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DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 173

HEAVY MINERAL STUDIES IN THE KLONDIKE AREA, YUKON TERRITORY

C. F. Gleeson

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By
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PREFACE

The report describes a heavy mineral study of both alluvium and underlying weathered bedrock in the placer gold bearing Klondike area, Yukon Territory.

A simplified standardized technique of sampling and preparation of heavy mineral concentrates is described. Spectrographic analyses proved to be a useful tool in the rapid study of concentrates. In all, some forty-eight heavy minerals were identified in the alluvium, most of which come from the immediately underlying bedrock. Some can be shown to be derived from specific types of gold-bearing veins, but unfortunately none is a better indicator of the presence of such veins than gold itself. Moreover, none of the heavy minerals, which include barite, chlorite, cassiterite, monazite, rutile, scheelite, and sulphides, shows promise of being present in economic quantities in the alluvium.

The report draws attention to several unworked areas of auriferous gravel, and suggests some possible localities where lode gold might be found.

Y.O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, March 15, 1966

BULLETIN 173 — Untersuchung von Strandsanden des Klondike-Gebiets im Yukonterritorium

C. F. Gleeson

48 Strandsande sind in den Kiesen des Klondike-Gebiets gefunden worden und werden beschrieben; nur Gold ist jedoch in bauwűrdigen Mengen vorhanden. Anzeichen deuten darauf hin, dass geochemisches Prospektieren mit anschliessender Goldwäscherei mőglicherweise zum Markieren von berggoldhaltigen Gefűgen von Nutzen sein kőnnen.

БЮЛЛЕТЕНЬ 173 — Изучение тяжелых минералов в районе Клондайк территории Юкон.

Х. Ф. Глисон

Найдено и описано 48 тяжелых минералов в галечниках района Клондайк, однако только золото находится в количествах, пригодных к эксплуатации. Имеются признаки, указывающие на то, что ковшовая проба после геохимических поисков может оказаться полезной для определения золотоносных структур.

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HEAVY MINERAL STUDIES IN THE KLONDIKE AREA, YUKON TERRITORY

Abstract

The Klondike area is underlain by various schists belonging to the Nasina and Klondike Series. Foliated granite and ultramafic rocks cut both series as does a stock of biotite granite. Tertiary rhyolite porphyry bodies also intrude the two series. Eocene sediments and tuffs are present, and andesite, diabase, and ultramafic dykes are common.

Four types of lode gold deposits have been recognized: (1) gold with quartz-barite veins, (2) gold with quartz veins in chlorite schist, (3) gold with quartz stringers in shear zones, and (4) gold in tertiary conglomerates (ancient placers). No new placer deposits have been found, but large deposits of unworked high-level and valley gravels remain to be evaluated.

Forty-eight heavy minerals have been found and described from the gravels of the area, but only gold is present in mineable quantities. Indications are that geochemical prospecting followed by panning for gold might be helpful in outlining lode gold bearing structures.

Résumé

Différents schistes des séries de Nasina et de Klondike forment le sous-sol de la région du Klondike. Des granites foliacés, des roches ultramafiques et un stock de granite à biotite recoupent les deux séries. Des masses de porphyre à rhyolite du Tertiaire font aussi intrusion dans ces deux séries. On y trouve des sédiments et des tufs de l'Éocène, et couramment de l'andésite, de la diabase et des dykes ultramafiques.

On a distingué quatre catégories d'or filonien: 1) l'or dispersé dans des veines de quartz et barytine, 2) l'or dispersé dans des veines de quartz au sein de schistes chloriteux, 3) l'or mêlé aux filaments de quartz dans des zones de fracturation et 4) l'or dans des conglomérats du Tertiaire (anciens placers). Aucun nouveau gîte de type placer n'a été découvert, mais d'importants dépôts de graviers inexploités, de vallée et de niveau plus élevé, demeurent à évaluer.

L'étude des graviers de la région a révélé la présence de quarante-huit minéraux lourds, mais seul l'or présente un volume exploitable. Il semble que la prospection géochimique suivie de lavages pourrait faciliter la mise en évidence des structures aurifères.

Chapter I

INTRODUCTION

Scope of Research

Because of the decline of placer mining activity in recent years and the depletion of mineable ground under the present price of gold, it was felt that the possibilities of increasing placer reserves should be investigated. Special attention was paid to the possibility of recovering other valuable heavy minerals either as primary products, or more likely as byproducts from the production of gold. It was thought that the method of heavy mineral studies might prove fruitful in locating potential lode gold deposits, especially if these lode sources were contributing a specific heavy mineral or suites of heavy minerals to the eluvium and gravels.

Field work was initiated in 1959 by C.R. McLeod. In 1961 the writer and McLeod commenced heavy mineral sampling, and the results form the basis for this report. Field work was completed in 1962.

This report deals with observations made in the Klondike district, an area that includes the gold-bearing streams tributary to Klondike River as well as those tributaries of Indian River that contain or have contained important placer gold deposits. The most productive streams of the area have been Bonanza, Eldorado, Bear, and Hunker Creeks and Klondike River from its mouth to the mouth of Hunker Creek. Placer gold has been recovered at a profit in Gold Run, Sulphur, Dominion, Quartz, and Eureka Creeks. These streams form part of the Indian River drainage system. Allgold Creek, a tributary of Flat Creek, has also been worked at a profit.

In 1964 gold was being recovered on all these creeks or their tributaries except Bear Creek and Klondike River (Fig. 16). There were two bench operations on the left limit of the Klondike River at the mouth of Germaine Creek and at the mouth of Flat Creek.

Acknowledgments

The writer is grateful for the co-operation of the placer operators and the property owners in the area who supplied information and assistance. The general manager and staff of The Yukon Consolidated Gold Corporation Limited and G.R. Hilchey of Klondike Lake Gold Mines kindly provided valuable maps and plans; the former company also supplied several gold samples for spectrographic analyses.

Competent assistance was rendered by W. Berry, A. Burgoine, and D. Jordan during the summer of 1961, and by L. Hogg and J. Archibald during the summer of 1962. Special thanks are extended to C.R. McLeod who did preliminary studies on the project in 1959 and 1960. In 1961, McLeod aided in the development of field techniques and was also responsible for collecting samples designated by the letter "M" on the sample

maps in this report. In 1962 he did laboratory tests on heavy mineral separations and recovery of gold from the samples. Part of the section on placer mining was obtained from information supplied by McLeod.

G. Archibald, assisted by M. Pullen, N. Webber, and J. McCullough, carried out microscopic studies in 1962. In 1963 able assistance was rendered W.P. Wilson who identified and counted grain-mounts from one hundred and thirty samples. T. Sadler-Brown assisted in compiling some of the maps used in this report.

Most of the heavy liquid and Frantz Isodynamic separations were done in the mineral separating laboratories of the Geological Survey of Canada under the supervision of J.C. Paris. Many of the samples were sized, weighed, and superpanned by P.J. Lavergne. E. Field and R. Kelly of the sedimentation laboratory of the Geological Survey made the grain-mounts. R.N. Delabio was responsible for mineral identifications using the X-ray powder photograph technique. Spectrographic analyses were done in the optical spectrographic laboratory of the Geological Survey of Canada under the supervision of W.H. Champ. The writer is grateful for the extensive laboratory support received from the above individuals; without this the study could not have been completed.

Accessibility

The Klondike is accessible by a 330-mile, all-weather road (Fig. 1) from the Alaska Highway 8 miles north of Whitehorse. Dawson, the former capitol of the Yukon Territory at the confluence of Yukon and Klondike Rivers, is the main centre of the area. A summer road from Alaska crosses into the Yukon Territory along a ridge between Fortymile and Sixty Mile Rivers and follows the summits lying between Swede Creek and Yukon River. A ferry service across Yukon River connects this road to Dawson. Secondary roads along the creeks make most of the placer operations accessible. The town is serviced by regularly scheduled aircraft throughout the year. The population of Dawson has dwindled to about one twelfth of more than 9,000 people recorded in 1901. The Yukon Consolidated Gold Corporation Limited maintained offices, shops, and staff accommodations at Bear Creek and camps on Dominion and Sulphur Creeks until 1966, and placer mining was the most important source of employment in the district; employment is also offered in road construction and maintenance, merchandising, and more recently tourism.

Topography

The Klondike region is a thoroughly dissected upland that forms part of the Yukon plateau, a topographic division of the interior system of the Cordilleran region (Bostock, 1948). The plateau has been deeply dissected by numerous streams and several rivers, resulting in round-topped hills and ridges, most of which are 1,100 and 2,500 feet above the present water courses (Figs. 2 and 3). King Solomon Dome, at the head of Hunker Creek, has an elevation of 4,048 feet and is about 3,000 feet above Yukon River at Dawson. The important gold-bearing creeks flow from the Dome and the ridges that extend northwest from it. Bonanza, Hunker, and Allgold Creeks drain northward into Klondike River; Quartz Creek, Dominion Creek and its tributaries, Sulphur and Gold Run Creeks, drain southward into Indian River. Klondike River and Indian River flow west

C.F.G., 3-3-61

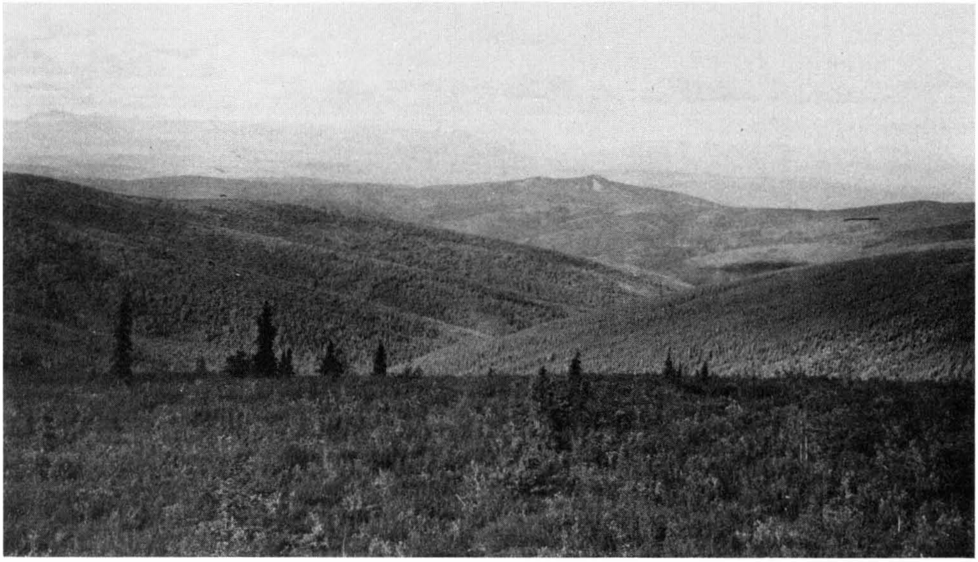
FIGURE 1. View of Dawson looking up Yukon River; Klondike River enters Yukon River from the left.

into Yukon River. These two rivers more or less mark the northern and southern boundaries of the Klondike district.

The ridges are long with steep sides and are dissected by narrow, V-shaped valleys. The crests of the ridges follow a sinuous course along the heads of the tributary valleys. McConnell (1903, p. 66) describes the topography as follows:

> The ridges are round-backed, branching elevations with slopes of from 10° to 20°. The crest line usually follows a zigzag course along the head of the tributary valleys and is broken, at intervals, by rounded prominences and bare rocky points.
>
> The valleys are flat and wide in their lower reaches, but gradually narrow toward their heads into steep-sided narrow gulches, which terminate abruptly in steep, rounded, cirque-like depressions cut into the sides of the ridges. The valley flats are marshy, partly wooded and wider on the Indian River side than on the Klondike slope. The flats bordering the lower parts of Dominion Creek have a width in places of nearly half a mile.

Rock-cut benches and terraces containing beds of gravel occur along Yukon and Klondike Rivers and extend up most of the creeks. Near Dawson the main rock terrace is about 500 feet above Yukon River and decreases to less than 100 feet above the river in the lower part of Stewart Valley (Bostock, 1942). Six miles below Dawson at Fort Reliance the main rock terrace is at 525 feet and increases to about 800 feet above the river below Fortymile River (O.L. Hughes, pers. com.). The altitude of the main rock



C.F.G., 1-17-62

FIGURE 2. View looking north down upper Hunker Creek showing rounded spurs and hilltops. Mount Leotta, in centre background, is underlain by ultrabasic rocks. Beyond Mount Leotta are Klondike River valley, Ogilvie Mountains, and the North Fork Pass of Klondike River.

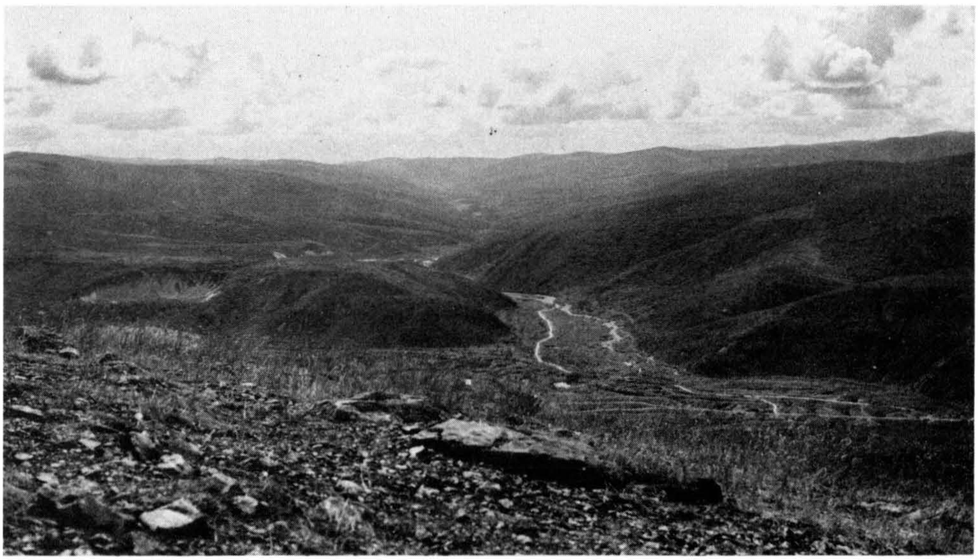


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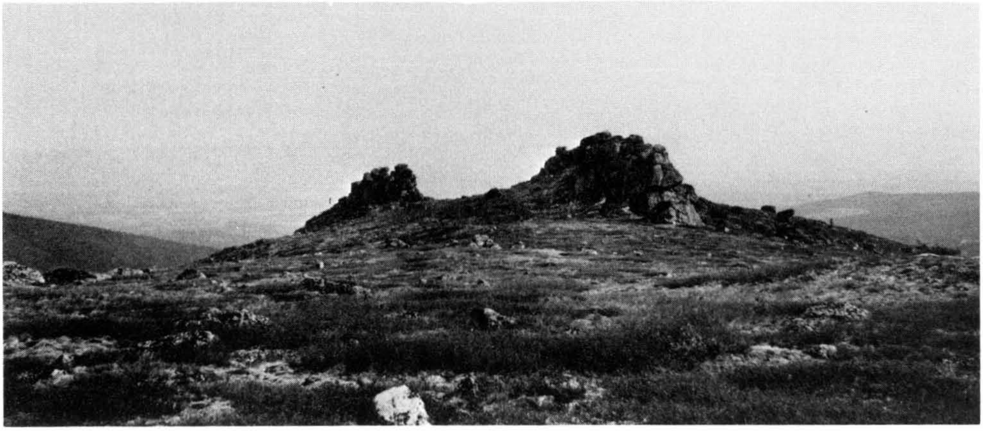
FIGURE 3. View looking south up Bonanza Creek. Before uplift in the area, Bonanza Creek flowed through hydraulicked area at left of photo. Over 300 feet of White Channel and Klondike gravels are exposed here. Note flat-topped terraces and rock-cut terraces marked by a line along the hill slopes.



C.F.G., 1-25-62

FIGURE 4. Castle-like remnants of weathered granite on Mount Burnham.

terrace increases towards the headwaters of Bonanza Creek and Hunker Creek and their tributaries, and reaches about 1,850 to 1,900 feet above sea level.

The Klondike district has not been glaciated; the rocks have been deeply weathered, and the surface is mantled by decomposed bedrock. Bedrock on the slopes of the hills is generally obscured by weathered rock and mixed slides of rock and moss, but it outcrops intermittently on the ridges and is often eroded into castle-like shapes. This is particularly noticeable in the vicinity of Mount Burnham on the ridge between Flat Creek and Dominion Creek (Fig. 4).

Permafrost, present throughout the area, is of variable thickness; it is thinner on ridges and southern slopes than in the valleys and on the northern slopes. It has been reported to a depth of at least 200 feet in the valley of Eldorado Creek (McConnell, 1903).

Chapter II

GEOLOGY

Previous Work

The Geological Survey of Canada published a preliminary report on the geology of the area by R.G. McConnell and J.B. Tyrrell in 1898. This was followed by a more complete report by McConnell in 1903. The results of the latter have formed the basis of geological knowledge in the Klondike area up to now. In 1906 McConnell's notable work on the gravels of the Klondike was published. Although his estimates on the gold reserves of the gravel later proved to be conservative, his classification, description, and distribution of the various gravels in the area were nevertheless found to be remarkably accurate. Brock (1909) and Cairnes (1911) reported on the geology and gold-bearing quartz occurrences of the area, and MacLean (1914) published detailed descriptions of most of the known lode deposits in the Klondike. Cockfield (1930, 1931) and Bostock (1933, 1934, 1935, 1936, 1937, 1938, 1939, and 1941), in their reports on the mineral industry of the Yukon, included brief descriptions of lode and placer operations in the Klondike. Most of the area is covered by Ogilvie map-sheet (Bostock, 1942), and more recently the geology of the north part of the Klondike has been reported by Green and Roddick (1962). Good descriptions of the present placer operations and lode exploration activities in the area have been given by Skinner (1961, 1962) and Green and Godwin (1963).

Description of Lithologic Units

Much of the Yukon Plateau is underlain by rocks designated as the Yukon Group (Bostock, 1942) that consists of gneisses, schists, micaceous quartzite, phyllite, slate, crystalline limestone, and some sheared greenstones. In places these rocks are accompanied by intrusions of granitic, basic, and ultrabasic rocks. Here and there sedimentary and volcanic rocks ranging from Paleozoic to Tertiary and Quaternary overlie the rocks of the Yukon Group.

Nasina Series

In the Klondike district the rocks of the Yukon Group are represented by a structurally complex series named Nasina in 1898 by McConnell (1903). The Nasina Series consists of dark grey rocks that grade from quartzites through micaceous quartzites to quartz-mica schist. Here and there these rocks are intermingled with green chlorite schists, locally graphitic, and bands of crystalline limestones, phyllite, and shale. Crinoid ossicles have been reported in Nasina rocks south of Yukon River near the Alaska border (Green and Roddick, 1962).

In the Klondike district the Nasina outcrops along Klondike River to Flat Creek and the lower part of Hunker Creek, and also to the southwest along Yukon River from Grizzly Creek to Indian River and up this river to Ruby Creek where it is covered by Tertiary sandstone and conglomerate. The Nasina reappears again just west of Eureka Creek and continues to the southern boundary of the district. A tongue-like outcrop of Nasina, about 2 miles wide, occurs on Dominion Creek between Burnham and Portland Creeks; Bostock (1942) and McConnell (1903) show this band pinching out near the head of Allgold Creek. Small irregular patches of Nasina schists also occur near Bonanza Creek on Boulder Hill, and on Cripple Hill. Minerals commonly present in this schist are quartz, chlorite, biotite, sericite, graphite, garnet, magnetite, calcite, pyrite, and occasionally feldspar.

Klondike Series

Most gold-bearing structures of the Klondike occur within this series. Schists of the Klondike Series range from white to light grey and light green; where they are chloritic they are a medium to dark green colour. The light coloured schist weathers to light buff. The Klondike Series is generally described as a sericite schist, but all gradations exist from hard, flaggy, quartzitic varieties to very soft, strongly sheared, sericitic types.

In some places the schist contains eyes of blue quartz. In addition, feldspar, colourless to white quartz, sericite, epidote, zoisite, magnetite, zircon, pyrite, calcite, goethite, hematite, and chlorite are commonly present; biotite is prevalent only in the chloritic varieties. The Klondike Series is cut in many places by quartz and quartz-barite veins some of which are gold bearing.

Earlier authors, McConnell (1903), Cockfield (1921), and Bostock (1942), postulated that the Klondike schists represented a series of altered quartz porphyry intrusions. More recently Green and Roddick (1962) suggested that these rocks could be metamorphic equivalents of gritty quartzites with minor amounts of sheared quartz-feldspar porphyries. The proportion of porphyry to quartzite has not been determined, but possibly could be if more detailed mapping and petrographic and geochemical studies were done in the area.

The rocks of the Klondike Series are foliated to different degrees. The strike of schistosity is northwesterly, dips vary from 5 degrees to vertical, but generally the rocks dip southwest at low to moderate angles. Northwest-trending shear zones cut the Klondike schists parallel to Tintina Trench. Some of these are large and show intense fracturing; they have been observed at the Lone Star property, on Bonanza Creek at McKay Gulch, on the left limit of Ready Bullion Gulch at its mouth, on Gold Hill near Grand Forks, on the right limit of Bonanza Creek above Mosquito Gulch, and in the vicinity of Oro Grande and Gay Gulches on Eldorado Creek. Similar zones are probably present elsewhere in the area, but they are hidden beneath overburden.

The shears are sericitized, pyritized, and invaded by quartz veins and stringers. Clay gouge material is usually found in them. Gold and minor amounts of galena, sphalerite, and barite occur in some of the shear zones. On fresh surfaces the rocks in these zones appear schistose, are white to light green, and have a pearly lustre due to the abundance of sericite. On the weathered surface the pyrite oxidizes and colours the schist buff brown.

Foliated Granite

Foliated granite outcrops along the divide between Flat and Dominion Creeks and extends southeast to Mount Burnham and to the head of Melba Creek, a tributary of Australia Creek. McConnell (1903) and Bostock (1942) also mapped these rocks on either side of Sulphur Creek near its mouth and on the west side of Quartz Creek near its mouth. The granite is more massive, is foliated rather than schistose, and is harder than the Klondike schists; its colour varies from reddish to grey. Bostock (1942) describes these granites as follows:

> Remnants of large feldspar or quartz crystals lie in a foliated groundmass of feldspar, quartz, mica, chlorite and, less commonly hornblende, tourmaline and garnet.

A traverse up the ridge between Jensen and Kentucky Creeks from Dominion Creek disclosed a gradual change from quartz-sericite-garnet schist into more compact quartz-feldspar gneiss and a coarse-grained foliated biotite granite. On Mount Burnham the granite is pegmatitic and contains coarse crystals of black tourmaline as long as several inches.

The foliated granite is younger than the Nasina and Klondike Series. Cairnes (1917) considered it to be intrusive into the Klondike schists; McConnell (1903), who thought the Klondike schists were altered quartz porphyries, mentioned that this granite was probably a part of the Klondike schists that had been cooled at greater depths. Cockfield (1921), in describing these rocks west of the Klondike area, suggested that they were intrusions that had been subjected to movements and stresses that resulted in their foliated structure. The writer agrees with Cairnes that these are porphyritic granites that intruded the Klondike and Nasina Series, and that subsequently they were altered by regional stresses to produce a cataclastic structure.

Tertiary Rocks

Tertiary (Eocene) sedimentary rocks occur along Klondike River below Flat Creek, in a small area exposed in the valley of Last Chance Creek, just above the junction with Hunker Creek, and south of Indian River opposite Quartz Creek. They vary in composition from shales, arkose, sandstones, tuffaceous sandstones, and agglomerates to conglomerates. The conglomerates, white and quartzose, are exposed along the south side of Indian River; they carry low gold values. In the vicinity of Indian River these sediments are cut by andesite and diabase dykes.

