1 Gold less than 21 ppb in stream sediment samples.</p> <p>0 No gold detected in stream sediment samples.</p>
	<p>PLACER MINERAL OCCURRENCES</p> <p>+2 Gold produced from one or more placers in the drainage system (i.e., placer gold mine).</p> <p>+1 One or more gold placer prospects or occurrences in the drainage system.</p> <p>0 No gold placer deposits known in the drainage system..</p>
	<p>LODE GOLD MINERAL OCCURRENCES</p> <p>+2 Gold produced from one or more lodes in the drainage system (i.e., lode gold mine).</p> <p>+1 One or more lode gold prospects or occurrences in the drainage system.</p> <p>0 No gold-bearing lodes known in the drainage system.</p>
+ + + = FAVOURABILITY	CONFIDENCE (number of kinds of diagnostic data) = _____
_____ = SUM OF FAVOURABILITY SCORES	GEOLOGIC PROBABILITY = _____
COMMENTS _____	

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Figure 42. Resource appraisal form used in the study.

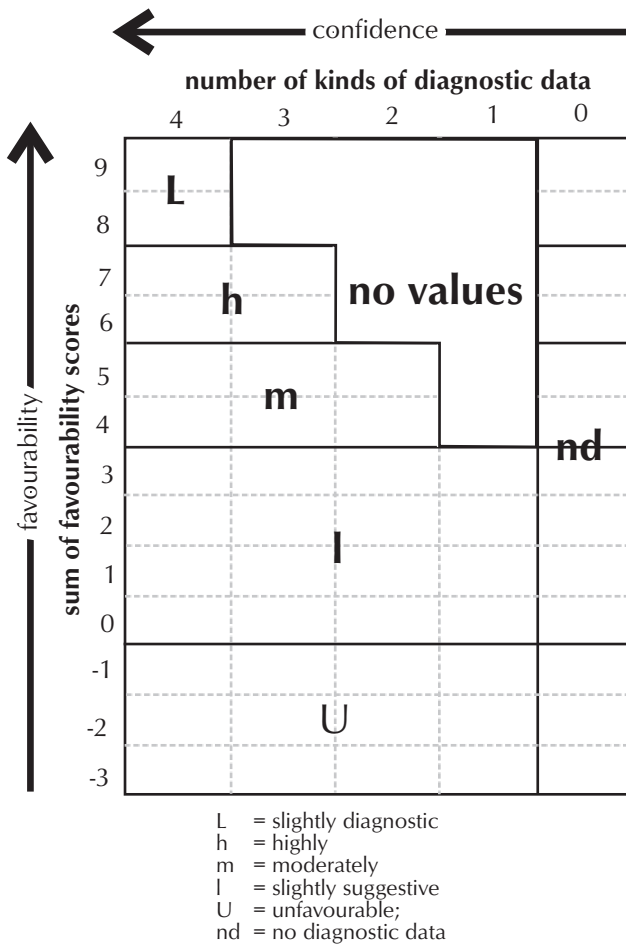


Figure 43. Confidence-favourability matrix used in the study.

types of diagnostic characteristics, or from high scores in some diagnostic characteristics, and low or negative scores in other types of diagnostic characteristics. Favourability scores for each type of diagnostic data used in the appraisal are shown on the map for each stream (+3 +0 +0 +2, correspond to rankings for alluvial geology, geochemical anomalies, placer occurrences and lode occurrences, respectfully).

The resource appraisal map for placer gold can be used in several ways. The first way is to determine which streams are worthy of further investigation to look for placer gold deposits. The streams with the highest placer gold potential (slightly diagnostic or 'L', with favourability scores of 8-9) have already been extensively mined (e.g., Bonanza, Sulphur and the upper part of Dominion creeks, the lower part of the Indian River, and the upper part of the Sixtymile River). Other streams with potential are those ranking 'highly suggestive' ('h',

with favourability scores of 6-7). This also includes many streams that have been extensively mined (Hunker and Gold Run creeks, the lower part of the Klondike River, Allgold Creek, the upper part of the Indian River, the lower part of Montana Creek, tributaries to the upper part of the Sixty Mile River, the Fortymile River, Maisy May, Thistle, Kirkman and Ten Mile creeks, and the Moosehorn Range area), and streams that have not been mined (Fifty Mile, Rosebud, Rosebute, and Eighteen Mile creeks, and the upper part of the North Ladue River and its tributaries). The majority of the streams ranked slightly diagnostic and highly suggestive are third-order streams (based on the Horton-Strahler stream ordering system and 1:250 000-scale topographic maps 115N&O and 116B&C; Strahler, 1957). The remaining streams ranked in the study area range from moderately suggestive ('m', with favourability scores of 4-5) to slightly suggestive (favourability scores of 0-3, or 'l'). Several of these streams have also been extensively mined (the lower part of Dominion, Black Hills, Scroggie and the upper part of Matson creeks), but some have not (unnamed tributaries to the North Ladue River and unnamed tributaries to the White River). Note that the majority of streams are unranked because no data was available; hence the probability of occurrence of placer gold for these stream is unknown, although many of these streams were probably extensively prospected for placer gold prior to, and following, the Klondike gold rush.

A second way that the resource appraisal map can be used is to determine which areas have known lode sources but no known placer deposits. For example, placer gold has not been reported from creeks draining the Brewery Creek mine. Either placer gold has not yet been found in these creeks, or placer gold was not deposited in these creeks due to the absence of a 'placer gold window' (i.e., the time interval between initial unroofing of the lode gold source by uplift and erosion and events that cut off the supply of gold, such as the migration of a drainage divide and stream capture; Craw and Leckie, 1996).

A third way that the resource appraisal map can be used is to determine which areas have known placer gold deposits, but no known lode gold source. For example, a lode gold source (or sources) has not been found for placer gold from creeks that drain Eureka Dome (i.e., Eureka and Black Hills creeks); similarly, a lode source has not been found for placer deposits along Thistle and Kirkman creeks. Both of these areas are prime targets for bedrock exploration.

RESOURCE POTENTIAL

Reliable estimates on gold resources are not commonly available. However, Newman and Chapman (1987), in a study on heap leaching the White Channel Gravel, determined that the average grade of 25 samples was 0.08 g/t Au. Henneberry (1990) reported in a feasibility study of placer mining in the Stewart River area that the average grade of creek and bench gravel along Ballarat, Barker, Black Hills, Brewer, Henderson, Kirkman, Maisy May, Scroggie and Thistle creeks was 0.022 oz/yd³ (0.895 g/m³).

Generally, most of the placers in the study area are considered marginally economic with the price of gold at \$300.00 U.S. per ounce, and Perkin et al. (2002) reported that the most common cutoff grade for placers was 0.015

or less ounces per cubic yard. Perkin et al. (2002) reported also that placer operations are extremely sensitive to the price of gold and the price of diesel fuel (e.g., a decrease in gold prices by \$25 CDN would cause more than 30% of the industry to shut down temporarily or go out of business, whereas an increase in gold prices by \$50 CDN would cause 28% of miners to lower grades and 11% to increase capital expenditures; a price increase of 25 cents a litre for diesel would cause most operations to mine only high-grade areas, temporarily shut down or slow production, and a price increase of 73 cents a litre would shut down almost all operations). In addition, Perkin et al. (2002) noted that it can take as long as five years to get a stream classified, making it very difficult for operators to move into new areas for a new mine to open.

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