Several areas of young volcanics, called andesites by McConnell, occur south of Indian River on Montana Creek and between Coal and McKinnon Creeks. They occupy an area on Yukon River opposite and below the mouth of Indian River, and also a small area at the mouth of Last Chance Creek. In places the rock is vesicular, and the cavities contain chalcedonic material. Hornblende, augite, biotite, plagioclase, ilmenite, leucoxene, magnetite, apatite, and sphene are present in the andesite. On the west side of Yukon River the andesite is cut by wide diabase dykes.

A body of rhyolite porphyry outcrops on the west side of Hunker Creek between Bordeleau and Tinhorn Gulches and extends over the ridge to Alki Creek and east to Goring Creek. The porphyry is white to light grey. The most abundant porphyritic mineral is dull, smoky quartz, about 1/8 inch in diameter, that forms rounded and corroded crystals as well as perfect dihexagonal pyramids. There are also phenocrysts of orthoclase and plagioclase (oligoclase) as long as 1/8 inch, and here and there biotite. Euhedral crystals of colourless topaz as much as 1/10 inch long are present in the heavy mineral concentrates from the porphyry. The matrix is made up of finer grained quartz and feldspar, biotite, zircon, hematite, limonite, chlorite; some stringers of colourless to purple fluorite containing traces of tourmaline are present. This rock is believed to be the source of cassiterite found in Hunker Creek and Klondike River. Hornfels is locally present where the porphyry cuts the Nasina Series on Hunker Creek.

Other Rocks

Other rock types in the area include an altered greenstone, called altered diabase by McConnell (1903), that forms the bluffs at Dawson. A massive, grey, unaltered, coarse, biotite granite stock intrudes the Nasina Series in the area of Jim Creek on the west side of Yukon River, 3 miles below Indian River. Several bodies of serpentinized ultrabasic rocks are present on the ridge bordered by Hunter Creek and Klondike River, between Allgold Creek and Tinhorn Gulch. Another small body occurs on the west side of Hunker Creek opposite Tinhorn Gulch and below Hester Creek. These bands are elongated northwesterly and cut the Klondike and Nasina schists. Ultramafic rocks also outcrop on the north side of Klondike River 2.5 miles above Dawson city. These rocks are dark green and weather to shades of yellow and brown; minerals such as pyroxene, olivine, serpentine, magnetite, and calcite are commonly present. In addition, andesite, diabase, and basic dykes cut the rocks of the area. These dykes vary from a foot to 20 feet in width. Generally the diabase and basic dykes strike northwesterly and have moderate to steep southwesterly dips.

Structure

The Tintina Trench occupies the northwesterly trending valley of Flat Creek and is believed to represent a topographic expression of a major fault extending from deep in Alaska to southeastern Yukon where it is *en echelon* with the northwest end of Rocky Mountain Trench (Green and Roddick, 1962). As stated above, many shear zones cut the schists of the Klondike area and appear to be nearly parallel to the Tintina Trench. Faults also cut the schists. A fault in Eldorado Creek near Gay Gulch is about 100 feet wide and strikes northwest with a dip of about 60 degrees southwest. The fault is filled with blue to grey clay containing quartz and schist fragments.

Other faults have been observed on Adams Hill on the left limit of Bonanza Creek, and on Paradise Hill on the left limit of Hunker Creek. These faults are low angle, contain mostly clay gouge and broken bedrock, and have offset the high-level gravels. The result of this late faulting has been to carry the bedrock and gravel on the hanging-wall side over the gravel on the footwall side. The movement up dip has been 30 to 40 feet on Adams Hill. Such thrust faults could explain anomalous gold values obtained by McConnell (1906) on Paradise Hill. His best gold values were not found on bedrock but 12 feet or more above bedrock. The strike of the fault on Adams Hill is N35°E and the dip is about 20° northwest. No attitude was obtained on the fault on Paradise Hill.

Green and Roddick (1962) thought that most of the folding in the area was isoclinal and tight. They describe the folding as follows:

> Most outcrops of units B and C (Klondike and Nasina schists respectively) are strongly foliated along micaceous partings. Most of the bedding appears to be parallel with this foliation

but in many outcrops, places can be seen where the bedding is at an angle to the foliation and beds have been sliced into tiny segments between micaceous foliation planes (gleitbrett structure). In addition, attenuated isoclinal folds up to 10 feet in amplitude are fairly common, mostly with axial planes parallel with the foliation. Much of the gleitbrett structure may represent the axial parts of folds that are so drawn out and deformed that the complete fold cannot be recognized.

In general the strike of the schistosity is northwest, but locally it varies. Dips as low as 15 degrees southwest have been observed in the vicinity of King Solomon Dome; vertical dips have been seen in the vicinity of Victoria Gulch, but they vary from 30 to 60 degrees to the southwest.

Gravel Deposits

Classification

McConnell (1906) was the first to classify the gravels of the Klondike. A modified version of his classification appears below.

Valley and creek gravels:
- gulch gravels
- creek gravels
- river gravels

Terrace gravels:
- low level (mostly on Indian River drainage)
- intermediate level (Klondike River drainage)
- high level (Klondike gravels; White Channel gravels)

Valley and Creek Gravels

The creek gravels have been the most productive. They cover the valley bottoms and are usually 4 to 10 feet deep. In the creeks and gulches they are mostly covered by 2 to 40 feet of permanently frozen silty, organic material, locally called muck. In many places this contains the skeletal remains of various extinct or still existing northern animals (Fig. 5): mammoth, buffalo, bear, horse, musk-ox, mountain sheep, goat, and moose.

The pebbles and boulder material of the creek gravels are rounded to subrounded, and schist fragments occur as flattened, disc-shaped pieces. Quartz schist and minor amounts of various dyke, sedimentary, volcanic, and intrusive rocks, all local in origin, make up the gravels in the creeks and gulches. In the gulches and near the heads of creeks the pebbles and gravels are angular to subangular.

The river gravels of Klondike and Yukon Rivers consist of well-rounded material. In Klondike River there are quartzite, slate, chert, granite, gabbro, and diabase pebbles and boulders. This material is derived mainly from the western slopes of the Ogilvie Range. River gravels containing gold in economic quantities have been dredged on Klondike River from Hunker Creek to Yukon River.

Terrace Gravels

Low-level Terrace Gravels

Low-level terraces are best developed on Dominion Creek from near its head to 2 miles below Jensen Creek, on Quartz Creek from its upper parts to below Calder Creek, and at the mouth of Gold Bottom Creek. Dominion Creek above Burnham Creek and the

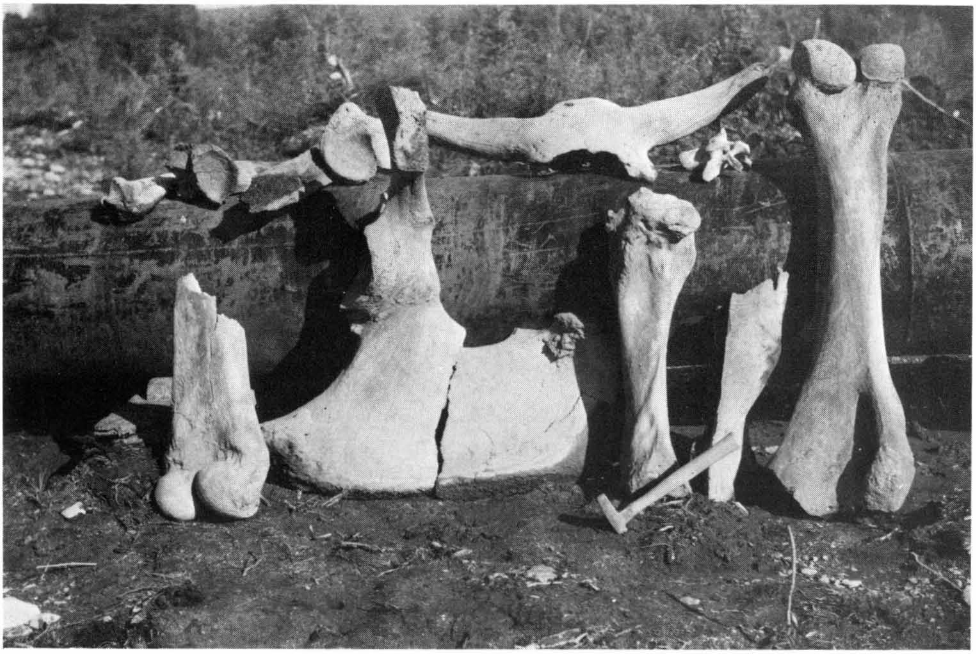

C.F.G., 5-8-61

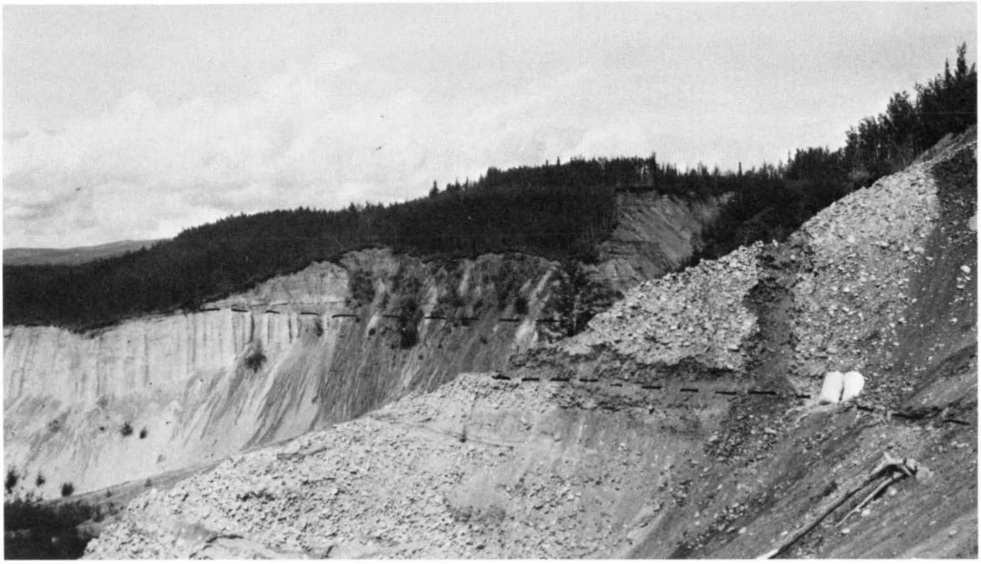
FIGURE 5. Bison and mammoth bones, Dominion Creek.

upper parts of Quartz Creek have been deepened slightly, hence bedrock elevations of these low terraces are usually a few feet to 40 feet above the present valley bottom.

In the lower parts of the creeks, however, recent creek gravels overlie a white siliceous gravel deposit similar to the high-level White Channel gravel. On the low benches of Dominion Creek the gravels are similar to creek gravels, but on Quartz Creek the bench gravel consists of compact greyish gravels below and looser yellowish gravels above. In some places, near the mouth of Little Blanche Creek, for example, these gravels are about 100 feet thick.

Intermediate Terrace Gravels

Intermediate rock terraces occur along Bonanza and Hunker Creeks. They have been formed by the deepening of the valleys and are remnants of former valley bottoms. An intermediate terrace occurs on the east side of Bonanza Creek just below Mosquito Gulch. At Skookum Gulch one of these terraces has been mined. There is another on the right limit of Bonanza Creek at Grand Forks. Several similar terraces occur along Hunker Creek; one of these is on the left limit just below Gold Bottom Creek and another on the right limit opposite Henry Gulch. The terraces are irregular in distribution; they occur at various elevations and usually are not very large. Gravel beds on the terraces are from 6 to 20 feet thick and contain the same material as the creek gravels, but the gravels show more wear. As a rule the gravels on these terraces are overlain by muck and rock debris; on Hunker Creek, near Gold Bottom Creek, the layer of muck is 100 feet thick.



C.F.G., 1-2-61

FIGURE 6. Lovett Hill looking north. Dashed line indicates contact between Klondike gravels on top and White Channel gravels below.

C.F.G., 3-8-61

FIGURE 7. White Channel and Klondike gravel section on Lovett Hill, Bonanza Creek.

High-level Gravels

High-level Klondike gravels are present along Klondike River, overlie the White Channel high-level gravels in the lower parts of Bonanza Creek (Figs. 6, 7) and Hunker Creek, and occupy the plateau area between these creeks. They consist mainly of old river deposits laid down by Klondike River when it ran at a much higher level than at present and occupied a somewhat wider valley.

The Klondike high-level gravels are about 450 feet above the present valley bottoms and vary in thickness from 150 to 175 feet. They consist of well-rounded brown boulders and pebbles of quartzite, chert, slate, granite, diabase, gabbro, and conglomerate, derived for the most part from rocks of the Ogilvie Range.

A bench on the south side of Klondike River at its mouth and another on the north side of Klondike River opposite Bonanza Creek have been worked for gold in the past; recently a low bench of Klondike gravels on the south side of Klondike River at the mouth of Germaine Creek has also been worked. It is possible that more of these low benches along Klondike River are auriferous.

The White Channel gravels, the second type of high-level gravel in the district, are present along the creeks that drain into Klondike River. Bonanza Creek, Hunker Creek, and their tributaries contain deposits of this gravel (Figs. 6, 7, 8). The White Channel gravel consists of rounded to subrounded quartz and leached schist pebbles and boulders that impart a white or light grey colour. Here and there pebbles and boulders derived from various dykes and stocks in the area are found in the gravel sections. The colour darkens to a light brown in the upper parts of the creeks due to the presence in the gravels of less-weathered brown schist containing hydrous iron oxide minerals. McConnell (1906)

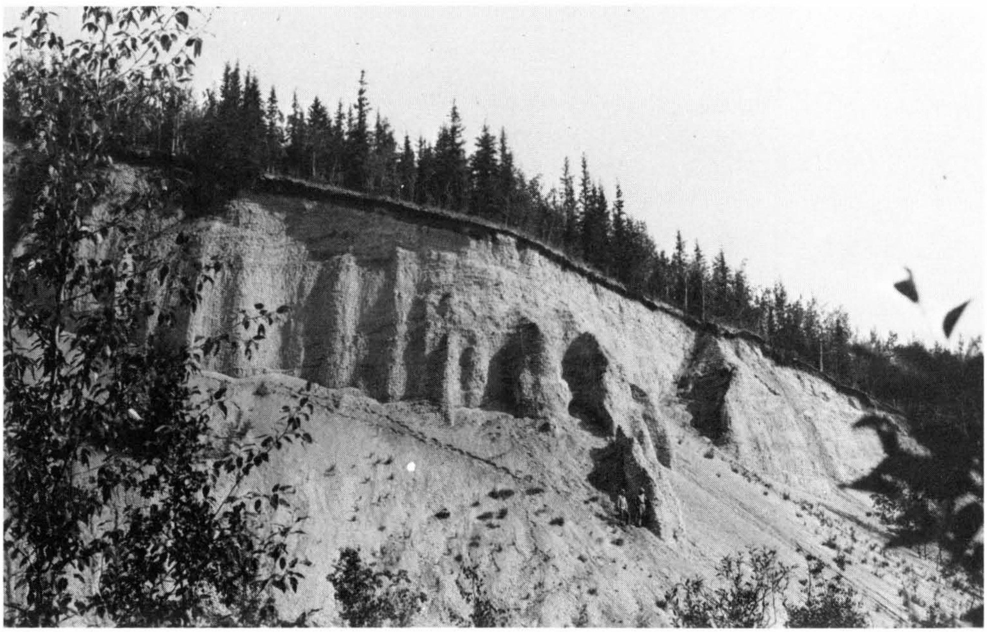


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FIGURE 8. White Channel gravel section at the south end of Lovett Hill.

called these deposits yellow gravels. The white gravels pass gradually, both horizontally and vertically, into these yellow gravels. The White Channel gravels vary in thickness from a few feet to over 150 feet, and in width from 100 feet to 2 miles or more.

The high-level gravels represent remnants of early creek deposits laid down in wide, flat-bottomed valleys. After deposition of the White Channel gravel, and probably during late Tertiary time, uplift occurred in the Yukon Plateau. The amount of uplift has been estimated by McConnell (1903) to be as much as 600 to 700 feet; this resulted in deep channel cutting by streams draining into Klondike River. They were able to cut quickly with renewed vigour through the deposits of White Channel gravel into bedrock and to their former valley floors. As a result the old gravels now occur on wide benches bordering the present valleys at elevations of from 150 to 300 feet above them. The elevation of the gravel deposits above the creeks increases down stream.

In the south part of the Klondike, uplift was not as great as in the north portion of the area, hence the creeks of the Indian River drainage system did not cut deeply into the valley gravels. As a result, white gravels, almost identical with the high-level White Channel type, underlie the recent creek gravels on the lower parts of Dominion, Quartz, Sulphur, and Gold Run Creeks.

Large accumulations of gold occurred in the White Channel gravels. Much of the gold that has been mined in the present valley bottoms represents reworked gold from the high-level gravels. In the past most of the White Channel gravel benches were mined hydraulically; now (1964) hydraulic operations are in progress on Cripple Hill, King Solomon Dome, Adams Hill, Dago Hill, Discovery Hill, and Preido Hill (Fig. 16). The largest areas of unworked White Channel gravels occur between the north end of Lovett Hill and Klondike River on the east side of Bonanza Creek (Figs. 6, 7, 8), and on Australian Hill on the east side of Hunker Creek at its mouth.

Lode Deposits

The locations of known lode occurrences are shown on Figure 16. Most of these properties were described by MacLean (1914), and most of the locations shown were obtained from his map. Although lode gold deposits containing silver values are the prominent type of mineral occurrence in the district, there are also several occurrences of copper mineralization.

Copper

At the Box Car Group, situated on the east slope of the divide between Bonanza and Soda Creeks (the latter a tributary of Gold Bottom Creek), the bedrock consists of grey to green quartz sericite-chlorite schist striking northwest and dipping at low angles to the southeast. A shaft has been sunk on the showing but it has caved in. The schist in the dump around the shaft is stained blue and green due to the presence of azurite and malachite, and rusty quartz is also common. MacLean obtained low gold values from the oxidized schist and quartz, but found silver values ranging from 0.07 to 26.53 ounces per ton. E. Kindle (pers. com.) reports copper values of 3.25 per cent from a grab sample.

The second copper occurrence is in the bed of Gold Bottom Creek about 2.5 miles up from Hunker Creek. A 70-foot shaft was sunk on the showing by Yukon Consolidated Gold Company in 1948. The mineralization consists of chalcopyrite, pyrite, and bornite in brecciated chloritic Klondike schist. A grab sample from the dump assayed 4.34 ounces of silver per ton and 7.31 per cent copper (E. Kindle, pers. com.).

Gold

At least four types of gold deposits have been recognized in the area.

1. Gold associated with quartz-barite veins containing minor amounts of galena. The Violet deposit is an example of this type.

2. Gold associated with quartz veins in the chloritic phase of the Klondike schist. The quartz weathers to rusty, vuggy masses due to the oxidation of pyrite; coarse pyrite is also present in the quartz and in the schist next to the quartz veins. The veins usually contain minor amounts of galena. The Mitchell deposit is an example.

3. Gold in strong northwest-trending shear zones. The zones have been extensively sericitized and pyritized, and contain stringers and veins of quartz and minor amounts of galena and sphalerite. Zones of clay are common in the shears. The Lone Star deposit is typical.

4. Gold in Tertiary conglomerate. These deposits are south of Indian River and were described by McConnell (1906) as ancient placer deposits. The Britannia deposit on McKinnon Creek is an example.

Mining Properties

No attempt is made to describe every lode occurrence in the area. Cairnes (1911) and MacLean (1914) reported most of the lode gold occurrences, hence descriptions in this report are limited to three types of deposits from which heavy mineral samples were obtained.

Lone Star Mine

Development

The Lone Star mine is located near the head of Victoria Gulch on the divide separating Bonanza and Eldorado Creeks (Fig. 16). The original claims were staked in 1899. Between 1909 and 1914 development work was done, consisting of mining an open-cut 150 feet by 20 feet by 20 feet along the strike of the showing. In addition, an adit and several drifts were opened about 60 feet below the surface, under and in the vicinity of the open-cut. A small stamp mill was built and was in operation between 1912 and 1914. No more work was done until 1946-47 when the Yukon Consolidated Gold Company did 200 feet of crosscutting underground, bulldozed eight trenches, and drilled six churn drillholes. Since then the property has been idle.

Geology

Numerous veins, lenses, stringers, and irregular bodies of quartz occur in a large sericitized and pyritized shear zone that strikes about N50°W and dips 50°-70°SW. The zone is 300 to 400 feet wide and has been traced to the northwest for 1,500 to 1,600 feet. MacLean (1914) states that this shear zone outcrops at the head of Thirteen Pup, 1,000 to 1,500 feet southwest of the open-cut. The rock in the zone is sheared Klondike schist. Fresh surfaces are white with rare green chloritic patches. On the weathered surface the pyrite oxidizes and colours the rocks light brown. Zones of clay material are common, and they probably represent fault gouge within the shear zone.

Gold is associated with quartz veins and stringers; some parallel the schist, but others, although similar in strike, dip 25°-35° NE or at about right angles to the dip of the shear zone. The gold occurs as yellow flakes and grains in quartz and in the schist wall-rock near the quartz veins. There is some indication that much of the gold is associated with the northeast-dipping quartz veins. Here and there are small pockets of sulphides commonly comprising pyrite, galena, and sphalerite; these weather dark brown and invariably carry good gold values. One such small rusty seam assayed 6.19 ounces of gold and 0.98 ounce of silver per ton, and the schists around the rusty spot gave gold values of 0.093 ounce and 0.03 ounce of silver per ton. Unfortunately these rich pockets are not common. Samples of quartz taken by the writer from the shear zone average 0.01 ounce of gold and 0.03 ounce of silver per ton. Heavy minerals present in the shear zone include goethite (pseudomorphous after pyrite), barite, epidote, sphene, apatite, biotite, hornblende, hypersthene, ilmenite, magnetite, martite, garnet, zircon, dolomite, and monazite.

Many similar shear zones occur in the Klondike schist and several have been opened up on the north side of Gay Creek by Klondike Lode Gold Mines Ltd. Quartz from one of these assayed 1.83 ounces of gold and 0.41 ounce of silver per ton. Two similar zones occur on Bonanza Creek below Victoria Gulch (Fig. 20), and another is present at the mouth of Ready Bullion Gulch. There are similar zones along other parts of Bonanza and Eldorado Creeks, and MacLean (1914) describes one on the north side of Indian River about 2.5 miles above Quartz Creek. Undoubtedly more of these zones are present throughout the Klondike, but they are concealed by overburden. Exploration for lode gold occurrences should concentrate on evaluating the known shear zones and discovering new ones.

Mitchell Deposit

Development

The Mitchell deposit is on the crest of the divide separating Hunker and Gold Bottom Creeks and about a mile north of King Solomon Dome (Fig. 16). The Mitchell group, owned originally by Mrs. Margaret J. Mitchell, is now covered by the Mayhap group of claims. Prior to 1914 the occurrence was extensively trenched and a shaft was sunk to a depth of 84 feet on a gold-quartz vein reported to be a foot wide at surface, but which narrowed to half an inch at the bottom of the shaft. Some spectacular specimens of rusty quartz exhibiting free gold were taken from this property in the early days. More recently trenches were made by bulldozer at 50- to 100-foot intervals along a strike length of about 3,000 feet. In 1962 more bulldozer work was done on the Moose and Caribou group of claims, which join this property to the north, and to a limited extent on the Mayhap group.

Geology

The country rock in the vicinity of the Mitchell deposit is a dark green, quartz-chlorite schist. Where it is sheared, biotite schist is common, but in places the country rock is massive and slabby and has the appearance of an impure quartzite. Iridescent blue octahedra of magnetite make up 1 to 5 per cent of the schist, and locally sericite and actinolite are common; siderite, calcite, and dolomite are uncommon constituents. Other minerals found in the chlorite schist include pyrite, epidote, hypersthene, clinopyroxene, apatite, goethite (pseudomorphous after pyrite), and jarosite.

The schist strikes N5°-20°W and dips 15°-30°SW, but local variations occur, especially where shearing has taken place. At least two sets of quartz veins cut the schists. One large, white, massive vein, 4 to 6 feet wide, occurs near the south part of the property, strikes north, dips 60° E, and has been exposed for a length of about 400 feet; only low gold values have been found along this vein. A narrow quartz vein 4 to 18 inches wide cuts the schists in the vicinity of the shaft. This vein, traced for about 350 feet, strikes north and dips 60°-70°E. It is along this vein that most of the gold values on the Mitchell deposit have been found. Associated with the quartz vein and schist wall-rock is pyrite in cubes as much as 0.5 inch square. Where pyrite is oxidized the quartz is rusty and vuggy; gold is found in some of these rusty vugs, also minor amounts of galena. There are other small veins of quartz that strike N10°-12° E and dip 55°-70° E. These also have pyrite associated with them and they are auriferous.

The chloritic phase of the Klondike schist covers an area containing the wedge of ground between Gold Bottom and Hunker Creeks and extending southward over King Solomon Dome along the divide between Dominion and Sulphur Creeks, and thence down Gold Run Creek. Lenses and irregular patches are also found throughout the areas, especially on Carmack Fork.

Violet Deposit

Development

This occurrence is at the head of Golden Gulch near the top of the divide between Eldorado and Ophir Creeks, the latter a tributary of Indian River (Fig. 16). Before 1910, an open-cut 50 by 12 by 15 feet was dug, and three shafts were sunk to depths of 55 feet, 33 feet, and 150 feet (Cairnes, 1911). Little work has been done since, and the shafts have caved in or are flooded, filling the open-cut with debris.

Geology

The country rock consists of siliceous, flaggy, Klondike schist containing quartz eyes and about 10 to 15 per cent sericite. Several massive, white, quartz-barite veins cut the schists in the immediate area. One of these is 4 to 6 feet wide, strikes S85° E, dips 80° S, and can be traced in outcrops for several hundred feet. A lineament suggests that the vein may continue for another several thousand feet toward Chief Gulch. The vein contains milky white crystalline quartz, white barite, and minor galena; is stained by limonite; and is badly fractured and shattered. About 2,000 feet north of the main shaft a sample from a similar quartz-barite vein assayed 0.02 ounce of gold per ton and 0.035 ounce of silver per ton, as well as 1.42 per cent lead and 1.3 per cent barium. In addition to native gold, barite, galena, goethite, and limonite, the following heavy minerals have been identified from the Violet deposit: jarosite, pyrite, clinopyroxene, hypersthene, biotite, zircon, magnetite, ilmenite, and hornblende; chalcopyrite was reported by MacLean (1914).

It is not known how prevalent auriferous quartz-barite veins are in the district, but results of heavy mineral studies suggest that barite is a major constituent in many of the creek gravel and eluvium samples. Barite is more abundant in samples taken from the less schistose Klondike Series rocks than it is in the samples taken from the moderate to very schistose Klondike schist.

Chapter III

PLACER MINING

History

Prospecting in the Klondike area began on Indian River and Quartz Creek in 1894 when they were visited by Robert Henderson and a small party. The following year Henderson returned and crossed the divide at the head of Quartz Creek to Gold Bottom Creek, a tributary of Hunker Creek. In 1896, while returning from Ogilvie with supplies, he met G.W. Carmack, a trader travelling with two Indians, who followed him and staked on Gold Bottom Creek. Carmack's party returned to the Klondike via Bonanza Creek, and on August 17, 1896, made the famous discovery of gold that touched off the great Klondike rush. In September, 1896, a discovery claim was staked by Andrew Hunker on the creek that now bears his name, and the following year discoveries were made on Dominion, Sulphur, and Quartz Creeks. The first hillside or bench claim was staked on Eldorado creek in August, 1897. Following this discovery of gold in an older, higher channel, similar deposits were subsequently found and staked on Bonanza, Bear, Quartz, Dominion, and Hunker Creeks. In June, 1897, nearly 800 claims had been recorded, and by September, 1898, the number exceeded 17,000 (Innis, 1936).

Methods

Creek claims in the early days were worked by either underground or surface mining methods. Where the overburden and gravel were relatively deep, a shaft was put down to bedrock and drifting was done across the channel of the creek to locate the "pay streak" or rich gold-bearing gravels, usually found on or near the surface of the bedrock. When the pay streak was found, sometimes only after several shafts had been put down and drifting had been completed across most of the width of the creek bottom, other shafts were put down along its length and the gravel was hoisted to surface for sluicing. Fires or heated stones were used to thaw the frozen ground so that it could be removed. During summer thawing, roof and shaft gravels tended to loosen and fall, thus making underground operations much more hazardous than in winter, and underground work was usually begun in the fall. In the spring the dumps containing the pay gravels that had been mined were sluiced to recover the gold.

Surface mining was done where the depth of overburden and gravel was shallow, usually less than 15 feet. Pits were put down to delimit the area containing workable gravels, and the area was cleared of trees, bushes, and moss. Ditches were cut through the overburden, which remains permanently frozen except for 2 or 3 feet at surface that thaws and freezes annually, and in the spring water was diverted through the ditches to thaw and carry away the muck, leaving the gravels exposed for natural thawing. As thawing progressed, waste gravels were removed until the pay gravel was reached, and this was then put through sluice boxes. This method of mining, termed open-cutting, was used effectively and extensively on most creeks. The chief problem involved was the disposal of waste gravels and tailings. To make room for tailings, sluice boxes were sometimes elevated, but this necessitated raising the gravels and water also.

On bench or hillside claims mining was more difficult and expensive because of the scarcity of water and greater depths of barren overburden and gravel. Drifts were driven along bedrock from the rim, or from the bottoms of shafts if the deposits were wide, often more than 100 feet deep and sunk to bedrock. Some open-cut work was usually done along a face at the rim. The gravel was usually washed in rockers because of the small amount of water necessary, or alternatively, trammed down to the creeks for sluicing there.

With improved transportation facilities and consequent reductions in freight rates, it became economical to bring in heavier equipment for mining purposes. Steam thawing was introduced in 1899 (Tyrrell, 1907) and soon replaced thawing with wood fires or stones; with steam the thawing could be done more quickly and controlled to better advantage. Thawing with fires had rapidly depleted the readily available wood, and the boilers used in steam thawing made much more efficient use of the available supply. In 1903 a report by Superintendent Cuthbert of the Northwest Mounted Police showed there were seven hundred and twelve boilers of from 10 to 50 horsepower on the creeks. Large pumps enabled water to be raised for sluicing in the creeks, thus alleviating the problem of the disposal of tailings, and also making it possible for water to be elevated for use on the benches. Considerable money was expended in the construction of ditches and flumes that resulted in more water being made available for both creek and bench workings. Steam-powered hoists, such as the self-dumping cable-tram or "Dawson carrier", greatly increased the efficiency of underground workings. Steam shovels and hydraulic plants enabled lower grade ground to be worked, as larger quantities of gravel could be handled at lower costs per cubic yard than was possible using manual labour (Figs. 9 and 10).

The first dredge in the Klondike area began working on Bonanza Creek in 1901 (Canada, Dept. Interior, 1907). This method of mining proved to be efficient and economical if the gravels were thawed, but was hampered by the high cost of steam thawing sufficient quantities of frozen ground necessary for dredging. The development of hydraulic stripping and cold-water thawing procedures overcame the natural difficulties, however, and lowered costs sufficiently to ensure the future of dredging in the Yukon. The realization that adequate testing of ground was necessary before dredging resulted in better methods of prospecting. The discovery that holes could be drilled in frozen ground without casing them meant greatly reduced drilling costs and the development of a prospecting procedure, as described by Nordale (1947), designed to delimit the workable area and enable the stripping, thawing, and dredging operations to be properly planned. In 1962 five dredges were being operated in the area by The Yukon Consolidated Gold Corporation Limited (Fig. 11).

In recent years open-cut mining both on creeks and benches has proven to be economical using mechanical equipment. Stripping is usually done by hydraulic methods or with a bulldozer, and the ground is allowed to thaw naturally. A portable steel sluice box, with water supplied either by gravity from a ditch or by pump from the creek, is set

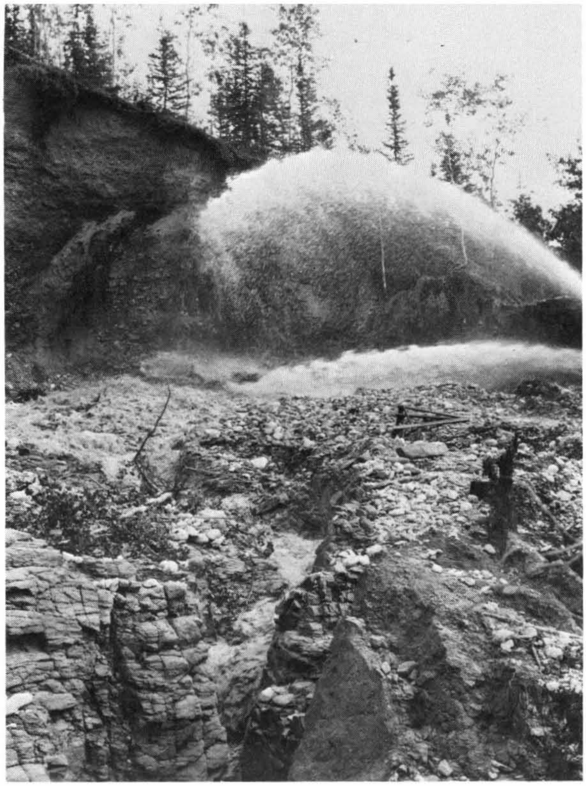

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FIGURE 9
The start of hydraulic mining on Cripple Hill.

C.F.G., 2-8-62

FIGURE 10. Hydraulic mining of White Channel gravels on Cripple Hill.

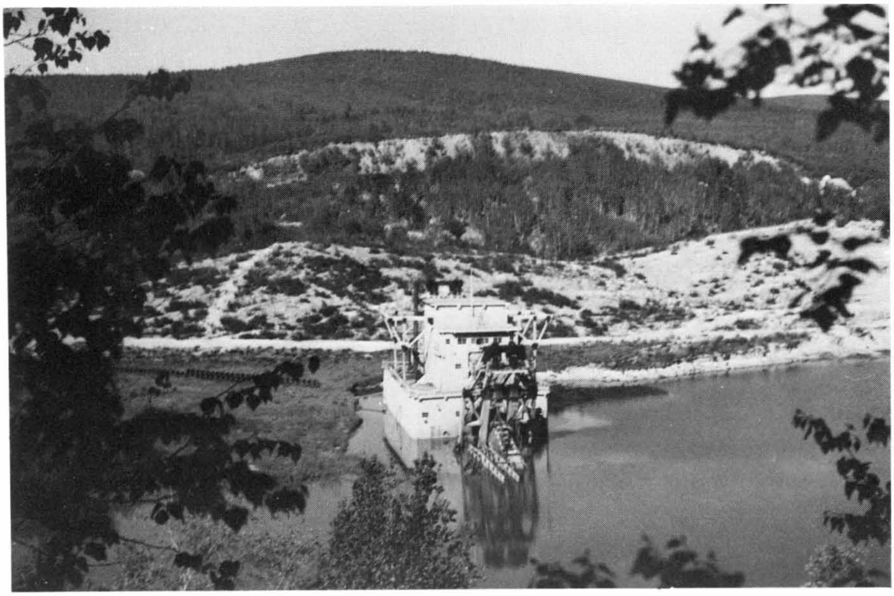

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FIGURE 11. Abandoned No. 4 dredge on Bonanza Creek; Orofino Hill in background tailings from Orofino Hill in foreground.

FIGURE 12
Bulldozer sluicing operation on Dominion Creek.

C.F.G., 5-2-61

up and the gravel is pushed into the head of the box with a bulldozer (Fig. 12). Tailings are usually removed from the lower end of the box by a bulldozer. Such operations are extremely flexible and adaptable to a variety of working conditions.

In 1963 Ballarat Mines Limited introduced a new method of thawing and stripping the muck by using irrigation sprinklers; costs (as reported by the operators) are about half those of hydraulic stripping.

Production

Recorded production of gold from the Yukon Territory totals more than 10 million fine ounces, valued in Canadian funds at over $253,700,000 (Green and Godwin, 1963). These figures are considered low, however, because in the early days production was calculated from the amounts of gold on which royalty was paid, and considerable gold dust left the camps unrecorded and escaped royalty payments. A small amount of gold from lode operations is included in the above figures, but nearly all was produced from placer deposits, and most of this since 1897 has come from the Klondike area. For the 12 years preceding 1897, production averaged about 6,200 fine ounces annually, chiefly from the Stewart and Fortymile River areas, then rose to a record 1,077,553 fine ounces produced in 1900. Since 1919 annual production has been less than 100,000 fine ounces, averaging about 70,000 fine ounces from 1956 to 1962, about 82 per cent of which came from the Klondike area. Much of the recent Klondike production was recovered from the dredging operations of The Yukon Consolidated Gold Corporation Limited. In 1964 there were six dredges, seven hydraulic operations, and sixteen bulldozer-sluicing plants operating in the area (*see* Fig. 16); complete and accurate descriptions of these operations have been given by Green and Godwin (1963). The company ceased operations in 1966.

Chapter IV

HEAVY MINERAL STUDIES

Field Techniques

Samples of 1 cubic foot were taken from creek gravels, terrace gravels, an eluvium or weathered bedrock. Before a sample was taken, all cobbles and rock fragments greater than 3 inches in diameter were removed. Samples were placed in bags and back-packed to the nearest road to the concentrating unit. The samples were washed through a standard steel 8-mesh screen held in an aluminum frame and into an aluminum feeder box. A continuous spray of water, from a row of holes drilled in a pipe that entered the box from one side, washed the sample into a set of four sluice boxes (Figs. 13 and 14). The sluice boxes, each 7 feet long, were made of aluminum, and the bottoms were covered with rubberized riffle fabric. The boxes were made to telescope into one another and they were set up at a slope of 1 to 2 degrees. Water was fed through the unit at a rate of 24 gallons per minute. This included the water necessary to wash the sample through the screen.

Coefficient of recovery was tested for magnetite, epidote, and garnet. To do this, a quantity of White Channel gravel was put through the sluice repeatedly until all the heavy minerals were removed. A known quantity of magnetite, epidote, and garnet was added to 1-cubic-foot portions of clean gravel. This gravel was sluiced, and the heavy minerals recovered and cleaned from the concentrate using bromoform, a hand magnet, and a Frantz Isodynamic separator. The recovery was calculated by dividing the amount of the added heavy mineral by the amount cleaned from the concentrate and multiplying by one hundred. The coefficients of recovery obtained by this method are compared with recovery figures as quoted by Overstreet (1962), from work done by Sigov (1939) using an "Asiatic Ladle", essentially a gold pan with a handle; and by Theobald (1957) using a gold pan (*see* Table I).

The sluicing technique used in this work gave much higher recoveries than the panning method and slightly better recovery than the "Asiatic Ladle".

To treat the results of this study quantitatively a uniform recovery of the heavy minerals was essential. Although panning the sample at the sample site would have been easier, it was not deemed advisable because human errors and different individual abilities to pan result in variable recoveries of the heavy minerals. In a reconnaissance survey, panning at the sample site should be done by trained personnel, but in a more detailed area the method of sluicing used by the writer is practical and accurate. Lee (1963), in a detailed study of glacial fans in the Kirkland Lake area, used a modification of the writer's technique for concentrating heavy minerals from glacial till samples. After the sample was

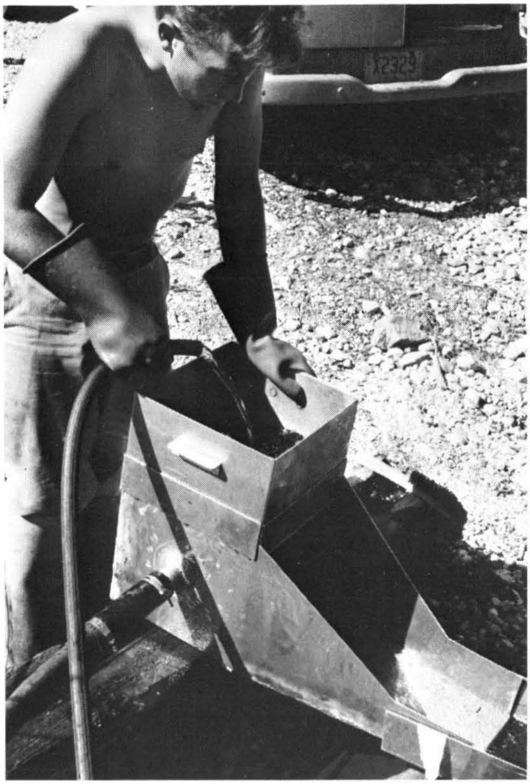

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FIGURE 13
Washing heavy mineral sample through 8-mesh stainless steel screen into an aluminum feed box. Water is pumped into the feed box through pipe on side. Inside the box, pipe is perforated with two rows of holes (1/8" diameter) along its length.

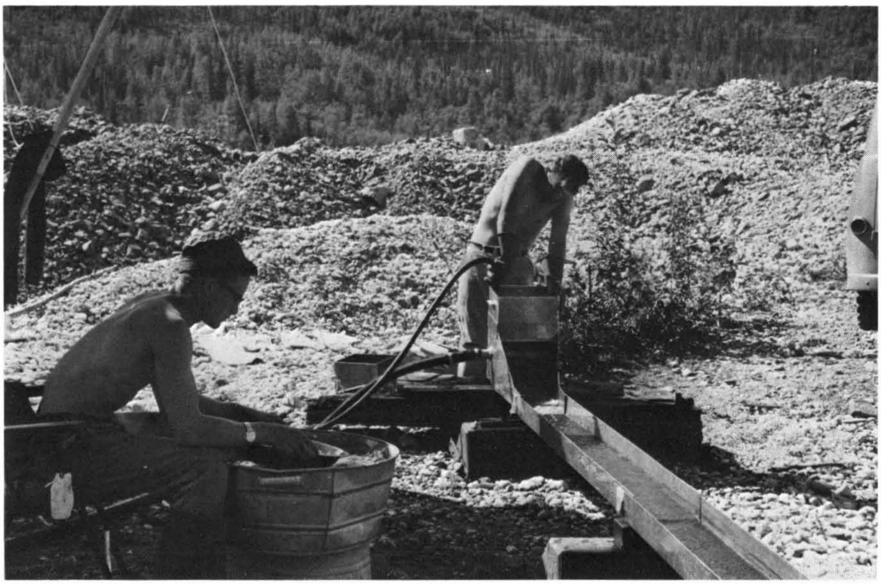

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FIGURE 14. Concentrating unit showing aluminum feed box and sluice boxes. Operator at left is panning sluice tailings to check recovery efficiency of unit.

TABLE I | *Coefficients of Recovery of Heavy Minerals Using an Asiatic Ladle, a Gold Pan, and a Sluice Box*

Sigov (Asiatic Ladle)			Theobald (panning)			Gleeson (sluicing)		
Heavy minerals	Sp. Gr.	Re-covery %	Heavy minerals	Sp. Gr.	Re-covery %	Heavy minerals	Sp. Gr.	Re-covery %
Magnetite	5.2	90	Magnetite		59	Magnetite	5.2	97
Hematite Ilmenite Zircon	4.4–5.1	83	Hematite		62	Garnet	4.1	84
Garnet Corundum Rutile	3.9–4.2	76	Ilmenite		64	Epidote	3.4	75
Limonite Staurolite Kyanite	3.6–3.8	60	Monazite		84			
Fraction with specific gravity 2.8–3.3	2.8–3.3	15	Rutile		68			
Fraction with specific gravity <2.8	<2.8	1	Zircon		72			

washed through the sluice boxes the riffle concentrate was washed into a large tub. A constant check was kept on the concentrating efficiency of the sluice·box by panning all tailings from the sluice box. Any heavy minerals recovered in this manner were combined with the riffle concentrate. The excess water was poured off, and the concentrate was placed in aluminum basins to dry. The dried concentrate was bagged and shipped to the laboratory for further treatment. The concentrate at this stage weighed from 1 pound to 5 pounds.

Laboratory Techniques

In the laboratory the riffle concentrate was sized into five fractions, and the heavy minerals of each fraction were recovered using bromoform (sp. gr. 2.89) as a separation medium (*see* flow sheet, Fig. 15). The heavy minerals (i.e., those that sink in bromoform) from each size fraction were weighed. The −60+100 mesh material was the fraction chosen for quantitative heavy mineral analyses. The bromoform sink products from the −60+100 fraction were separated into three magnetic products using a hand magnet and a Frantz Isodynamic magnetic separator. The hand magnetic material was removed with a Sepor Auto Magnet and the non-magnetic residue was put through the Frantz separator. The forward tilt was set at 25 degrees and the side tilt at 15 degrees. A magnetic product was taken off at 0.2 ampere and combined with the hand magnetic material to form the

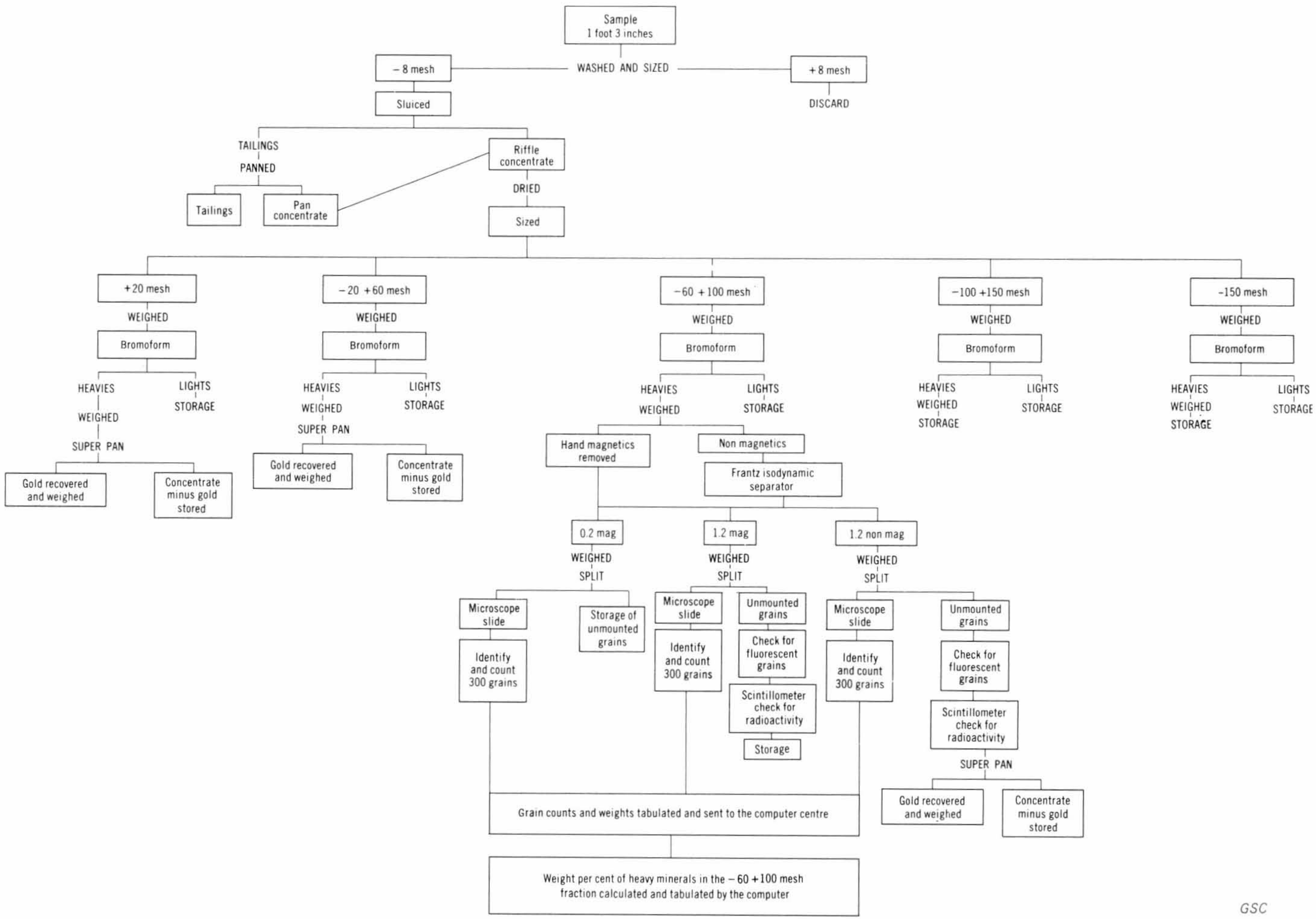


FIGURE 15. Flow sheet for field and laboratory treatment of heavy mineral samples.

0.2 magnetic fraction. Subsequent separations were made at 0.45, 0.95, and 1.2 amperes, and these products were combined to form the 1.2 magnetic fraction. The non-magnetic residue at 1.2 amperes made up the 1.2 non-magnetic fraction. Each of the three Frantz products was weighed and then split to about 1,000 grains. The grains were mounted on glass slides in Canada balsam. The 1.2 non-magnetic Frantz product was superpanned and the fine gold recovered. Superpanning was also done on the +20 and −20+60 mesh heavy minerals to recover the coarser gold.

About 300 grains were identified and counted on each slide of each Frantz product giving a total of about 900 grains per sample. Identifications were made with the aid of binocular and petrographic microscopes and X-ray diffraction powder photographs. All products were subjected to examination under long (3660Å) and short wave (2537Å) ultraviolet light. The identification of apatite was made easier by treating each slide with a mixture of nitric acid and a saturated solution of ammonium molybdate resulting in the formation of a yellow precipitate of ammonium phosphomolybdate on the apatite grains (the excess solution was immediately washed off with a spray of water). In addition, all samples were checked for radioactivity with a scintillometer. The grain counts were converted to weight per cent. To do this the following factors were recorded for each sample:

1. The weight of each Frantz product
2. The name and number of grains of each heavy mineral counted on each slide
3. The specific gravity of the heavy minerals identified

The simple but laborious mathematical calculations were done using a computer and the results recorded as a weight per cent of the total heavy minerals in the −60+100 mesh bromoform heavy fraction. By using this method one percentage figure for each heavy mineral in the −60+100 mesh heavy fraction was obtained. Otherwise it would have been necessary to resort to the unwieldy procedures of recording two or three figures for each heavy mineral in the various Frantz products of each sample.

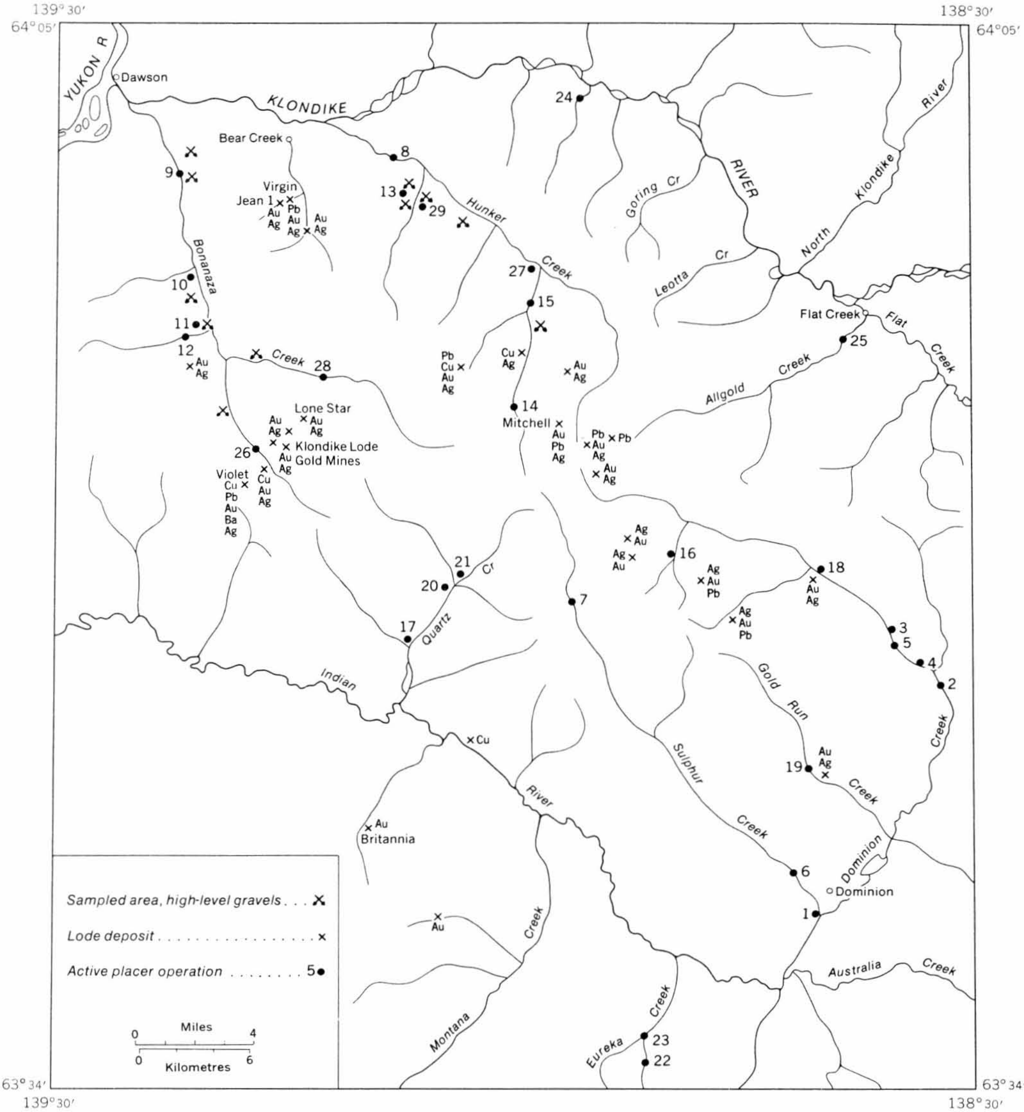
Heavy Minerals in Gravels

Valley, Creek, and Low-level Gravels

Wherever possible an undisturbed sample of gravel was taken. This was often difficult because most of the gold-bearing creeks, especially Bonanza and Hunker Creeks, had been worked extensively, and thus many of the creek gravel samples actually represented material from washed gravels or old tailings reworked by the streams. Wherever active placer operations were in progress, undisturbed gravels were obtained on or near bedrock. Many of the samples on Quartz Creek and Dominion Creek above Jensen Creek were obtained from low benches that were being worked or had recently been worked; on Indian River, samples were taken from the heads and outer edges of the gravel bars.

Figure 17 (*in pocket*) illustrates the weight per cent of the heavy minerals in the −60+100 mesh bromoform heavy fraction; also recorded is the total weight in grams of the heavy minerals from all size fractions, the weight in grams of the heavy minerals in the −60+100 mesh fraction, and the weight in milligrams of the gold recovered from each cubic-foot sample.

Generally the heavy minerals in the −60+100 mesh fraction of the creek and gulch gravels are angular to subangular, but in the gravels of Indian River and the lower part of



INDEX TO PLACER OPERATIONS

1. *Yukon Consolidated Gold Corporation, dredge No. 6*
2. *Yukon Consolidated Gold Corporation, dredge No. 10*
3. *Yukon Consolidated Gold Corporation, bulldozer mining operation No. 15*
4. *Yukon Consolidated Gold Corporation, bulldozer mining operation No. 16*
5. *Yukon Consolidated Gold Corporation, dredge No. 17*
6. *Yukon Consolidated Gold Corporation, dredge No. 8*
7. *Yukon Consolidated Gold Corporation, dredge No. 9*
8. *Yukon Consolidated Gold Corporation, dredge No. 11*
9. *Cripple Hill Mining Co. Ltd., hydraulic operation*
10. *A. T. Fry, hydraulic operation*
11. *H. C. Boutillier and D. F. Boutillier, hydraulic sluicing plant*
12. *H. C. Boutillier and D. F. Boutillier, bulldozer sluicing plant*
13. *J. Bremner and I. C. Bremner, hydraulic pit*
14. *B. Bratsberg, bulldozer sluicing plant*
15. *O. Lunde, bulldozer sluicing plant*
16. *A. Burgelman, bulldozer sluicing plant*
17. *Ballarat Mines Ltd., bulldozer sluicing plant*
18. *Ballarat Mines Ltd., bulldozer sluicing plant*
19. *J. Lamontagne and E. Schink, bulldozer sluicing plant*
20. *L. M. Fuhr, bulldozer sluicing plant*
21. *A. Sundt, bulldozer sluicing plant*
22. *Eureka Placers Yukon Ltd., bulldozer sluicing plant*
23. *Northern Yukon Services Ltd., bulldozer sluicing plant*
24. *J. Werbiski, bulldozer sluicing operation*
25. *K. and S. Placers Ltd., bulldozer sluicing plant*
26. *Ballarat Mines Ltd., bulldozer sluicing plant*
27. *G. Fant and I. Norbeck, hydraulic and bulldozer sluicing plant*
28. *E. Lesaux and F. Perret, bulldozer sluicing plant*
29. *O. Moen, hydraulic pit*

GSC

FIGURE 16. Locations of high-level gravel samples, lode deposits, and active placer operations, Klondike area.

Dominion Creek they are more rounded. The coarser heavy minerals (i.e., −60 mesh) exhibit more rounding than the finer grains. The only angular coarse heavy minerals occur near the heads of the creeks and gulches.

Mineralogy

Actinolite

This mineral occurs as blue-green, prismatic, euhedral to subhedral grains. Although usually forming 1 to 7 per cent of the mineral content, locally erratic highs occur and a group of samples from upper Bonanza Creek and Carmack Fork contain from 9 to 62 per cent actinolite. There a band of amphibolite in the Klondike schist has contributed a flood of actinolite to the Bonanza Creek. Similarly, the high actinolite values on Hunker Creek (G241 and G150) and on Gold Bottom Creek (G149) can be attributed to actinolite-rich phases of a chlorite schist that occurs in the wedge of ground between Hunker and Gold Bottom Creeks.

Anatase

About 10 per cent of the gravel samples contains anatase. The amount present in the −60+100 mesh heavy fraction varies from a trace to 2 per cent. Sample M42 on Flannery Pup, a tributary of Carmack Fork, is exceptional in that it contains 20 per cent anatase. Where anatase forms euhedral crystals it is not difficult to recognize, but in many samples it is present as an aggregate with quartz or muscovite; some material that originally was called leucoxene proved to be fine-grained anatase. In its anhedral aggregated form it is difficult to distinguish from sphene.

Andalusite

Prismatic grains of andalusite, grey to black due to carbonaceous inclusions, occur in samples near the mouth of Bonanza Creek; usually less than 1 per cent is present. This mineral has been derived mainly from the Klondike high-level gravels that have been dissected by Bonanza Creek; it probably originates in rocks that are cut by North Fork Klondike River. Apparently it is rare in the bedrock of the Klondike area.

Apatite

This mineral commonly forms colourless anhedral grains, but here and there dark grey to black, euhedral to subhedral varieties are present; the colour is due to carbonaceous inclusions. A few samples contain a variety of blue apatite. In some instances identification of apatite under the petrographic microscope was made difficult because of anomalous birefringence, and much colourless apatite was originally mistaken for barite. To overcome and correct this error, dilute nitric acid was mixed with a large excess of ammonium molybdate and this was applied to all slides. When the solution came in contact with apatite a yellow precipitate of ammonium phosphomolybdate appeared over the grains, and a count of the apatite grains could readily be made under the binocular microscope. Some apatite is fluorescent and appears faint bluish white under ultraviolet light.

Apatite makes up from 1 to 28 per cent of the heavy minerals in the −60 to+100 mesh bromoform heavy fraction. The highest concentration appears to be in the upper parts of the creeks and gulches, although there are erratic highs in other parts of the creeks. Most of the apatite is derived from the Klondike schist; a minor amount comes from the Nasina Series and from basic dykes that cut the schists in the area.

Barite

This mineral forms white, colourless, yellowish brown, and bluish white anhedral grains, some exhibiting good cleavage, and is present in quantities ranging from a trace to 36 per cent of the −60+100 mesh fraction.

French, O'Neil, Victoria, and Nugget Gulches and Adams, Bryant, Montana, and Baker Creeks all contain plentiful barite at one or more points along their courses. Generally the upper part of Quartz Creek contains more than 7 per cent barite. Samples from Indian River and Dominion, Sulphur, Gold Run, and Hunker Creeks carry low percentages of barite. The upper part of Bonanza Creek above Victoria Gulch has background values for barite except for one sample on Flannery Pup, a tributary of Carmack Fork, and another sample on Ready Bullion Gulch. The former contains 15 per cent barite and the latter 6 per cent.

Barite in the area is derived from quartz-barite veins that cut the Klondike schists. These veins have been observed at and in the vicinity of the Violet deposit. H.C. Boutillier (pers. com.) reports that there are barite veins in some placer cuts on Adams Creek. The large amounts of barite in the creeks draining the east and west sides of the ridge between Yukon River and Bonanza - Eldorado Creeks suggest that quartz-barite veins are particularly common there.

Biotite

Biotite is present in very few gravel samples from the area; 4 per cent was found in a sample taken from Bordeleau Creek, a tributary of Hunker Creek that drains an area underlain by rhyolite porphyry and Nasina schists. Coarse-grained biotite granite intrudes the Nasina Series in the southwest part of the area, and samples taken in the vicinity of this intrusion on Jim Creek and on a small creek south of it contain 2 and 9 per cent biotite, respectively. Biotite is also common in sections where the Klondike schists are chloritic. Generally, however, the Klondike Series is low in biotite.

Cerussite

The mineral is present in only one sample, G105 from Adams Creek, and probably originates from the oxidization of galena in a barite vein that H. Boutillier (pers. com.) reported from the left limit of the creek near this sample.

Chlorite

About half the gravel samples contain green chlorite in amounts varying from a trace to 25 per cent. The highest values are in the creeks draining the areas of chloritic Klondike schist. Chlorite lenses in the Klondike schists also account for some of the erratic high values. Maximum concentrations are found at the heads of Dominion, Sulphur, and Gold Bottom Creeks; all these drain an area in which chlorite schist is abundant.

Chromite

Chromite is rare in the creek gravels. One sample on Bear Creek and one on Too Much Gold Creek have small quantities of this mineral, and Ray (1962) reports its presence in placer concentrates from Hunker and Dominion Creeks. It forms black metallic octahedrons and is probably derived from sill-like masses and dykes of ultrabasics. The largest of these outcrop on the ridge between Hunker Creek and Klondike River.

Clinopyroxene

Clinopyroxene, for the most part green augite, is not common in the area underlain by Klondike schists. About one quarter of the samples contain clinopyroxene derived mainly from basic dykes and ultrabasic intrusions. Clinopyroxene in the samples from the mouth of Bonanza Creek and in the tributaries near its mouth is derived by erosion of the high-level Klondike gravels.

Clinozoisite

Clinozoisite occurs infrequently in the heavy mineral samples and makes up a trace to 2 per cent of the bromoform heavies in the −60+100 mesh fraction. It is probably more common than indicated on Figure 17 because in most samples it has been grouped with epidote.

Dolomite

Dolomite, present here and there throughout the area, is derived from lenses and pods of crystalline limestone that occur in the Nasina schists and occasionally in the Klondike schist.

Epidote

Epidote, in yellow to yellowish green anhedral to euhedral grains, is abundant throughout the Klondike. It occurs in all gravel samples in quantities ranging from 1 to 77 per cent of the −60+100 mesh heavy fraction. High values for epidote are recorded in the following places: at the mouth and at the head of Bonanza Creek, in Carmack Fork, on Gold Bottom Creek, at the head of Hunker Creek, at the head of Dominion Creek, and on Sulphur, Quartz, and Gold Run Creeks. This study shows that the areas underlain by the chloritic phase of the Klondike schist contribute more epidote to the streams than the sericitic phase. Smaller quantities of epidote are derived from the Nasina Series and from diabase dykes.

Fluorite

Colourless, white, and occasionally purple and blue fluorite occurs sparingly in the Klondike area. It makes up less than 1 per cent of the heavies in a gravel sample from Bordeleau Creek, a tributary of Hunker Creek, and 1 per cent of the −60+100 mesh heavies from a gravel sample obtained on a low bench at the mouth of Germaine Creek, a tributary of Klondike River. Both localities are underlain by rhyolite porphyry, the source of the fluorite.

Garnet

Garnets, commonly forming dodecahedral and trapezohedral crystals and less commonly irregular fragments, occur in many gravel samples. They vary from light pink, to dark pink, to red; some are orange and others are almost black due to inclusions. Most garnets are manganese-rich spessartite types, although here and there almandite and grossularite are present.

Garnet is found in small amounts in most of the creeks that cut the Klondike schist. In samples from Bonanza, Eldorado, Hunker, Quartz, upper Sulphur, upper Gold Run, and upper Dominion Creeks, garnet is rarely present in amounts greater than 1 to 2 per cent. In Swede, Ensley, and Jim Creeks, in the lower part of Dominion Creek below Portland Creek, in Indian River, in Leotta, Too Much Gold, and Allgold Creeks, however, garnet is abundant and makes up 15 to 79 per cent of the bromoform heavies in the

−60+100 mesh fraction. Garnet is also plentiful in the +60 mesh fractions of the samples from these creeks. Most of these creeks cross Nasina schist at some place along their courses. Garnet is very abundant in areas where the schists are intruded by granites (e.g., Dominion Creek).

Goethite (limonite, hematite)

In this report the term goethite is usually applied to a mixture of limonite-hematite and goethite. Some distinction has been made on the basis of colour and streak. The colour of the goethite is usually medium to dark brown; it becomes more yellowish brown as the limonite content increases, and reddish brown as hematite increases. The mineral invariably forms euhedral cubes and pyritohedrons pseudomorphous after pyrite; centres of unoxidized pyrite are present in some of the goethite grains.

Every gravel sample contains goethite or hematite. The latter is more abundant in Indian River samples, although small amounts are found in many samples elsewhere. Goethite is most prevalent in Eldorado and Bonanza Creeks, especially in the upper parts of the gold-bearing sections of these creeks and their tributaries. The values range from less than 1 per cent to 69 per cent of the −60+100 mesh heavy fraction. It is interesting to note that Carmack Fork and Bonanza Creek above this fork are low in goethite, so too is Chief Gulch. Mineable quantities of placer gold have never been found on these creeks. The creeks of the Indian River drainage system contain variable amounts of goethite. Dominion Creek above Portland Creek and the head of Sulphur Creek have considerably more goethite than their lower parts. The heads and upper sections of these creeks are underlain by Klondike schists, but the lower part of Dominion Creek is underlain by Nasina schists and the lower end of Sulphur Creek is underlain by foliated granite. Klondike schists contribute more goethite to the creek gravels than do the Nasina schists or granites. This partly explains the distribution of goethite in these creeks. The lower parts of Dominion, Sulphur, Gold Run, and Quartz Creeks are flowing over a quartzose gravel similar to the White Channel gravels of Hunker and Bonanza Creeks. Goethite is not a very resistant heavy mineral and tends to decrease in quantity in the sections of these creeks that are underlain by well-worked White Channel type gravels.

Creeks not mined for placer gold but containing large amounts of goethite include Toronto Creek, a tributary of Quartz Creek; and Bryant, Ensley, and Montana Creeks, tributaries of Yukon River. All these streams cut Klondike schist.

Gold

Gold is present in many gravel samples. The number of milligrams of gold in samples from which material larger than 3 inches had been removed from creek, river, and low bench gravels is shown in red on Figure 17. If a fineness of 800 is assumed, then 1 milligram of gold in a cubic foot of material would be worth about 0.084 cent (gold at $35.00 an ounce), or 2.3 cents per cubic yard of gravel. The description and fineness of the placer gold from the various creeks of the Klondike is given in McConnell's reports (1903, 1906).

Most samples that contain large quantities of gold were taken from active placer operations. Exceptions to this are samples G282 and M17 from Bonanza Creek, and G128 and G130 from Gold Run Creek. Sample G282, a gravel sample taken near bedrock from a low terrace on the right limit of Bonanza Creek at its junction with Eldorado Creek, contains 706.4 milligrams of medium- to fine-grained gold. Bedrock on the bench is about 10 feet higher than in the creek, and is composed of blocky, moderately schistose, sericite schist. The gravel is about 4 feet thick and is covered by 10 to 15 feet of muck; both gravel and muck are frozen. The length and width of this bench are not known, but it extends up Bonanza Creek for at least several hundred feet. Results from the one sample are sufficiently promising to warrant further exploration along this bench[1]. Another small terrace of unworked auriferous gravels is just below Mosquito Gulch on the right limit of Bonanza Creek. Sample M17 from this low bench contains 54.2 milligrams of gold in a cubic foot of gravel.

On Gold Run Creek sample G130 was taken from a low bench on the left limit of the creek 1.5 miles from its mouth. The sample, obtained from atop bedrock, contains 99.3 milligrams of gold. At the sample site, about 4 feet of gravel rests on quartz-chlorite schist bedrock, and the gravel is covered with 20 to 25 feet of muck. This bench has been partly worked by means of a bulldozer-sluicing operation. The second sample from Gold Run Creek that contains considerable gold is G128. It was obtained from a pile of quartz-chlorite schist rubble that was excavated from an exploration shaft in the early days. Apparently the material on the dump was never sluiced, and a cubic-foot sample from it yielded 139.2 milligrams of medium- to coarse-grained gold. Although the immediate area appears to have been prospected and probably mined to a certain extent by hand methods, no evidence of extensive mining operations was found. It is possible that sections of Gold Run Creek contain quantities of payable gravels. Presently J. Lamontagne and E. Schink have a lease on claims 35 to 51 and they are operating a bulldozer-sluicing operation on the lower part of these claims (Green and Godwin, 1963).

Another interesting placer gold occurrence is located on a small, low terrace at the mouth of Germaine Creek on the left limit of Klondike River (sample G276). There J. Werbiski has a placer operation on a low bench of Klondike gravels (Green and Godwin, 1963); the gold is flat and well worn. Similar deposits of auriferous Klondike gravels may occur on similar low terraces bordering Klondike River.

The gravel bars on Indian River contain small amounts of fine-grained gold; values vary from 0.2 milligram to 9 milligrams per cubic foot. The richest sample, G258, came from just below the mouth of Eureka Creek where active placer operations are presently in progress (Green and Godwin, 1963).

There is a large area of quartzose gravel on Dominion Creek between Australia and Gold Run Creeks, but although some of this ground was worked by hand methods in the early days and more recently by dredges, large volumes of unworked gravels still remain. If payable quantities of gold were found in these gravels the placer life of the camp could be extended for many years.

Samples G139 and G143 were taken from small low benches on Sulphur Creek. These samples contain 13.3 and 32.6 milligrams of gold, respectively. Sample G143 could represent old placer tailings, but G139 was taken from unworked gravels. These samples are of particular interest because no auriferous gravel benches have been reported on Sulphur Creek. One reason postulated for this is that after uplift of the area Sulphur Creek eroded the gravels from both sides of its narrow valley. It is possible that other large benches concealed by slide material and muck occur along Sulphur Creek. Drilling beyond the present valley bottom might prove rewarding in outlining such buried benches.

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[1] In the summer of 1963 Ballarat Mines Limited worked this bench.

HEAVY MINERAL STUDIES IN KLONDIKE AREA

The results of heavy mineral studies on gravels in the Klondike area indicate that gold itself is the most useful guide mineral when prospecting for placer gold deposits. There is some suggestion that goethite might be a useful pathfinder mineral in the upper parts of the creeks. Unfortunately, it is not very resistant and breaks down rapidly or mixes with other heavy minerals farther along the course of the creeks, and as is the case in Dominion Creek, it becomes subordinate to other heavy minerals such as garnet and magnetite.

In 1903 (B.C. Bureau of Mines, 1903) it was reported that a small sample of gold from near Dawson was tested and yielded 390 milligrams of osmiridium to an ounce of gold. To confirm this report the writer obtained six samples of gold from the Yukon Consolidated Gold Company's operations; additional samples of gold were obtained from pan concentrates on Bonanza, Eldorado, and Quartz Creeks. The gold was analyzed spectrographically by W.F. White of the Geological Survey; the results are shown in Table II.

No platinum of osmiridium is present in the gold from the creeks of the Klondike. Mercury is used to amalgamate the fine-grained gold, hence it is difficult to determine how much occurs naturally in the gold. According to Mustart (1965), the gold from

TABLE II — *Semi-quantitative Spectrographic Analyses of Placer Gold from Klondike Area, Yukon Territory*

Location	Major >10%	Minor 1–10%	Strong trace 0.1–1%	Trace 0.01–0.1%	Faint trace <0.01%
Bonanza Creek opposite Queen Gulch	Au,Ag		Ti,Pb,As	Hg,Fe,Si, Sb,Mg	Al,Cu, V
7 Pup of Victoria Gulch, a tributary of Bonanza Creek	Au,Ag			Hg,Si	Al,Mg,Fe, Cu,Ti
Eldorado Creek below Gay Gulch	Au,Ag		Fe	Cu,Si	Mg,V,Ti, Sb,Pb, Al, Mn, Ba
Hunker Creek dredge No. 11	Au,Ag			Hg,Fe,Si	Cu,Mg, Al,Ti
Quartz Creek near its mouth	Au,Ag			Hg,Si	Mg,Al,Ti, Fe,Cu
Sulphur Creek dredge No. 9	Au,Ag			Hg, Si	Mg,Al, Fe,Cu, Ti
Sulphur Creek dredge No. 8	Au,Ag			Hg,Si	Mg,Al, Fe,Cu, Ti
Dominion Creek dredge No. 6	Au,Ag			Hg,Si	Mg,Al, Fe,Cu, Ti
Dominion Creek dredge No. 10	Au,Ag			Si	Mg,Al, Fe,Cu
Dominion Creek bench operation No. 15	Au,Ag			Hg,Si,Ti, Al	Mg,Fe, Cu

Bonanza Creek is higher in mercury than placer gold from Hunker Creek or the Mayo Lake area. Tin is not found in detectable amounts in samples of gold analyzed for this report, but Mustart (1965) reports tin in all placer gold samples from Klondike area analyzed by him. The elements in trace amounts in nearly all the samples include Mg, Al, Fe, Si, Cu, and Ti. Lead is present in samples of gold from Bonanza Creek and Eldorado Creek and the former also contains traces of As, V, and Sb.

The significance of these differences is not apparent, but the results suggest that some gold is probably associated with sulphides and/or sulphantimonides or arsenides. More samples and accurate quantitative analyses would have to be done before concrete conclusions could be reached on the significance of trace elements in the Klondike gold. Such a study might assist in determining the genesis of the gold deposits of the area. It has been suggested by Mustart (1965) that spectrographic analysis of alluvial gold could be helpful in delimiting metallogenic zones.

Hornblende

About 65 per cent of the samples contain hornblende as subhedral to euhedral, brown to green grains, in quantities that range from a trace to 29 per cent of the −60+100 mesh heavy fraction. A few erratically high values occur in the creeks draining areas of Klondike schist, but generally the stream gravels from these areas contain only small quantities of hornblende. High values occur where the creeks or their tributaries drain areas of granitic rocks. Jim Creek, Ensley Creek, the first small creek south of Jim Creek, lower Sulphur Creek, Burnham Creek, and Dominion Creek below Burnham Creek are typical examples. Eureka Creek and two samples on Indian River below Eureka Creek have 20, 16, and 20 per cent hornblende, respectively. Values for hornblende along Indian River are never less than 7 per cent; diabase and Tertiary andesites (McConnell, 1903) contribute much of this hornblende. Leotta and Too Much Gold Creeks contain as much as 19 per cent hornblende derived principally from a band of ultrabasic rock that crosses the creeks in the vicinity of two upper sample points.

Hypersthene

Light brown to green, glassy, euhedral grains of hypersthene, frequently containing gas bubbles and inclusions of magnetite and ilmenite, is common throughout the area. The Klondike schist and mafic dykes that cut the schists contribute most of this mineral to the creek gravels. Hypersthene is present in quantities that vary from a trace to 26 per cent. Several high-percentage samples occur at the head of Chief Gulch and near the head of Calder Creek.

Ilmenite

Black, metallic, elongated grains of ilmenite, often with a high lustre and containing patches of leucoxene alteration, are common in the gravels of the area. Nearly all samples contain some ilmenite. It is less abundant in the creeks draining the areas underlain by Klondike schists, and more abundant in creeks that cut through Nasina schists. Ilmenite is relatively abundant on gravel bars of Indian River, where in places it forms the core of well-rounded leucoxene and fine-grained anatase grains.

Jarosite

Light tan, irregular grains of jarosite are present in less than 10 per cent of the gravel samples in amounts varying from less than 1 per cent up to 2 per cent. It is restricted mainly to Bonanza Creek and its tributaries, but Baker, Bryant, and Swede Creeks contain small amounts. All these creeks drain areas underlain by quartz-sericite schists of the Klondike Series.

Kyanite

The occurrence of elongated bluish to colourless blades of kyanite is confined almost exclusively to the lower part of Dominion Creek and along the bars of Indian River. It is present in quantities that range from less than 1 per cent to 4 per cent, and is probably derived from areas where the schists are intruded by foliated granite, such as Mount Burnham east of Dominion Creek, the mouth of Sulphur Creek, and the west side of the mouth of Quartz Creek. In most places staurolite accompanies kyanite.

Leucoxene

Small amounts of leucoxene have been found in a few gravel samples in the area. Generally it forms a minor alteration product on some of the ilmenite grains. X-rays showed that much of the material initially called leucoxene was really very fine grained anatase or sphene.

Magnetite

Magnetite forms anhedral to euhedral, black to iridescent blue grains and has been identified in every gravel sample. The quantity varies from less than 1 per cent to 43 per cent of the −60+100 mesh bromoform heavy fraction. It is derived mainly from basic dykes that cut the Klondike and Nasina schists, ultrabasic bodies on Leotta and Too Much Gold Creek, and from chlorite schists. The magnetite in the chlorite schist is generally euhedral and has a distinctive iridescent blue colour. Reddish brown martite pseudomorphic after magnetite occurs here and there.

Micrometeorites

Trace amounts of small, black, shiny, metallic, magnetic balls occur in samples M4, M35, M88, and M90 in the vicinity of Bonanza and Eldorado Creeks; and in sample M125 on Toronto Creek, a tributary of Quartz Creek. They are usually less than 0.15 mm in diameter. Several have been identified as magnetite and one as olivine, but most are too small and too scarce to permit analytical work. They could be artificial products produced from forges, thawing fires, boilers, or weld droppings, or they could be extraterrestrial in origin because two meteorites have been found and described from Gay Gulch and Skookum Gulch (Johnston, 1915). More analyses would have to be done on these balls before definitely establishing their origin.

Monazite

Colourless, light yellow to yellowish brown, anhedral grains of monazite have been identified in several gravel samples from Montana Creek, Ensley Creek, and Indian River. The amount present is 1 per cent or less of the −60+100 mesh heavy fraction. Acidic intrusions, especially rhyolite porphyry, contribute monazite to the alluvium.

Muscovite (sericite)

Muscovite is present in all gravel samples in quantities that vary from less than 1 per cent to 81 per cent of the −60+100 mesh bromoform heavy fraction. The mineral is flaky and varies from colourless, to light green, to brown. Usually the brownish colour is caused by limonite staining. In some instances inclusions of zircon are present. Klondike schist, especially the very schistose variety, is the main contributor of muscovite to the creek gravels. It is more abundant in creeks that drain areas of sericite-rich Klondike schists, particularly along tributaries of Bonanza and Eldorado Creeks. It is not a very resistant mineral, and this coupled with the change in rock types accounts for its paucity in the gravels of Indian River and the lower parts of Sulphur and Dominion Creeks. Although the mineral has been referred to here as muscovite, it is probably a mixture of hydromica, sericite, and muscovite. For this report no attempt was made to separate or distinguish these micas.

Olivine

Olivine is present in samples from the mouth of Germaine Creek, from Leotta Creek, and from Too Much Gold Creek – all tributaries of Klondike River. The olivine is generally colourless with black inclusions and is derived from ultrabasic rocks that outcrop along each of the above creeks. Its content in the −60+100 mesh bromoform heavy fraction of the concentrates varies from 1 to 8 per cent.

Pyrite

Euhedral pyrite in the form of cubes and pyritohedrons occurs in about half the heavy mineral concentrates from the creek gravels. Generally it is present in quantities that vary from a trace to 5 per cent of the −60+100 mesh bromoform heavy fraction, but sample G235 from Bryant Creek has 13 per cent, and G49 from the mouth of Ready Bullion Creek has 57 per cent. Most of the pyrite readily oxidizes to goethite.

Pyrite is commonly associated with gold-bearing quartz veins and shear zones, but it is also disseminated through the Nasina and Klondike schists. It is not a very resistant heavy mineral, hence little of it is found in the well-worn gravels of Indian River and Dominion, Gold Run, and Sulphur Creeks. The large amounts found in samples G235, G49, and M18 are due to local concentrations of pyrite in bedrock.

Rutile

Rutile is a common constituent in many of the concentrates from the creek and river gravels. It makes up from a trace to 9 per cent of −60+100 mesh bromoform heavy concentrate. The shape of the rutile is dominantly prismatic; euhedral grains are common, but many are fractured and have conchoidal and splintered ends. Knee or elbow twins are fairly common, and most grains are longitudinally striated. The colour varies from a bright yellowish orange through shades of red to black. Rutile is more abundant in the tributaries of Indian River than in the samples from creeks draining into Klondike River. On a low bench on Quartz Creek and in the vicinity of sample G270, rutilated quartz boulders have been seen.

Scheelite

White anhedral scheelite, which fluoresces bluish white under ultraviolet light, is present in trace amounts in concentrates from Bonanza and Eldorado Creeks and their tributaries, and also from Dominion, Sulphur, Gold Run, Quartz, Eureka, Jim, and Ensley Creeks. Only one sample on Indian River contains scheelite, and that is near the mouth of Eureka Creek. No scheelite is present in the samples from creeks draining into Klondike River above Hunker Creek, nor is any present in the samples from Hunker Creek. Scheelite is partly associated with gold-bearing quartz veins and the granite intrusion that is cut by Jim Creek and the upper part of Ensley Creek.

Sphalerite

Trace amounts of sphalerite are present in samples G230 and M6 from Too Much

Gold Creek and Bonanza Creek, respectively. It occurs as anhedral brown aggregates and has been identified by means of X-ray powder photographs. Sphalerite probably occurs as local concentrations in fracture filling or veins in the Klondike and Nasina schists.

Sphene

Sphene is found in nearly every concentrate taken from the creek gravels of the Klondike area. It varies from white to grey to buff brown, and occurs as anhedral masses and aggregates and occasionally as euhedral flattened crystals. Its high relief is characteristic. Sphene is present in the −60+100 mesh bromoform concentrates ranging from a trace to a maximum of 42 per cent, but values of 1 to 5 per cent are common. Sphene appears to be more abundant in the streams that dissect Klondike schist.

Spinel

Black, glassy spinel with a conchoidal fracture makes up 2 per cent of the −60+100 mesh bromoform concentrate of sample G110 from Examiner Gulch near the mouth of Bonanza Creek. In the vicinity of this sample the high-level Klondike gravels contain spinel, and obviously it has been reconcentrated from these high terraces by Examiner Gulch.

Staurolite

Transparent, glassy, orange, anhedral grains of staurolite are concentrated mainly in the lower parts of Dominion and Sulphur Creeks and Indian River. In the −60+100 mesh bromoform concentrate the quantity varies from less than 1 per cent to 8 per cent. Concentrations of staurolite and kyanite are found almost exclusively on lower Dominion and Sulphur Creeks and along Indian River; they reflect an area of metamorphic rocks, associated with foliated granite, that outcrops east of Dominion Creek on Mount Burnham and at the mouth of Quartz Creek. A small amount of staurolite has also been found on Too Much Gold Greek and Alki Creek, and at the mouth of Germaine Creek where it is probably reconcentrated from the high-level Klondike gravels that contain staurolite.

Topaz

Colourless, euhedral, prismatic crystals of topaz are found in trace amounts in sample G169 on Bordeleau Gulch, a tributary on the east side of the lower part of Hunker Creek, and in sample G276 at the mouth of Germaine Creek. This mineral is derived from rhyolite porphyry that outcrops between Hunker Creek and Klondike River. Topaz is also present in minor amounts in samples G258, G257, and G256 at the head of Indian River.

Tourmaline

There are at least two varieties of tourmaline in the area. One makes up a trace to 1 per cent of the −60+100 mesh bromoform concentrate from three samples on Bonanza Creek and one sample on Boulder Creek, a tributary of Bonanza Creek. The tourmaline forms greyish green prismatic euhedral crystals. The second variety occurs in lower Dominion Creek and in parts of Indian River. It is black and glassy, forms euhedral prismatic crystals, and is present in quantities varying from less than 1 per cent up to 11 per cent of the −60+100 mesh bromoform heavies. The higher amount occurs in a sample at the mouth of Burnham Creek on Dominion Creek where high concentrations are not surprising because the pegmatite phase of the granite in the Mount Burnham area contains large amounts of coarse tourmaline.

Tremolite

Colourless, clear, subhedral to euhedral, prismatic, tremolite crystals are present in twenty-two samples of concentrates from the creek gravels of the Klondike River. The amount in the −60+100 mesh bromoform heavy fraction varies from a trace to 6 per cent. Samples from the creeks draining the Nasina Series (Eureka, Leotta, and Too Much Gold Creeks) tend to have more tremolite than the concentrates from creeks draining the areas underlain by the Klondike Series. Tremolite is probably associated with lenses of crystalline limestone that occur within the Nasina Series.

Zircon

Zircon occurs in 95 per cent of the −60+100 mesh bromoform concentrates of the creek gravels of the Klondike area. Much zircon is in the form of euhedral and well-terminated crystals, although some spherical, clear, light pink zircon is found in several samples. Generally the zircons vary from colourless, to white, to a dirty grey, and occasionally brown. Most zircon is marked by an orange fluorescence under short wave ultraviolet light.

Although zircon is present in many samples it seldom exceeds 1 per cent of the −60+100 mesh bromoform concentrates. One anomalous sample, M35 on Bonanza Creek above Victoria Gulch, contains 6 per cent zircon; all rocks in this area are Klondike schists. Two samples, one from Jim Creek (G280) and one on a small creek south of Jim Creek (G249), each contain 1 per cent zircon. The zircon in these samples is derived from a coarse-grained granite stock cut by these creeks.

Zoisite

Less than 10 per cent of the concentrates from the creek and river gravels contain zoisite. It occurs as colourless, prismatic, euhedral crystals that exhibit anomalous deep blue interference colours under the petrographic microscope. In the −60+100 mesh bromoform concentrates quantities vary from a trace to 2 per cent (sample G231). There does not seem to be any regularity in its distribution.

Cassiterite

Cassiterite has not been found in any of the −60+100 mesh bromoform concentrates from the gravels of the area, although it has been recovered in placer concentrates from the mouth of Klondike River to Hunker Creek, on Hunker Creek below Tinhorn Gulch, on Dominion Creek below Portland Creek, and on Sulphur Creek below Meadow Gulch. Some has been recovered from Boulder Hill at the mouth of Boulder Creek on the left limit of Bonanza Creek; Dago, Preido, and Paradise Hills have also produced cassiterite. At present (1964) some cassiterite is being recovered from a placer operation on a small bench at the mouth of Germaine Creek.

Cassiterite in the Klondike area has a colloidal texture, a variety often referred to as "wood tin". The pebbles are light tan, light brown, medium brown, reddish brown, or dark brown. Individual bands vary in width from 0.07 mm to 0.45 mm, and the grain size from 0.01 mm to 1.3 mm. Minor inclusions of quartz, fluorite, plagioclase, monazite, and zircon occur. The pebbles usually contain more than 70 per cent tin and 3 to 7 per cent iron. Aluminum and silica form less than 1 per cent, and manganese, magnesium, titanium, beryllium, calcium, barium, strontium, copper, tungsten, and mercury are present in trace amounts. Some tin has been derived from the rhyolite porphyry body that occurs in the area east of Hunker Creek opposite Last Chance Creek. Although cassiterite has been found with placer gold in several creeks of the region, it has never been sufficiently abundant to warrant recovery as a byproduct.

High-level Gravels

Figure 16 shows the locations of the high-level terraces sampled. These terraces are occupied by White Channel gravels or by White Channel gravels overlain by Klondike gravels. The weight percentages of the heavy minerals in the −60+100 mesh bromoform sink product, the weight of the heavy products, and the weight of the gold in each sample of high-level gravel are given in Table XI, and on Figure 18 (*in pocket*) a graphical representation of some of the same information is given.

One-cubic-foot channel samples 6 to 12 feet in length were taken. The samples started at or as close as possible to the bedrock surface and continued to the top, or as close to the top of the sections as was practically possible. Where hydraulic mining operations were in progress almost complete sections could be obtained, but on the terraces that were not being worked sloughing of the slopes made it impossible to obtain samples from near bedrock surfaces. The samples were given the same field and laboratory treatment as previously described for the valley, creek, and low-level gravels.

Mineralogy

Mineralogical descriptions can be obtained from Table X (*in pocket*). Usually the heavy minerals of the high-level gravels have characteristics similar to those of the creek gravels, except that the heavy minerals in the former are slightly more rounded.

Gold is well worn and flaky. A good description of the gold and its distribution in the high-level gravels has been given by McConnell (1903, 1906). In most of the samples gold increases with depth, but the weight of the heavy minerals decreases (Fig. 18 and Table XI). There does not seem to be a consistent agreement between the distribution of gold and a particular heavy mineral or suites of heavy minerals.

Lovett Hill is the only gravel section sampled that contains both the White Channel and Klondike gravels. The heavy mineral content of the two gravels is markedly different. Topaz, clinopyroxene, staurolite, andalusite, kyanite, and spinel are present in the Klondike gravels, but absent from the White Channel gravels. Ilmenite, sphene, and garnet are more abundant in the Klondike gravels, but epidote, goethite, muscovite, magnetite, rutile, apatite, and gold are more abundant in the White Channel gravels than in the Klondike gravels. Table III illustrates the relative abundance of the heavy minerals in each gravel section. Epidote is the most abundant heavy mineral in eight out of eleven White Channel gravel sections. The distribution of goethite is interesting because it increases in the upper 50-55 feet of gravel on Adams Hill, and goethite is the most abundant heavy mineral in the section on French Hill. Most of the goethite is derived from the yellow gravels that overlie the White Channel deposits in the upper parts of the gravel sections of these hills. McConnell (1906) thought these yellowish brown gravels represented flood plain deposits laid down at the same time as the White Channel gravels. They are not leached of iron as are the white, White Channel deposits; they are loosely compacted, low in gold, and contain more brown schist and less quartz than the typical White Channel gravels. Hence the yellow gravels reflect a change in weathering conditions that apparently occurred near the close of the depositional period of the White Channel gravels.

TABLE III *Abundance of Heavy Minerals[1] in −60+100 Mesh Bromoform Heavy Fraction of the High-level Gravels of the Klondike Area*

Klondike gravel	White Channel gravel										
Lovett Hill	Lovett Hill	Cripple Hill	Monte Cristo Hill	Adams Hill	French Hill	Bunker Hill	Dago Hill	Discovery Hill	Preido Hill	Gold Bottom Hill	Paradise Hill
Heavy minerals present in decreasing order of abundance											
epidote	epidote	epidote	epidote	epidote	goethite	epidote	ilmenite	ilmenite	epidote	epidote	epidote
sphene	sphene	muscovite	actinolite	goethite	epidote	actinolite	epidote	rutile	ilmenite	muscovite	ilmenite
ilmenite	muscovite	ilmenite	muscovite	muscovite	muscovite	magnetite	rutile	muscovite	clinozoisite	apatite	muscovite
hornblende	actinolite	sphene	magnetite	sphene	sphene	sphene	clinozoisite	epidote	rutile	hematite	goethite
actinolite	ilmenite	rutile	apatite	magnetite	apatite	goethite	magnetite	clinozoisite	muscovite	magnetite	dolomite
muscovite	rutile	magnetite	sphene	actinolite	actinolite	apatite	muscovite	garnet	zircon	actinolite	clinopyroxene
apatite	apatite	anatase	goethite	ilmenite	rutile	muscovite	goethite	sphene	topaz	ilmenite	rutile
garnet	magnetite	apatite	ilmenite	apatite	magnetite	ilmenite	sphene	leucoxene	actinolite	goethite	
staurolite	goethite	garnet	rutile	anatase	ilmenite	hornblende	topaz	anatase		rutile	
rutile	garnet	actinolite	barite	rutile	hornblende	hypersthene	hypersthene	magnetite			
				hornblende	garnet		anatase	zircon			
				garnet	hematite		barite				
							zircon				
Heavy minerals present in minor amounts											
andalusite	hornblende	goethite	garnet	hematite	barite	rutile	hornblende	hematite	garnet	garnet	magnetite
topaz	zircon	hornblende	hypersthene	barite	anatase	barite	tourmaline	chromite	magnetite	hypersthene	hematite
clinopyroxene	anatase	hypersthene	anatase	hypersthene	hypersthene	garnet	leucoxene	clinopyroxene	goethite	hornblende	garnet
zircon	barite	tourmaline	chlorite	zircon	zircon	anatase	zoisite	hypersthene	tourmaline	clinopyroxene	topaz
hypersthene	hypersthene	kyanite	zircon	zoisite		zircon	actinolite	goethite	zoisite		sphene
magnetite	hematite	tremolite	tourmaline	tremolite		tremolite	chromite	actinolite	biotite		
kyanite	tourmaline	jarosite	pyrite			clinopyroxene	dolomite	apatite	chromite		
sphene	zoisite		jarosite				hinsdalite	olivine	olivine		
biotite	biotite						apatite				
tremolite	chlorite						garnet				
zoisite							hematite				
barite							clinopyroxene				
goethite							biotite				
							martite				
							vesuvianite				
							monazite				

[1] Gold not included.

Heavy minerals in the White Channel gravels are derived from bedrock. Bunker Hill exhibits an increase in actinolite and magnetite due to the magnetite-rich chloritic and actinolitic green schists that occur in upper part of Bonanza Creek. Dago, Preido, and Paradise Hills contain topaz and tourmaline; both are characteristic of the rhyolite porphyry that occurs in the area. Cassiterite in the form of "wood tin" has been recovered by the miners on these hills, and it too originates from rhyolite porphyry. Chromite and olivine on the hills of Last Chance and Hunker Creeks are derived from ultrabasic rocks east and west of Hunker Creek. Dolomite is derived from crystalline limestones in the Nasina schists. Ray (1962) reports finding a piece of cinnibar in a clean-up concentrate from Dago Hill. He postulates that it came from Tertiary volcanic rocks that outcrop along Last Chance Creek. In addition he found abundant monazite in the −35+48 mesh fraction of his sample from Dago Hill.

Epidote, garnet, magnetite, actinolite, zircon, and titanium-bearing minerals are generally more plentiful in the White Channel gravels than in the creek gravels. This is a reflection of their degree of resistance to weathering and wear. The softer, more readily weathered minerals, such as goethite, barite, chlorite, jarosite, muscovite, pyrite, and hypersthene, are less abundant in the white White Channel deposits than in the creek and valley gravels.

All the terraces that have been sampled, except the one on Gold Bottom Creek, have been mined hydraulically. In 1964 hydraulic operations were in progress on Cripple, Adams, Dago, Discovery, and Preido Hills and King Solomon Dome (Fig. 16). The White Channel gravel sample taken from the bench on Gold Bottom Creek was obtained by digging a pit, but at a depth of 6 feet permafrost was encountered and bedrock was not reached. The gold values in this sample are low. Little prospecting has been done on this terrace, which is about 1,200 feet in length and 300 feet in width, and more detailed sampling and prospecting is warranted. The gravel samples from Bunker Hill have interesting gold values and it too should be considered in future prospecting.

One of the largest reserves of unworked White Channel gravel in the area is on Lovett Hill between Klondike River and Lovett Gulch. McConnell (1906) estimated that this hill contained 38,015,530 cubic yards of workable gravels with an average grade of 14.9 cents per cubic yard (gold at $20.00 an ounce). To date less than 20 per cent of this volume has been mined.

Similarly, the hills along Hunker Creek – Paradise, Nugget, and Dago – contain large reserves of White Channel gravels. The largest area of unworked high-level gravel is on Australian Hill at the mouth of Hunker Creek on its right limit where McConnell (1906) reports 35,947,000 cubic yards of White Channel gravels. The area is overlain by barren Klondike gravels as much as 130 feet thick. McConnell estimated the volume of Klondike gravels to be 39,200,000 cubic yards.

The early prospectors and McConnell were unsuccessful in locating a pay streak on this hill, but with modern drilling methods and practices it should be worthwhile to sample these large reserves systematically and re-evaluate their potential in the light of the present price of gold. Studies would have to be made on the feasibility of pumping large volumes of water from Klondike River to these terraces for hydraulic operations.

No minerals of economic importance other than gold are present in quantity in the White Channel and Klondike high-level gravels of the Klondike area. Some consideration

TABLE IV *Average Weight of Bromoform Heavy Concentrates, Average Weight Per Cent of Heavy Minerals in −60+100 Mesh Bromoform Heavy Fraction, and Average Gold Content of Eluvium over Klondike Schists*

Type of Klondike schist	Number of samples averaged	Wt. of bromoform heavies (gm.)	Wt. of −60+100 mesh bromoform heavies (gm.)	Average weight per cent of heavy minerals in eluvium from Klondike schists −60 +100 mesh bromoform heavy fraction (gm.)																										Gold (mg./cu. ft.)
				Goethite	Muscovite	Apatite	Hypersthene	Hornblende	Actinolite	Sphene	Magnetite	Ilmenite	Epidote	Chlorite	Barite	Jarosite	Martite	Garnet	Tourmaline	Clinopyroxene	Scheelite	Biotite	Tremolite	Zircon	Pyrite	Anatase	Rutile	Hematite	Zoisite	
Poorly schistose	38	68.6	11.4	25.3	34.1	3.6	1.0	1.3	3.9	1.6	4.0	1.1	12.5	0.3	6.3	2.3	tr	0.3	1.1	tr	tr	0.1	0.1	0.1	0.2	0.6	0.2	tr	tr	0.06
Moderately schistose	35	77.9	9.6	27.7	38.6	7.0	2.4	1.7	3.4	1.7	2.9	1.0	6.5	0.6	2.6	1.9	tr	tr	tr	1.7	tr	tr	tr	tr	tr	0.1	0.4	tr	tr	0.08
Very schistose	28	99.0	10.5	36.5	31.9	13.4	0.8	0.8	3.5	1.1	1.8	0.5	5.4	0.3	1.6	1.1	tr	tr	–	tr	tr	0.1	0.1	0.4	0.1	0.3	0.3	tr	–	0.15

TABLE V *Average Heavy Mineral Content of the −60+100 Mesh Bromoform Heavy Products from Eluvium Taken over Rhyolite Porphyry and the Nasina Schist in Contact with the Porphyry East of Hunker Creek*

Rock type	Av. Wt. of bromoform heavy products (gm.)	Av. Wt. of −60+100 mesh bromoform heavy products (gm.)	Average weight per cent of heavy minerals in −60+100 mesh bromoform heavy fraction																											
			Goethite	Magnetite	Fluorite	Wad manganese	Hematite	Ilmenite	Biotite	Tourmaline	Topaz	Martite	Epidote	Hornblende	Limonite	Clinopyroxene	Muscovite	Dolomite	Hypersthene	Apatite	Chlorite	Garnet	Rutile	Zircon	Actinolite	Anatase	Jarosite	Monozite	Pyrite	Sphene
Rhyolite porphyry[1]	67.0	11.4	34.8	21.9	9.9	6.5	5.4	4.9	2.7	2.4	2.0	1.9	1.3	1.3	1.0	1.0	0.7	0.6	0.5	0.4	0.3	0.2	0.2	0.1	tr	tr	–	tr	tr	tr
Nasina schists[2] in contact with rhyolite porphyry	222.6	16.8	38.3	3.3	–	19.9	6.7	4.1	13.6	–	0.3	0.2	2.3	0.5	6.0	0.9	1.2	tr	0.7	–	0.4	tr	1.1	0.3	0.1	–	tr	–	–	0.1

[1] Average of seven samples.
[2] Average of three samples.

should be given to the re-evaluation of the large reserves of unworked White Channel gravels in the lower parts of Bonanza and Hunker Creeks.

Heavy Minerals in Eluvium and Bedrock

To determine with more certainty the provenance of the gold and other heavy minerals on the gravels and the relationship of these heavy minerals to the placer gold of the Klondike area, heavy mineral sampling was done across various phases of the Klondike Series. Most samples were taken near the two most productive creeks, Bonanza and Eldorado. Samples were also taken across the Nasina Series and a rhyolite porphyry east of Hunker Creek; several samples were obtained from a foliated granite and its contact rocks near Mount Burnham and on the west slope of the ridge between Dominion and Flat Creeks.

Setting and Methods

The hills along Bonanza and Eldorado Creeks have moderate to steep slopes, and soil and rock creep are common on the hillsides. In an attempt to avoid contamination of heavy minerals from up slope, most sample points were selected where bedrock was exposed. One-cubic-foot samples of eluvium were taken from road cuts, hydraulic rock cuts, creek banks, bulldozer cuts, and pits. The rocks in the area are deeply weathered and are not too difficult to dig especially where the schist is sheared and very schistose. Rock fragments greater than 2 or 3 inches in diameter were discarded before the samples were taken. The samples were given the same field and laboratory treatment as the gravel samples.

Figure 17 shows the sample locations, the weight of the bromoform sink products, and the weight per cent of each mineral in the −60+100 mesh bromoform heavy fraction of the eluvium samples. The results from four samples taken over and near the foliated granite east of Dominion Creek are shown in Table VII. The distribution of the gold, goethite, muscovite, apatite, barite, topaz, tourmaline, fluorite, magnetite, ilmenite, epidote, jarosite, and pyrite are shown on Figure 19 (*in pocket*). Some detailed work was done in the vicinity of the Lone Star mine and between O'Neil and Victoria Gulches on upper Bonanza; the results of this work, including the geology, are presented on Figure 20 (*in pocket*).

Results

Klondike Series

The author has grouped the schists of the Klondike Series into three types according to their degree of schistosity. The first is a poorly schistose, flaggy, light to medium greyish variety, in parts resembling medium to finely bedded impure quartzite. Eyes of bluish quartz are common. The second is a moderately schistose grey rock with cleavage planes 1/16 inch or more apart. Quartz eyes are also found in this phase of the schist. The third variety is a very schistose rock commonly associated with shear zones in the area. It is soft, friable, greasy to touch, and it has a pearly lustre on the cleavage planes owing to the abundance of sericite and muscovite. On the fresh surface it is white or light green, but on the weathered surface it is a light tan to brown due to oxidation of pyrite. Subordinate amounts of chlorite schist occur in all three types.

Table IV illustrates the average weight of the bromoform heavy products and the amounts of heavy minerals in the eluvium from the three varieties of Klondike schists. The results show that the total weight of the bromoform sink product and the quantity of goethite (oxidized pyrite), apatite, and gold increases with increasing schistosity; conversely, magnetite, ilmenite, epidote, barite, and jarosite decrease. Some of these differences are due to hydrothermal activity along zones of shearing. Hydrothermal solutions have introduced apatite, gold, and pyrite into the shear zones, but some pyrite formed at the expense of magnetite. The increase of barite in the eluvium derived from the more competent Klondike schists is to be expected, because the largest barite veins occur as fracture fillings in the more massive, more competent Klondike schists.

Local variations in the heavy mineral content of the eluvium from the Klondike schists are common (*see* Figs. 17, 19). Samples G74 to G78 and M46, on the ridge between Gold Bottom Creek and Bonanza Creek, are very high in epidote and in some instances magnetite. Also high in magnetite are samples G30 and G31 on Bonanza Creek below Gauvin Gulch; they were taken from at and near a basic dyke cutting the Klondike schists. Muscovite and goethite appear to be ubiquitous in the schist, and near known lode deposits one or the other predominates. Barite makes up more than 1 per cent of the heavy minerals in the −60+100 mesh bromoform heavy fraction of the eluvium samples taken at the mouths of Gay, French, and Irish Gulches on Eldorado Creek; between Victoria and McKay Gulches; at the mouth of Skookum Gulch; and below Adams Creek on Bonanza Creek.

The distribution of the placer and lode gold found in the eluvium samples is shown on Figure 19. Samples containing unworn lode gold are indicated by a square, and those containing placer gold by a circle; the weight of the gold in milligrams is written in the middle of the squares and circles. The presence of placer gold in the weathered bedrock is not surprising. Fractures in the bedrock act as riffles to trap gold and even after bedrock has been mined some gold may remain. Gold is three to five times heavier than most other heavy minerals; therefore it readily settles into rock fractures and openings, and any movement of the rock allows it to settle deeper; this is especially true of the flaggy variety of schist. Sample M7 taken on a bench from which a considerable amount of bedrock has been mined contains more than 100 milligrams of placer gold. Placer gold, in quantities greater than 2 milligrams, is present in samples M16, G30, G31, and M28.

Small amounts of lode gold were found in several samples near Eldorado Creek in the vicinity of Gay Gulch, on Bonanza Creek in the vicinity of Victoria Gulch, near Skookum Gulch, above Queen Gulch, and between Pure Gold and Mosquito Gulches on Bonanza Creek. Eluvium samples M43 to M48, G69, and G71 to G78 along the ridge between Bonanza and Hunker Creeks contain from 0.02 to 0.52 milligram of lode gold in a cubic foot of eluvium. This gold is flaky, fine grained, usually less than 60 mesh, and most has a black coating that makes it difficult to identify. The coating is partly soluble in concentrated hydrochloric acid.

It is possible to recover extremely small quantities of gold using this method of heavy mineral sampling and analyses. The above results suggest that the Klondike area should be explored in more detail for lode gold possibilities, and also when using the method of heavy mineral prospecting, the best guide mineral is placer gold. It can be detected in quantities lower than 0.1 milligram per cubic foot. This would be equivalent to an assay of approximately 0.00006 oz./ton.

Nasina Series and Rhyolite Porphyry

Cassiterite exhibiting the colloidal texture "wood tin" has been found in the creek, valley, and terrace gravels by the placer gold operators in the lower parts of Hunker Creek, on Klondike River from the mouth of Hunker Creek to Yukon River, on Dago, Preido, and Paradise Hills, on Dominion Creek, Sulphur Creek, at the mouth of Germaine Creek, and at Boulder Hill on Bonanza Creek. The cassiterite has never been retained, hence no figures are available on the actual amounts recovered by the placer operators. Indications are that some parts of the creeks and benches contained considerable amounts of cassiterite, but that generally quantities were insufficient to warrant recovery as a byproduct of the placer gold. One of the most likely source rocks for "wood tin" would be the body of porphyritic rhyolite that outcrops on the ridge and slopes between the lower part of Hunker Creek opposite Last Chance Creek and Klondike River. The rhyolite mass is about 3 miles wide and 4 miles long.

Eluvium samples were taken over the porphyry and its contact rocks. The latter are Nasina schists, in part graphitic. Figures 17 and 19 show the locations and heavy mineral assemblages of these samples. Samples G159, G160, G163, G170, G172, G173, and G177 are from the rhyolite; G161, G162, and G171 are from the schists at or near the contact of the rhyolite porphyry. The average weights of the bromoform heavy products and the weight per cent of the heavy minerals in the −60+100 mesh bromoform heavy product is shown in Table V. The average weights of the heavy minerals in the schists are greater than in the rhyolite. White, blue, or purple fluorite and blue-green tourmaline make up an average of 9.9 and 2.4 per cent, respectively, of the heavy minerals in rhyolite, but no fluorite or tourmaline was found in the schists. Topaz, in colourless euhedral crystals, makes up 2 per cent of the heavy minerals in the −60+100 mesh fraction of the rhyolite, and only 0.3 per cent of the heavy minerals in the same fraction of the bordering schists. In addition, magnetite, ilmenite, martite, hornblende, and monazite are more abundant in the rhyolite porphyry than in the Nasina schist. Conversely, black amorphous wad manganese, hematite, goethite, biotite, epidote, limonite, and rutile are more common in the contact schists than in the porphyry. No cassiterite was identified in the eluvium samples, but the presence of minerals such as topaz, tourmaline, and fluorite in the samples taken over the rhyolite indicated that this rock could be tin-bearing.

Spectrographic analyses (*see* Table VI) were done on the −60+100 mesh bromoform heavies from the schists, rhyolite porphyry, and a foliated granite; magnetite and ilmenite was removed prior to analyses. The samples over the foliated granite were taken from Mount Burnham and on the ridge east of the mouth of Jensen Creek, a tributary of Dominion Creek.

Tin was present in four of the five samples from the rhyolite porphyry, and none was found in any of the samples from the Nasina schists or foliated granite. Hence it appears that the cassiterite found in Hunker Creek, at the mouth of Germaine Creek, and in Klondike River is derived from the rhyolite porphyry. The source of the cassiterite in Dominion and Sulphur Creeks remains unknown. Although the body of foliated granite that outcrops along the ridge between Dominion and Flat Creeks could be a source, the spectrographic analyses (samples G278 and G281) show that this granite does not contain tin. No rhyolite porphyry bodies have been mapped in the area of Sulphur and Dominion Creeks, and because cassiterite does not appear to be present in the Nasina schists, it may

TABLE VI | *Spectrographic Analyses[1] of −60+100 Mesh Bromoform Heavy Products from Eluvium over Rhyolite Porphyry, over Nasina Schist in Contact with the Porphyry, and over Foliated Granite*

Rock type and sample No.	Si	Al	Fe	Ca	Mg	Ti	Mn	Sr	Ba	Cr	Zr	V	Ni	Zn	Cu	Y	Nb	Co	Pb	Sc	Sn	B	Yb	Be	Ag	Mo
Rhyolite porphyry																										
G159	>10	>10	>10	1	1.5	3	1.5	0.007	0.03	0.007	1.0	NF	0.03	0.5	0.003	0.5	0.2	NF	0.02	0.015	0.05	0.7	0.1	<0.01	0.002	NF
G160	>10	>10	>10	0.5	2	7	5.0	0.015	0.5	0.015	0.07	0.05	0.15	0.5	0.05	0.2	NF	0.05	0.15	0.003	NF	0.07	0.02	<0.01	0.005	0.03
G163	>10	7	>10	5	0.5	2	1.5	0.01	0.015	0.007	0.3	0.03	NF	0.3	0.005	0.15	0.1	NF	0.02	0.005	0.1	0.03	0.02	<0.01	NF	NF
G172	>10	>10	>10	5	5	>10	0.5	0.05	0.15	0.07	0.2	0.07	0.05	NF	0.015	0.03	0.1	NF	NF	0.01	0.15	0.1	0.005	NF	NF	NF
G173	>10	7	>10	2	2	>10	0.7	0.015	0.07	0.03	1.0	0.03	<0.02	0.3	0.15	0.15	0.5	NF	0.2	0.005	0.5	0.025	0.05	<0.01	NF	0.01
G177	>10	>10	>10	>10	0.5	3	1.5	0.2	0.1	0.007	0.1	0.02	NF	0.2	0.15	0.7	NF	NF	0.5	NF	0.3	0.7	0.05	<0.01	NF	0.07
Nasina schist																										
G161	>10	7	>10	7	1.5	10	2.0	0.02	0.3	0.015	0.07	0.07	0.15	0.5	0.1	0.5	NF	0.03	0.02	0.003	NF	0.03	0.03	<0.01	NF	0.02
G162	>10	7	>10	5	0.5	2	1.5	0.01	0.15	0.007	0.3	0.03	NF	0.3	0.005	0.15	0.1	NF	0.02	0.003	NF	0.05	0.05	<0.01	NF	0.05
G171	>10	7	>10	3	1.5	7	0.2	0.02	0.15	0.015	0.07	0.07	0.05	NF	0.015	0.01	NF	NF	NF	0.003	NF	0.03	0.001	NF	NF	NF
Foliated granite																										
G278	>10	7	>10	>10	3	>10	0.7	0.007	0.03	0.007	0.7	0.03	<0.02	NF	0.007	1.0	0.03	NF	NF	0.01	NF	0.3	0.2	<0.01	NF	0.03
G281[2]	>10	>10	>10	>10	7	3	0.5	0.015	0.01	0.015	0.07	0.02	NF	0.2	0.01	0.15	0.05	NF	NF	NF	NF	>1	0.02	NF	NF	NF

[1] Spectrographic analyses by R.J. Bolton, Geological Survey of Canada; all values are percentages.
[2] Tourmalinized.

TABLE VII | *Heavy Minerals Associated with Foliated Granite and its Contact Rocks East of Dominion Creek*

Rock type	Sample No.	Wt. of bromoform heavies (gm.)	Wt. of −60+100 bromoform heavies (gm.)	Weight per cent of −60+100 mesh bromoform heavy fraction																				
				Actinolite	Anatase	Apatite	Biotite	Clinopyroxene	Epidote	Garnet	Goethite	Hematite	Hornblende	Hypersthene	Ilmenite	Limonite	Magnetite	Martite	Muscovite	Rutile	Sphene	Staurolite	Tourmaline	Zircon
LOVETT HILL: Klondike gravel																								
Quartz–sericite–garnet–schist (Nasina)	G280	139.6	4.4	0.4		4.3	2.5		tr	26.5	4.2	<0.1			0.1		0.1		58.9	3.0				
Gneiss (granitic)	G279	22.2	6.6		2.0	38.1	0.9	tr	4.7	24.0	19.2	2.6	1.7	0.7	0.8	1.6	0.4	tr	2.1	tr	0.7			0.5
Foliated granite	G278	158.7	9.8			3.8	81.7		0.5	<0.1	0.6	0.7	2.4	0.5	6.2		0.6		2.5				0.5	tr
Foliated granite (tourmalinized)	G281	106.2	13.4			22.0	tr		1.0	13.2	tr		tr	tr	0.2		0.5		2.1			3.8	57.2	

have come from quartz-cassiterite fracture fillings in the schist of the area, or possibly from yet unknown rhyolite porphyry bodies.

Topaz is ubiquitous to the tin-bearing rhyolite, and fluorite is common. No topaz or fluorite is present in the heavy mineral concentrates from Sulphur or Dominion Creeks; therefore the "wood tin" in these creeks may be unrelated to the rhyolite.

The presence of yttrium, niobium, and ytterbium indicates that monazite may be more prevalent in the rhyolite porphyry than is shown on Figure 17.

Foliated Granite

Table VII shows the heavy minerals associated with eluvium samples from the foliated granite body that outcrops along the ridge between Dominion and Flat Creeks. Samples G278 and G281 are from the middle of this granite; samples G279 and G280 are from a gneiss and garnetiferous schist, respectively. Although there appears to be a gradation from the schist into the gneiss and from the gneiss into the granite, outcrop is insufficient to confirm this definitely.

The major heavy minerals in the schist are muscovite (sericite), garnet, apatite, goethite, rutile, and biotite. In the gneiss between the granite and schist, apatite, garnet, goethite, epidote, hematite, muscovite, anatase, hornblende, and limonite are the major heavy minerals. The granite is distinguished by abundant tourmaline and biotite; garnet, apatite, ilmenite, muscovite, and staurolite are common in one or both of the eluvium samples from the granite. Although no kyanite is present in these samples, it is common in the creek gravels from Dominion Creek opposite the area occupied by this granite.

Spectrographic analyses on the bromoform heavies (Table VI) show that the granite does not contain tin. Sample G278 gave 1 per cent yttrium and 0.2 per cent ytterbium. These rare-earth elements are believed to be associated with the biotite that commonly contains pleochroic haloes.

Table VIII summarizes the provenance of the heavy minerals present in the eluvium and gravels of the Klondike area. There are no quantities of valuable heavy minerals other than gold associated with the rocks of the area. Cassiterite is not present in sufficient quantities to warrant recovery as a valuable byproduct. Most of the gold is derived from lode deposits within the Klondike schists, although there could be minor occurrences in the Nasina schists. The gold in Eureka Creek is probably derived from such a source.

Spectrographic analyses of heavy mineral concentrates is a useful method for delineating areas of tin and possibly other types of mineralization.

Heavy Minerals Associated with Lode Gold Deposits

One-cubic-foot samples of rubble or bedrock were taken in the vicinity of three types of gold occurrences in the area – the Violet, Mitchell, and Lone Star deposits. The heavy mineral analyses of these samples are shown on Figure 20 (*in pocket*).

Violet Deposit

A sample taken from a rubble pile was composed chiefly of quartz taken from an open-cut near the shaft. Major heavy minerals in decreasing order of abundance include barite, goethite, jarosite, and muscovite. Hypersthene, hornblende, magnetite, ilmenite, clinopyroxene, pyrite, biotite, zircon, and galena are present in trace to minor amounts; 3.1 milligrams per cubic foot of flaky gold is also present.

TABLE VIII *Heavy Minerals Associated with the Various Rock Groups of Klondike Area*

Rock group	Major heavy minerals	Minor heavy minerals
Nasina Series	Biotite, chlorite, dolomite, goethite, muscovite (sericite), magnetite, pyrite, ilmenite, tremolite, epidote, garnet, hematite, hornblende	Zoisite, clinozoisite, tourmaline, sphene, anatase, zircon, hypersthene, scheelite, wad manganese, gold(?)
Klondike Series	Goethite, muscovite (sericite), epidote, apatite, hypersthene, hornblende, actinolite, sphene, ilmenite, rutile, barite, jarosite, pyrite, magnetite, gold	Garnet, martite, tourmaline, clinopyroxene, tremolite, zircon, anatase, monazite, dolomite, biotite, galena, hematite, scheelite, zoisite, clinozoisite, chalcopyrite, arsenopyrite
Ultrabasic rocks	Magnetite, ilmenite, hornblende, olivine, clinopyroxene, enstatite	Chromite, chlorite, spinel
Foliated granite	Biotite, apatite, tourmaline, staurolite, kyanite, garnet, muscovite, epidote	Goethite, hematite, anatase, hypersthene, magnetite, sphene, zircon, ilmenite, hornblende
Basic dykes	Magnetite, apatite, ilmenite, hypersthene, hornblende, sphene, limonite, epidote, clinopyroxene	Chlorite, biotite, actinolite, pyrite
Rhyolite porphyry	Goethite, hematite, ilmenite, magnetite, topaz, fluorite, epidote, limonite	Apatite, biotite, monazite, clinopyroxene, martite, hornblende, hypersthene, pyrite, muscovite, zircon, tourmaline, cassiterite, sphene, wad manganese

Mitchell Deposit

Several samples were collected: one from quartz rubble; a second from chlorite schist rubble near the shaft; and a third, a weathered bedrock sample, was taken from a quartz-biotite-chlorite schist outcropping in a trench 775 feet north of the shaft. One cubic foot of quartz rubble contains 39 milligrams of gold, and a cubic foot of the chlorite schist rubble has 0.4 milligram of gold. The gold in these samples tends to be in the form of somewhat spongy looking shots or pellets. A sample of rusty quartz from the rubble assayed 0.115 oz. gold and 0.035 oz. silver; the pyritic chlorite schist from the rubble assayed 0.03 oz. gold and 0.01 oz. silver. Cubes of pyrite as much as 1/2 inch square are abundant in the schist and quartz rubble; minor amounts of native copper are also present. Magnetite, in the form of blue iridescent octahedrons, is common in the schists. Chlorite is abundant in the schist rubble, and biotite makes up about 60 per cent of the −60+100 mesh heavy minerals in the bedrock sample from the trench north of the shaft. Epidote is common in all three samples. In addition, the quartz rubble contains muscovite, ilmenite, clinopyroxene, jarosite, and biotite in quantities greater than 1 per cent, and apatite, magnetite, hypersthene, hornblende, sphene, and galena in trace to minor amounts. Apatite, hypersthene, and dolomite are common in the chlorite schist rubble; muscovite, ilmenite, actinolite, and biotite are present in minor amounts.

Lone Star Deposit

The samples from the Lone Star deposit consist of four 1-cubic-foot samples from the soft, sheared, quartz-sericite schist in the open-cut. The location of these samples and the heavy minerals present in the −60+100 mesh fraction are shown on Figure 20. Gold content varies from 0.20 milligram to 2.50 milligrams per cubic foot. The gold is fine grained, yellow, flaky, and commonly occurs attached to or intergrown with the sericite grains. The average heavy mineral content of the four samples shows that the zone contains major quantities of muscovite and pyrite, more than half of which is oxidized to goethite. Less abundant but common are apatite, barite, ilmenite; and present in trace to minor amounts are dolomite, sphene, epidote, magnetite, hypersthene, biotite, monazite, zircon, clinopyroxene, hornblende, martite, garnet, and galena.

The heavy mineral studies of the rubble and bedrock from three types of lode occurrences in the Klondike area show the following similarities:

1. They all contain native gold
2. Pyrite, partly oxidized to goethite, is abundant in all deposits
3. All deposits contain a trace of galena

Hence the most reliable and easily recognizable heavy mineral usable as a guide in outlining auriferous lode zones in the Klondike region is gold itself.

Area of Detail

More and detailed heavy mineral sampling was done along a series of bulldozer cuts in the vicinity of Victoria Creek and O'Neil Gulch. These samples were taken to attempt to delineate the source of some of the angular gold that is found in these gulches, and to obtain more information on the heavy mineral assemblages associated with the Klondike Series. Figure 20 shows a sketch of the geology, the locations of the eluvium and alluvial heavy mineral samples, and the results of the heavy mineral study of this area.

General Geology

Strong shearing has occurred in parts of the Klondike schists parallel to Tintina Trench (N50°, 55° W). The Lone Star mine is in one of these zones. A similar strong shear zone about 400 feet wide crosses Bonanza Creek at McKay Gulch, and a smaller one occurs just below the mouth of O'Neil Gulch. These zones are pyritized and sericitized and contain many quartz stringers, veins, and veinlets and trace amounts of galena. Zones of white to grey clay (fault gouge) are common. The schists within the zones are white to light green on the fresh surface, but on the weathered surface the pyrite oxidizes and colours the schists brown. These rocks trend northwesterly with moderate to steep dips to the southwest. Some tight folding has taken place as the zone of very schistose schist appears to be badly contorted in the vicinity of 7 Pup. Quartz veins and stringers occur throughout the schists, and dykes of basic rocks cut all phases of the Klondike schists.

Heavy Minerals in Creek Gravels

Most of the gravels in Victoria Gulch and its tributaries were worked by the early placer miners, and therefore the alluvial samples shown on Figure 20 represent material taken from the creeks that flow over the worked gravels.

The heavy mineral assemblages in the −60+100 mesh fraction of these samples are typical of the creeks draining the Klondike schists. Goethite, muscovite, epidote, apatite, magnetite, hypersthene, actinolite, barite, sphene, and ilmenite are the major minerals found in all these samples. Clinopyroxene, hornblende, pyrite, garnet, biotite, rutile, zircon, chlorite, jarosite, tremolite, scheelite, and galena are less abundant. No valuable heavy minerals other than gold are present in quantity in these gravels.

Gold was found in all samples from O'Neil and Victoria Gulches; it is angular, particularly in the upper parts of the gulches and pups. The highest gold values were found on 7 Pup and on Victoria Gulch between 7 Pup and 13 Pup. No cutoff for gold was found on Victoria Gulch, suggesting that lode gold occurrences exist at or near the head of Victoria Gulch; similarly, on 7 Pup no cutoff was found. Although sample G217 near 7 Pup is classed as an eluvium sample, most of the gold in it probably has been transported from a source between it and the head of the pup.

Heavy Minerals in Eluvium

In 1961 and 1962 Klondike Lode Gold Mines Ltd. made a series of bulldozer cuts, varying from 3 to 20 feet in depth, on the slopes of the hills between O'Neil and Victoria Gulches. The samples of eluvium shown on Figure 20 were taken from weathered bedrock on the bottom of these cuts, hence the heavy minerals in these samples should be indicative of the underlying bedrock. There is a possibility, however, that some of the heavier minerals, especially gold, are derived from bedrock up slope from the samples. Except for magnetite and ilmenite, the relationship of the heavy minerals to the degree of schistosity of the Klondike schist is the same as previously described for eluvium samples in the rest of the Klondike area.

Gold in the eluvium is usually yellow, fine grained, and flaky. The gold in samples G37 and G36 is probably derived from the shear zones slightly up slope from these samples. Sample G210 was taken over a basic dyke, and the gold associated with it probably has moved down hill. Sample G217 in the upper part of 7 Pup contains 43 milligrams of fine- to coarse-grained angular gold. This sample is from the depression cut by this pup; thus it is quite likely that the gold is actually placer in origin and has been derived from a source up hill from G217. The large amounts of barite and magnetite in this sample indicate that basic dykes and barite veins are probably present in the vicinity. More prospecting between this sample site and the Lone Star deposit might reveal hidden lode deposits.

The strong shear zone that crosses Bonanza Creek at McKay Gulch was examined in more detail for lode gold possibilities. A 30-pound composite sample of the schist was taken across the width of the zone where it is exposed in dredge tailings in Bonanza Creek. Two similar samples were taken from the less-sheared schists on either side of this zone. The three rock samples were pulverized; one quarter of each of the pulverized samples was submitted for gold and silver assays, and the remaining portion was concentrated on a superpanner. The superpan concentrates weighed 5 to 10 pounds. These concentrates were analyzed quantitatively by optical spectrography for sixteen elements, and colorimetrically for copper, lead, and zinc. The results of these analyses are shown in

TABLE IX *Analyses of Superpan Concentrates and Assays of Schist from a Shear Zone and its Contact Rocks on Bonanza Creek near McKay Gulch*

Rock type	Sample No.	Spectrographic analyses[1] of superpan concentrates (%)															
		Si	Al	Fe	Ca	Mg	Ti	Mn	Sr	Ba	Zr	V	Zn	Cu	Pb	Sc	Bi
Poor to moderately schistose Klondike schist	G48a	>20	7.6	1.6	0.41	1.1	0.083	0.017	0.0065	0.20	0.012	NF	NF	NF	NF	NF	NF
Very schistose, sheared Klondike schist	G50b	>20	9.2	3.5	0.50	3.3	0.17	0.080	0.0048	0.091	0.0076	<0.007	0.32	0.0054	0.20	NF	NF
Poorly schistose Klondike schist	G51a	>20	9.3	0.36	0.36	1.4	0.17	0.026	0.011	0.32	0.012	<0.007	NF	NF	NF	NF	NF

Sample No.	Colorimetric analyses[2] of superpan concentrates (ppm)			Assays[3] of schist (oz./ton)	
	Cu	Pb	Zn	Ag	Au
G48a	20	45	30	NF	NF
G50b	24	440	1800	0.055	tr
G51a	8	10	80	NF	NF

[1] Analyses by Spectrographic Laboratory, Geological Survey of Canada. Ni, Co, Sn, B, Be, Ce, Y, Nb, La, Yb, As, Mo, Ag not found.

[2] Analyses by J. Lynch, Geological Survey of Canada.

[3] Analyses by Mines Branch, Dept. Energy, Mines and Resources.

Table IX. The assays show that the schist in the shear zone contains traces of gold and 0.055 ounce of silver per ton. Gold and silver are not present in detectable amounts in the adjoining schists.

The spectrographic analyses show that iron, calcium, magnesium, manganese, copper, lead, and zinc are present in greater amounts in the zone of shearing than in the less-sheared contact rocks; conversely barium is lower in the shear zone. It has been shown (*see* Table IV) that barite is present in lower concentrations in eluvium taken over the very schistose phase of the Klondike schists, but the opposite is true of goethite (oxidized pyrite). The increase in iron in this shear zone is a result of the zone being pyritized.

Traces of galena are found in the heavy mineral concentrates from the three lode deposits described previously. This shear zone is geologically and mineralogically similar to the Lone Star deposit, and the spectrographic and colorimetric analyses show that it contains much greater amounts of lead and zinc than the schists on either side of it.

It would appear that in addition to heavy mineral work, geochemistry might be of great value in prospecting for structures that are favourable loci for lode gold deposits in the Klondike area. Geochemical soil surveys should be a very effective prospecting tool, especially as the soils in the area are residual.

Geochemical soil prospecting has decided advantages over heavy mineral prospecting when searching for the lode gold deposits. The geochemical soil sample does not have to be concentrated, only a small quantity of material is needed, and field tests are simple and rapid. Hence by using soil geochemistry it would be possible to cover an area in more detail and more quickly, and delineate favourable targets more accurately and at less cost than with heavy mineral surveys. Zinc, lead, and possibly copper, are the pathfinder elements for gold deposits in the Klondike area. Once favourable targets have been indicated by geochemistry, then systematic panning for gold could be done over and in the vicinity of these targets.

Chapter V

SUMMARY AND CONCLUSIONS

This report reviews the history and development of the placer mining industry in the Klondike area. The general geology and the surficial geology are discussed, and descriptions of the gravel, placer gold, and lode deposits are given. The lode gold deposits of the area are classified as follows:

1. Gold associated with quartz barite veins
2. Gold associated with quartz veins in the chloritic phase of Klondike schist
3. Gold associated with quartz veins and stringers in northwest-trending shear zones
4. Gold in Tertiary conglomerates (ancient placers)

Although new placer gold deposits have been found, indications are that large volumes of unworked gravels remain on Dominion Creek and Gold Run Creek, and on the hills near the mouth of Hunker Creek and Bonanza Creek. The potential of this ground could be evaluated by systematic drilling and sampling. Mining methods and costs would be an important factor in determining the feasibility of mining these large reserves.

Forty-eight heavy minerals have been identified in the various gravel deposits of the area, but gold is the only mineral of economic importance that is present in mineable quantities. Most heavy minerals in the gravels of the Klondike area are from local bedrock sources. The exception is the Klondike gravels; the heavy minerals in these are derived partly from the Klondike area and partly from sources east and north of the area in Ogilvie Mountains.

Cassiterite "wood tin" in the area of Hunker Creek and Klondike River originates from rhyolite porphyry. Topaz, fluorite, blue-green tourmaline, and monazite have the same provenance as the cassiterite. Spectrographic analysis of heavy mineral concentrates is a useful technique for detecting tin and other valuable heavy metals associated with the rocks of the area.

Pseudomorphs of goethite, limonite, and less commonly hematite, after pyrite are found in quantity in the creek gravels and eluvium over and near deposits of lode gold. Also associated with these deposits are small amounts of galena, and in some places chalcopyrite and sphalerite. In addition, barite, muscovite (sericite), magnetite, chlorite, and apatite are common heavy minerals associated with one or more of the four types of lode gold deposits. The best pathfinder heavy mineral for gold in the area is gold itself. Very small quantities of gold can be recovered from the eluvium or gravels by either panning or sluicing.

Flakes of lode gold have been found in a number of heavy mineral samples from the eluvium. The largest concentrations are in a series of samples on the ridge between Gold

Bottom Creek and Bonanza Creek (Figs. 17 and 19). Follow-up work should be done in this area. A large shear zone that crosses Bonanza Creek at McKay Gulch is also auriferous, and several heavy mineral samples along Eldorado and Bonanza Creeks contain lode gold. The significance of the gold in these samples can be determined only by more detailed work. The heavy mineral results indicate that sources of lode gold other than those already known occur in the vicinity of Victoria Gulch. Also, in recent years Klondike Lode Gold Mines Ltd. have found several auriferous veins in the vicinity of Gay Gulch east of Eldorado Creek. The Klondike area has not been thoroughly prospected for lode deposits.

Indications are that geochemical prospecting using soil analyses would be a more useful, cheaper, and a faster method for outlining gold-bearing structures than heavy mineral work. Zinc, lead, and possibly copper are the pathfinder elements for gold.

Spectrographic analyses of placer gold from the major producing creeks of the Klondike show no traces of platinum metals.

TABLE XI | *Heavy Minerals in the High-level Gravels of the Klondike*

Elevation (ft.)	Total Wt. Brom. Hvs.[1] (gm.)	Wt. -60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of −60+100 mesh heavy fraction																										
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Bar.	Hyp.	Hem.	Zir.	Topaz	Clpyrox.	Staur.	Tour.	Zois.	Andal.	Kyan.	Trem.	Spin.	Biot.	Chlor.
LOVETT HILL: Klondike gravel																														
1615–1627	64.0	21.2		38.8	9.8	15.9	0.1	4.5	10.8	0.5	1.1	4.3	6.8	1.3			0.8		0.1	0.4		2.4			0.4	0.6	0.7	0.4	0.3	
1603–1615	71.7	22.0	0.41	22.5	13.3	28.1		3.8	5.4	0.3	0.1	1.9	14.6	2.9			0.8		1.1	1.1	0.8	1.8			1.2	0.3				
1591–1603	46.1	16.9	0.05	32.8	9.0	22.1		4.3	15.9	0.5	1.6	4.6	2.8	2.1					0.1	0.6	2.0	0.8		0.1	0.2	0.1		0.4		
1579–1591	60.8	17.8	0.12	24.6	28.9	21.0	tr	3.0	3.5	0.3	0.5	3.6	5.4	6.6		0.4			0.1			0.7		tr	1.1	0.3				
1570–1579	53.1	15.6	0.04	28.0	31.8	9.3	tr	6.8	0.9	0.1	1.5	3.1	17.0	0.4					0.1	0.1		0.4			0.1			0.4		
LOVETT HILL: White Channel gravel																														
1562–1570	47.2	10.1		49.8	4.8	15.2	0.6	3.4	12.2	0.1	4.0	9.6		0.3																
1550–1562	34.4	6.2		35.3	2.5	24.7		13.6	13.1	0.3	1.7	7.0	tr	1.0	0.1														0.4	0.3
1538–1550	31.1	7.3	0.26	44.2	0.7	19.8		8.1	13.6	0.4	5.3	6.0	0.3	1.6																
1526–1538	27.4	5.8	0.18	33.5	3.0	17.8	3.6	15.4	8.2	0.5	4.4	5.5	5.3	2.8			tr	tr												
1514–1526	30.4	5.9	0.90	63.4	2.6	11.5	1.0	7.1	8.4	0.3	1.2	4.1		tr			0.4													
1502–1514	11.2	1.7		73.8	6.4	5.7		1.1	2.8	1.7	6.5	0.7		1.0		0.1			0.2											
1490–1502	16.7	5.2	1.51	60.5	7.5	6.3	1.4	2.9	1.0	6.0	9.6	1.8	1.1	1.5				0.3	0.1											
1478–1490	31.9	10.9	0.39	46.9	19.1	4.6	0.7	3.4	1.8	13.0	7.6	1.9		1.0					tr											
1466–1478	26.9	7.7	2.43	54.7	3.6	5.0	12.9	10.5		0.7	9.5	2.1	0.3						0.7											
1454–1466	25.8	6.1	1.17	56.6	5.7	12.6	0.2	16.9	0.4	0.2	3.7	2.8		0.6					0.1											0.2
1442–1454	22.7	7.3	1.77	59.2	3.4	6.6	0.1	16.5		3.9	6.8	1.1		1.3			tr	tr	0.4				0.3	0.4						

[1] Bromoform heavies.

TABLE XI (*cont.*)

Elevation (ft.)	Total Wt. Brom. Hvs. (gm.)	Wt. −60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of −60+100 mesh heavy fraction																											
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Clzois.	Bar.	Hyp.	Hem.	Zir.	Topaz	Clpyrox.	Tour.	Leuc.	Zois.	Chro.	Dolom.	Biot.	Mart.	Ves.	Hinsdal.
DAGO HILL: White Channel gravel																															
1684–1696	8.3	1.3	5.8	6.3	30.3	2.8	4.1	3.6	0.8	5.9	22.9	0.7	3.4	1.5	2.9	4.5		4.9	0.4	0.3	1.2	1.1	0.5	1.1	0.2	0.5			0.1		
1672–1684	11.6	2.5	2.5	10.6	47.5	2.1	1.2	3.4	0.2	1.7	22.5		0.6	tr	1.6	2.0		0.6		0.3	1.5	0.6	1.5	0.7	0.6	0.6				0.2	
1660–1672	13.1	3.4	1.3	17.8	49.1	1.7	0.8	0.6	0.1	5.8	11.7		0.5	0.1		6.0		0.5		0.7	0.4	0.3	0.5	0.4	2.3	0.4	0.3				
1654–1660	16.0	4.2	2.3	44.0	27.4	1.2	1.2	1.9	0.5	3.6	4.7	0.4			0.2	8.1	3.0	tr		0.8	0.4	0.4	0.5	0.4				0.7	0.3		0.3
1648–1654	15.9	3.7	3.3	45.2	22.4	0.7	1.6	1.5	1.5	3.5	9.7				0.8	1.0	3.2	tr	0.1	1.0	1.8	1.3	0.3	0.8	0.7	tr	1.5				1.4
1644–1648	15.6	3.3	11.9	32.6	26.3	1.6	2.1	1.1	0.2	1.7	18.7		0.3	0.6	1.5	7.1		1.3		0.4	1.6	0.2	1.2	0.6	0.5	0.1			tr	0.3	

Elevation (ft.)	Total Wt. Brom. Hvs. (gm.)	Wt. −60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of −60+100 mesh heavy fraction																								
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Clzois.	Hyp.	Hem.	Zir.	Topaz	Clpyrox.	Tour.	Leuc.	Zois.	Chro.	Dolom.	Biot.	Oliv.
PREIDO HILL: White Channel gravel																												
1650 on bedrock	55.0	12.5	88.4	68.7	12.3		0.4	3.2	0.9	0.5	4.7			0.5		5.5			1.4	1.1		0.3		0.3	tr		0.3	tr
DISCOVERY HILL: White Channel gravel																												
1706 Bedrock 1700	5.2	1.4	25.9	11.1	38.3	2.9	0.6	12.2	0.2	1.1	17.5	0.2		3.1	1.2	5.8	0.3	0.8	1.1		0.5		2.1		0.8			0.2
PARADISE HILL: White Channel gravel																												
1703 Bedrock 1700	38.4	7.7	2.6	57.8	23.0	0.3	5.7	7.4	0.3	0.6	0.8			0.4				0.5		0.3	1.2					1.7		
GOLD BOTTOM: White Channel gravel																												
1894 Bedrock 1890	165.4	18.4	1.2	41.6	2.3		2.0	21.9	2.7	6.0	1.3	12.5	0.4	0.8			0.7	7.7			0.1							

Elevation (ft.)	Total Wt. Brom. Hvs. (gm.)	Wt. –60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of –60+100 mesh heavy fraction																	
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Bar.	Hyp.	Hem.	Zir.	Zois.	Trem.
ADAMS HILL: White Channel gravel																					
1733–1742	121.7	14.6	0.31	20.8	2.8	5.2	50.8	8.8	1.7	3.8	1.7	2.9	0.4		tr	0.2		0.7	0.1		
1721–1733	61.4	9.5	0.25	11.5	4.6	9.7	45.6	15.8	1.5	5.7	0.8	2.8	0.6			0.6	0.1	0.7			
1709–1721	73.3	6.5		12.4	2.2	3.7	53.9	5.1	0.5	7.6	3.3	3.1	1.1	0.4	5.3	0.1	0.4	0.8	0.1		
1697–1709	195.4	24.4	0.69	8.6	2.2	28.4	16.4	21.1	6.8	8.9	1.1	4.6	0.5			0.6	0.1	0.7			
1685–1697	115.9	15.7	0.85	31.2	4.1	8.0	16.6	10.8	9.4	7.0	1.5	1.8	2.1	0.4	6.1	0.2	0.1	0.3	0.1		0.3
1673–1685	100.2	20.1	1.06	50.1	2.5	4.1	1.6	8.4	14.4	2.6	2.9	3.1	1.4	1.3	7.0	0.3		0.2	0.1		
1661–1673	50.8	10.1	1.11	39.6	9.2	5.7	10.9	8.8	7.6	7.6	2.3	1.2	4.3		1.1		0.2	1.5	tr		
1655–1661	57.0	12.9	0.63	58.1	5.7	4.8	0.9	11.0	6.5	4.0	1.9	2.0	3.4	tr		0.1	0.8	0.6	0.1	0.1	
1649–1655	58.6	13.2	5.40	33.2	2.2	4.2	13.1	14.1	4.2	12.3	1.4	0.6	1.9	11.6		tr		1.2	tr		tr

Elevation (ft.)	Total Wt. Brom. Hvs. (gm.)	Wt. –60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of –60+100 mesh heavy fraction															
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Bar.	Hyp.	Hem.	Zir.
FRENCH HILL: White Channel gravel																			
1873–1885	80.0	7.0	0.42	30.1	2.0	3.3	29.1	5.1	7.0	5.8	5.3	6.2	0.6	0.4		0.6		4.4	0.1
1861–1873	140.1	14.5	0.71	24.8	2.4	8.6	35.6	14.3	3.7	2.6	3.7	3.2	0.8			0.1	tr	0.2	
1849–1861	148.6	23.2		24.9	4.5	5.7	37.3	3.9	4.9	4.2	4.4	2.8	4.9	1.3		tr	0.8	0.3	0.1
1837–1849	133.2	13.7	2.83	19.8	6.3	6.4	27.9	18.8	0.9	2.8	2.6	6.1	0.7	4.3	1.5	1.4	tr	0.4	0.1

TABLE XI (*conc.*)

Elevation (ft.)	Total Wt. Brom. Hvs. (gm.)	Wt. −60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of −60+100 mesh heavy fraction																	
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Hyp.	Zir.	Tour.	Kyan.	Trem.	Jaro.
CRIPPLE HILL: White Channel gravel																					
1512–1524	19.3	4.3	0.90	62.6	6.1	5.0		16.0	1.6	1.3	2.3	0.1		1.8	3.0		0.2				
1500–1512	16.4	4.6	1.90	59.9	9.9	6.2		10.6	2.5	3.5	6.9	0.1		tr	0.1		0.3				
1488–1500	38.1	13.9	1.13	37.9	36.9	2.0	0.2	3.8	2.0	12.7	3.2	0.2	0.2	0.6			0.3				
1476–1488	25.9	7.3	1.62	55.8	11.3	3.0	0.1	15.0	0.5	5.5	5.0	2.2		1.1	0.1		0.4				
1464–1476	24.1	6.0	1.18	62.3	8.5	5.7	tr	12.0	1.0	1.5	5.5	2.0		0.6			0.5	0.2		0.2	
1452–1464	9.1	1.5	1.12	70.3	3.1	8.7		4.6	0.7	2.0	6.6	1.6		1.9		0.4	0.1	tr			
1440–1452	16.7	2.0	25.99	57.1	3.9	8.9	0.4	18.1	0.3	0.1	6.7	1.1	0.4	3.2	0.6		0.1		0.1		tr
1434–1440	8.8	1.8	3.25	38.4	4.1	9.6	tr	27.5	0.4	0.7	4.0	4.1	0.4	2.6	8.1		0.1				
1428–1434	21.1	5.0	25.55	38.9	1.0	2.6		40.6	0.4	0.3	3.8	5.8		0.6	5.5		0.1	0.4			

Elevation (ft.)	Total Wt. Brom. Hvs. (gm.)	Wt. −60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of −60+100 mesh heavy fraction																
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Bar.	Hyp.	Zir.	Clpyrox.	Trem.
BUNKER HILL: White Channel gravel																				
1869.5–1875	354.3	45.3	0.59	37.2	2.0	4.9	8.2	5.6	21.9	15.1		4.6					0.5			
1860–1869.5	28.6	5.0	0.02	25.6	2.4	34.2	1.4	2.6	13.0	2.2	0.9	8.2	4.6	tr	0.1	0.5	3.8	0.5		
1848–1860	469.3	59.1	1.25	29.2	2.6	6.2	11.1	4.0	22.6	19.1	0.4	4.2	0.3		0.1	0.1		tr	0.1	
1836–1848	401.5	35.0	3.04	36.5	2.3	6.5	7.5	2.7	18.1	16.7	0.2	5.7	3.6		tr	0.2		tr		
1824–1836	244.0	31.7	10.95	52.0	1.3	6.2	3.9	2.4	14.4	11.5		6.7	0.3	0.4	0.1		0.4		0.1	0.3

Elevation (ft.)	Total Wt. Brom. Hvs. (gm.)	Wt.−60+100 Brom. Hvs. (gm.)	Gold (mg./cu.ft.)	Weight per cent of −60+100 mesh heavy fraction																		
				Epid.	Ilmen.	Sphe.	Goeth.	Musc.	Actin.	Mag.	Rutile	Apat.	Hbl.	Garn.	Anat.	Bar.	Hyp.	Zir.	Tour.	Chlor.	Pyr.	Jaros.
MONTE CRISTO HILL: White Channel gravel																						
1693–1701	57.1	15.3	0.26	51.6		9.0	1.3	5.0	16.8	5.6	1.0	5.6	1.4	1.0	tr	0.3	0.1					
1681–1693	46.6	19.5	0.63	31.8	1.0	3.3	1.4	35.0	16.4	2.4	0.6	4.8	1.2	tr	0.2	1.2	0.7				tr	
1669–1681	64.4	14.7	0.70	41.6	1.3	6.5	5.9	6.7	18.9	9.6	0.5	5.5	2.3	tr		0.1		tr		1.0	0.1	
1657–1669	82.8	18.0	0.27	45.5	0.8	3.0	9.6	3.2	8.3	20.9	0.5	3.5	2.4	tr	tr	1.9	0.4				tr	tr
1645–1657	49.4	13.3	0.25	56.3	0.4	4.0	3.3	9.1	9.6	4.0	1.0	7.2	1.8	1.4	0.2	1.6	tr	0.1			tr	
1633–1645	59.1	16.0	0.31	53.4	1.3	6.3	1.9	8.0	17.2	1.6	0.8	5.5	2.6	tr	tr	1.2		0.1			tr	
1621–1633	49.2	10.1	0.82	75.7	2.3	3.7	0.2	3.4	3.6	1.3	1.4	7.3	0.3	tr	tr	0.8					tr	
1613–1621	34.5	10.1	4.83	71.6	2.4	4.4	tr	3.6	6.2	3.2	2.0	3.5	0.8	0.1	0.2	0.8		tr	tr		0.2	

Abbreviated mineral names:

actinolite	actin.
anatase	anat.
andalusite	andal.
apatite	apat.
barite	bar.
biotite	biot.
chlorite	chlor.
chromite	chro.
clinopyroxene	clyprox.
clinozoisite	clzois.
dolomite	dolom.
epidote	epid.
garnet	garn.
goethite	goeth.
hematite	hem.
hinsdalite	hinsdal.
hornblende	hbl.
hypersthene	hyp.
ilmenite	ilmen.
jarosite	jaros.
kyanite	kyan.
leucoxene	leuc.
magnetite	mag.
martite	mart.
muscovite	musc.
olivine	oliv.
pyrite	pyr.
sphene	sphe.
spinel	spin.
tourmaline	tour.
tremolite	trem.
vesuvianite	ves.
zircon	zir.
zoisite	zois.

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GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES

Mineral Name	Colour	Lustre	Shape	Crystal System	Optic sign and 2V	Refractive Indices	Birefringence	Cleavage	Extinction	Specific gravity	Hardness	Remarks
Actinolite	Light to medium green, bluish green	Vitreous	Euhedral to subhedral elongated prisms	Monoclinic	Negative 2V = 80°	α = 1.614 β = 1.630 γ = 1.641	Strong	Perfect (110)	Inclined 15°-20°	3.0-3.3	5.0	Pleochroic, usually some shade of green, prismatic; common in 1.2 mag. fraction
Anatase	Colourless, white, bluish grey, blue	Adamantine, vitreous, sub-metallic	Occasionally euhedral, generally anhedral, irregular	Tetragonal	Uniaxial negative	ω = 2.554 ϵ = 2.493	Strong	Euhedral grains, perfect (001) and (111)	–	3.9	5.5-6.0	Bluish grains, usually euhedral. anhedral grains often aggregated with quartz; common in 1.2 non-mag. fraction
Andalusite	Colourless to grey black	Vitreous	Subhedral, prismatic	Orthorhombic	Negative 2V = 86°	α = 1.634 β = 1.639 γ = 1.643	Weak	Perfect (110)	Straight	3.2	7.5	Frequently black or grey due to presence of carbonaceous inclusions; found in 1.2 non-mag. fraction
Apatite	Colourless, white, occasionally bluish and black	Vitreous to dull	Anhedral, rarely euhedral, irregular to prismatic	Hexagonal	Uniaxial negative	ω = 1.649 ϵ = 1.644	Generally weak, but occasionally moderate	Perfect (0001)	Straight	3.23	5.0	Inclusions of black (carbonaceous?) material sometimes present, as are bubbles of fluid or gas; found mainly in 1.2 mag. fraction; occasionally fluoresces light orange under short wave ultraviolet light
Barite	Colourless, white, yellowish, and bluish white	Vitreous, pearly, dull	Anhedral, irregular, occasionally prismatic	Orthorhombic	Positive 2V = 37°	α = 1.636 β = 1.637 γ = 1.648	Moderate	Perfect (001) and (110)	Straight on prismatic grains	4.5	3.0	Generally irregular grains with moderate birefringence, soft, often colourless to white but occasionally brownish and bluish white; rarely fluoresces faint bluish white in ultraviolet light; found chiefly in 1.2 non-mag. fraction
Biotite	Dark brown	Vitreous, resinous, or dull	Tabular, pseudo-hexagonal	Monoclinic	Negative 2V small	α = 1.584 β = 1.648 γ = 1.648	Strong	Perfect basal (001)	Straight or slightly inclined	2.9-3.1	2.5-3.0	Dark brown, platey, occasionally with pleochroic haloes; found mostly in the 1.2 mag. fraction
Cerussite	Yellowish	Vitreous	Irregular massive	Orthorhombic	Negative 2V small	α = 1.804 β = 2.076 γ = 2.078	Strong	Distinct (110) and (121)	–	6.5	3.0-3.5	Found in the 1.2 non-mag. Frantz fraction
Chlorite	Medium to dark green	Pearly to greasy	Scaly, platy, irregular	Monoclinic	Positive 2V small	α = 1.598 β = 1.600 γ = 1.602	Weak	Perfect (001)	Straight or slightly inclined	2.9	2.5	Sometimes contains inclusions of magnetite; found in 0.2 and 1.2 mag. fractions
Chromite	Black	Metallic to sub-metallic	Euhedral octahedrons	Isometric	Opaque	–	–	–	–	4.5	5.5	Found in 0.2 mag. fraction, opaque
Clinopyroxene (Augite)	Dark green to brown, colourless	Vitreous	Anhedral, irregular, subhedral prismatic	Monoclinic	Positive 2V = 60°	α = 1.69 β = 1.68-1.71 γ = 1.72	Strong	Good (110)	Inclined 35°-50°	3.2	5.0-6.0	Occurs in 0.2 and 1.2 mag. fractions, often contains black inclusions; most clinopyroxene is probably augite but some diopside may be present
Clinozoisite	Colourless	Vitreous	Subhedral, elongated	Monoclinic	Positive and negative 2V = 65°	α = 1.72 β = 1.71-1.73 γ = 1.73	Moderate	Perfect (001)	Inclined 2°-15°	3.35	6.5	Found in 1.2 mag. and non-mag. fractions, lower 2V than in epidote
Copper, native	Green, reddish brown	Dull	Rounded to subangular, flat	Isometric	Opaque	–	–	–	–	8.8	2.5-3.0	Surface pitted and mottled rust brown, grey, and pale green; some calcite present in copper, ductile, fresh surface is shiny copper yellow
Dolomite	Colourless, white, or buff	Vitreous to dull	Anhedral, irregular, massive	Rhombohedral (trigonal)	Uniaxial negative	ω = 1.681 ϵ = 1.500	Very strong	Perfect (1011)	Straight	2.9	3.5-4.0	Powder effervesces in HCl; found in 1.2 non-mag. fraction
Epidote	Yellow to yellowish green	Vitreous	Euhedral to subhedral, prismatic	Monoclinic	Negative 2V = 80°-90°	α = 1.73 β = 1.76 γ = 1.77	Strong	Good (001)	Straight or slightly inclined	3.3	6.0-7.0	Found in 1.2 mag. fraction; weakly pleochroic
Fluorite	Colourless, light purple	Vitreous	Irregular, massive	Isometric	Isotropic	1.434	–	Perfect (111)	–	3.18	4.0	Commonly found in 1.2 non-mag. fraction
Garnet	Light to dark pink, red, brown, and orange	Vitreous	Dodecahedrons and irregular grains	Isometric	Isotropic	1.78-1.80	–	–	–	3.80-4.25	7.0	Found in 0.2 and 1.2 mag. fractions, some grossularite but mostly spessartite, occasionally almost black due to presence of inclusions
Goethite	Medium to reddish brown	Sub-metallic to earthy	Cubic after pyrite	–	Opaque	–	–	–	–	3.9-4.0	5.0	Generally forms pseudomorphs after pyrite, most goethite is a mixture of hematite, goethite, limonite, sometimes with a core of pyrite, found in 0.2 and 1.2 mag. fractions
Gold	Golden yellow	Metallic	Flakes, rounded grains, subhedral to angular grains	Isometric	Opaque	–	–	–	–	15.5-19.4	2.5-3.0	Soft, malleable, mostly yellow, sometimes coated black; found in 1.2 non-mag. fraction
Hematite	Reddish brown, black	Sub-metallic, dull	Irregular masses	Rhombohedral (trigonal)	Opaque	–	–	–	–	5.2	5.0	Some pseudomorphous after pyrite, gives red powder on crushing; found in 0.2 and 1.2 mag. fractions
Hinsdalite	Colourless	Vitreous	Anhedral irregular grains	Rhombohedral (trigonal)	Uniaxial positive, may also be biaxial with small 2V	ω = 1.671 ϵ = 1.689	Moderate	Perfect (0001)	Straight	3.65	4.5	$(2PbO.3Al_2O_3\ P_2O_5.2SO_3.6H_2O)$, contains small blue inclusions, identified by X-ray diffraction; found in 1.2 non-mag. fraction
Hornblende	Dark green	Vitreous	Euhedral to subhedral, elongated prismatic	Monoclinic	Negative 2V = 60°-90°	α = 1.66 β = 1.67 γ = 1.68	Moderate	Good (110)	Inclined 15°-25°	3.31	5.0-6.0	Strongly pleochroic; found in 0.2 mag. fraction
Hypersthene	Light brown to green	Vitreous	Generally euhedral, prismatic	Orthorhombic	Negative 2V = 80°-90°	α = 1.69 β = 1.70 γ = 1.705	Moderate	Fair (110)	Straight	3.45	5.0-6.0	Usually forms good crystals, often with inclusions of magnetite and ilmenite, pleochroic; found in 0.2 and 1.2 mag. fractions
Ilmenite	Black	Metallic	Flattened, prismatic, and irregular grains	Rhombohedral (trigonal)	Opaque	–	–	–	–	4.5-5.0	5.0-6.0	Occurs as black shiny grains, sometimes enclosed by leucoxene; found in 0.2 and 1.2 mag. fraction
Jarosite	Light tan	Dull	Irregular anhedral masses	Rhombohedral	Uniaxial negative	ϵ = 1.72 ω = 1.82	Very strong	Distinct (0001)	Straight	3.2	3.0	Found in 1.2 mag. fraction
Kyanite	Colourless, bluish	Vitreous, pearly	Elongate blades with irregular terminations	Triclinic	Negative 2V = 82°	α = 1.71 β = 1.72 γ = 1.73	Moderate	Perfect (100), Fair (010)	Inclined 30° on (100)	3.6	4.0-7.0	Elongated grains, often bluish colour, hardness 4 to 5 on (100) parallel to length of crystal and about 7 on (010); occurs in 1.2 non-mag. fraction
Leucoxene	White, light grey, or creamy	Dull, porcelanous	Irregular aggregates, microcrystalline	Amorphous	Opaque or semi-opaque	High	Strong	–	–	4.0	3.0-4.0	Occurs as rounded irregular masses, probably microcrystalline sphene and anatase alteration products associated with ilmenite; found in 1.2 mag. and non-mag. fraction
Limonite	Yellowish brown	Earthy	Irregular grains or powdery aggregates	Amorphous	Opaque to translucent	–	–	–	–	3.8	4.0	Found in 0.2 and 1.2 mag. fractions, sometimes pseudomorphous after pyrite
Magnetite	Black to irridescent blue	Metallic	Octahedrons, dodecahedrons, and irregular grains	Isometric	Opaque	–	–	–	–	5.1	5.50-5.65	Blue iridescent octahedrons, common in chlorite schists; found in 0.2 mag. fraction
Wad manganese	Black	Earthy	Irregular masses	Amorphous	Opaque	–	–	–	–	4.0	3.0	Very soft, gives no X-ray diffraction pattern; found in 1.2 mag. fraction
Martite	Reddish black	Sub-metallic	Octahedral or dodecahedral, possibly pseudo- morphous, after magnetite	Isometric	Opaque	–	–	Octahedral parting	–	5.0	6.0-7.0	Pseudomorphous after magnetite, found in 0.2 mag. fraction
Micro meteorite	Black	Metallic	Spherical	–	Opaque	–	–	–	–	5.0	5.5	Metallic shiny magnetic balls less than 0.1 mm in diameter, some have been identified as magnetite, found in 0.2 mag. fraction
Monazite	Colourless, light yellow, yellowish brown	Vitreous to resinous	Anhedral irregular	Monoclinic	Positive 2V = 10°	α = 1.79 β = 1.80 γ = 1.84	Strong	Good (001)	Straight	5.0	5.0	Found in 1.2 mag. fraction
Muscovite (sericite)	Colourless, light green, rusty	Vitreous to pearly	Platey grains or tabular crystals	Monoclinic pseudohexagonal	Negative 2V = 30°-40°	α = 1.558 β = 1.595 γ = 1.601	Strong, but weak in cleavage (001) plates	Perfect (001)	Straight or inclined 2° or 3°	2.9	2.5-3.0	Sometimes with iron oxide stain and occasionally inclusions of zircon, aggregated with other heavy minerals; found in 1.2 mag. fraction and less often in 1.2 non-mag. fraction
Olivine	Colourless to grey	Vitreous to resinous	Prismatic, anhedral, or subhedral	Orthorhombic	Positive 2V = 88°-90°	α = 1.65 β = 1.66 γ = 1.68	Strong	Poor	Straight	3.3	6.5-7.0	Grains often contain black inclusions, found in 1.2 mag. fraction
Pyrite	Yellow	Metallic splendent, some tarnished	Cubes, pyritohedrons, as much as ½" square	Isometric	Opaque	–	–	Poor	–	5.0	6.0-6.5	Occurs in fine-grained masses and also as crystals as much as ½" square, coarse crystals are often covered with a dark to reddish brown tarnish, crystals are often striated; alters to limonite, goethite, and hematite; is found in 1.2 non-mag. fraction
Rutile	Black, reddish brown, red, reddish orange, yellowish	Metallic, adamantine, vitreous	Elongated prisms, subhedral to euhedral	Tetragonal	Uniaxial positive	ϵ = 2.90 ω = 2.61	Extreme	Good (110) and (100)	Straight	4.2	6.0-6.5	Crystals ranging from yellowish to black, usually striated, weakly pleochroic, found in 1.2 non-mag. fraction
Scheelite	White	Vitreous	Anhedral grains	Tetragonal dipyramidal	Uniaxial positive	ϵ = 1.935 ω = 1.919	Moderate	Good (101)	Straight	6.1	4.5-5.0	Fluoresces bluish white under ultraviolet light; found in 1.2 non-mag. fraction
Sphalerite	Dark amber brown	Resinous to dull	Irregular grains	Isometric	Isotropic	n = 2.37	–	Perfect (110)	–	4.0	3.5-4.0	Usually in brown aggregates; found in 1.2 mag. fraction
Sphene	Grey, white, buff, brown	Vitreous, resinous, dull	Irregular, occasionally euhedral prismatic, diamond or wedge shaped	Monoclinic	Positive 2V - 27°	α = 1.90 β = 1.91 γ = 2.01	Strong	Good (110)	–	3.5	5.0-5.5	Total extinction seldom observed, weak pleochroism; often found aggregated with epidote, mainly in 1.2 non-mag. fraction
Spinel	Black	Vitreous	Irregular grains	Isometric	Isotropic	n = 1.718	–	Poor (111)	–	3.6	8.0	Fragments exhibit conchoidal fracture; found in 1.2 mag. fraction
Staurolite	Orange	Vitreous	Anhedral, irregular	Orthorhombic	Positive 2V = 88°	α = 1.71 β = 1.74 γ = 1.75	Moderate	Good (010)	Straight	3.7	7.00-7.75	High relief with moderate pleochroism; found in 1.2 mag. fraction
Topaz	Colourless	Vitreous	Prismatic euhedral	Orthorhombic	Positive 2V = 60°	α = 1.61 β = 1.62 γ = 1.63	Weak	Good (001)	Straight	3.58	8.0	Colourless crystals, some with bubble (gas?) inclusions, also zircon and plagioclase inclusions, high lustre; found in 1.2 mag. fraction
Tourmaline	Black, greyish green, or brown	Vitreous, resinous	Prismatic, euhedral to subhedral, striated	Rhombohedral (trigonal)	Uniaxial negative	ϵ = 1.65 ω = 1.69	Strong	Imperfect (1120) and poor (1011)	Straight	3.10	7.00-7.75	Strong pleochroism, black variety most common, cross-section usually rounded triangle; found in 1.2 mag. fraction
Tremolite	Colourless	Vitreous	Prismatic, elongated, euhedral	Monoclinic	Negative 2V = 80°	α = 1.61 β = 1.62 γ = 1.63	Strong	Good (110)	Inclined 15°-20°	3.10	5.0-6.0	Usually found in 1.2 non-mag. fraction
Vesuvianite (idocrase)	Colourless	Vitreous	Prismatic irregular	Tetragonal	Uniaxial negative	ϵ = 1.705 ω = 1.713	Weak	–	Straight	3.40	6.5	Sometimes biaxial with 2V = 5°, shows anomalous blue interference colours; found in 1.2 non-mag. fraction
Zircon	Colourless, grey, or brownish pink	Adamantine or vitreous	Euhedral, prismatic, bipyramidal, occasionally rounded	Rhombohedral (trigonal)	Uniaxial positive	ϵ = 1.99 ω = 1.94	Strong	Imperfect (110)	Straight	4.7	7.5	Usually good crystals, fluoresces orange under ultraviolet light, occasionally spherical and pink; found in 1.2 non-mag. fraction
Zoisite	Colourless	Vitreous	Prismatic, euhedral, irregular	Orthorhombic	Positive 2V = 30°-60°	α = 1.700 β = 1.703 γ = 1.718	Moderate	Perfect (010)	Straight	3.31	6.0-6.5	Anomalous deep blue interference colours; found in 1.2 non-mag. fraction

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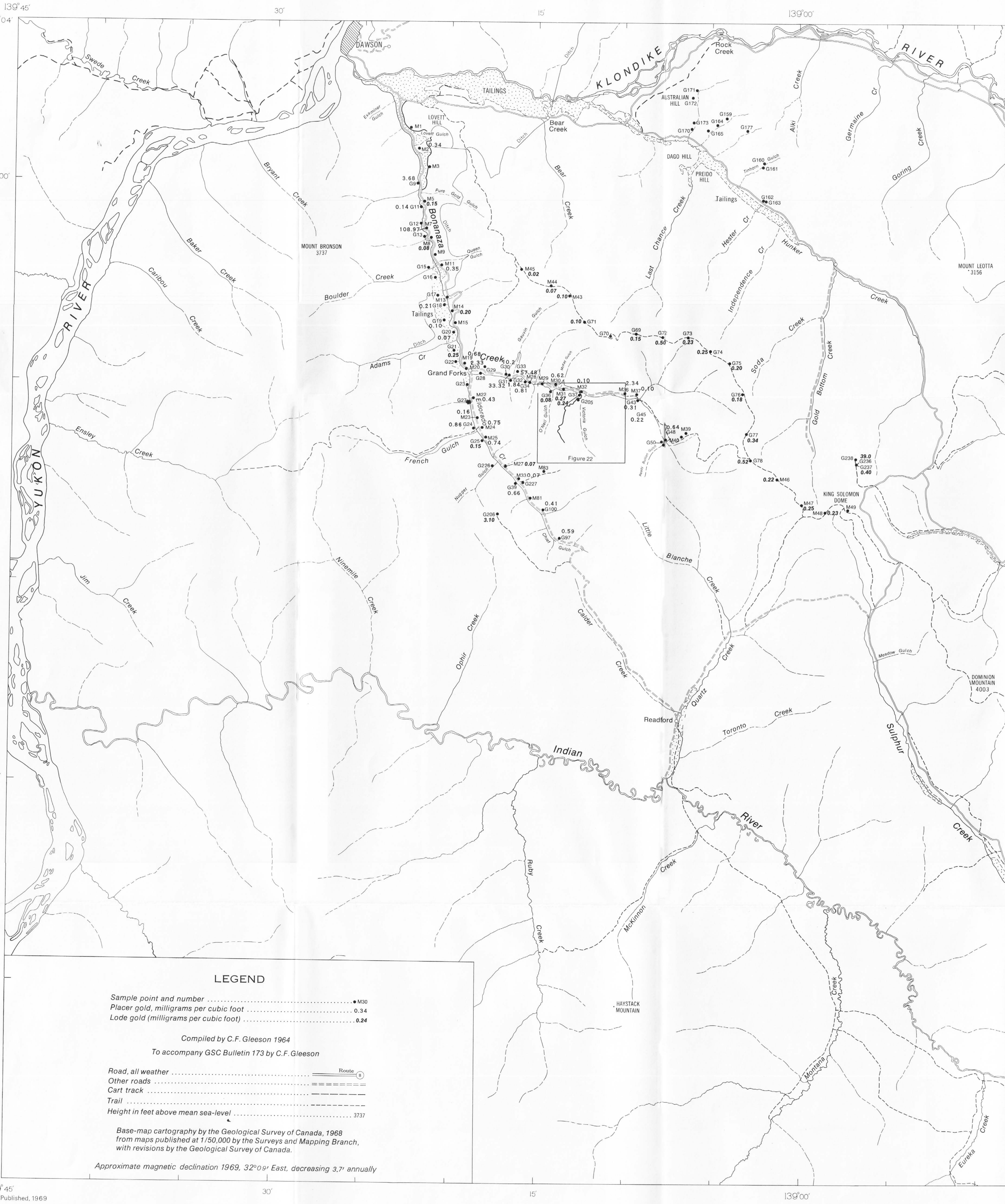
Table X. Mineralogy of heavy minerals Klondike Area, Yukon Territory.

To accompany GSC Bulletin 173 by C.F. Gleeson

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES



Sample number	Goethite	Muscovite	Apatie	Epidote	Jarosite	Ilmenite	Pyrite	Barite	Fluorite	Magnetite	Topaz	Tourmaline
M1	<25	<25	<5	>10		<1		>5		<1		
M2	25-50	25-50	5-10	3-10		<1		>5		>5		
M3	<25	<25	<5	<5		<1		1-5		1-5		>3
M5	>50	<25	5-10	5-10	1-5	<1		1-5		1-5		
M7	<25	<25	5-10	>10		<1		<1		>5		
M8	>50	<25	<5	5-10	<1	<1		>5		<1		
M9	25-50	25-50	<5	<5	>5	<1	<1	<1		1-5		
M11	>50	<25	<5	<5	1-5	<1	1-5	1-5		<1		
M13	25-50	25-50	<5	<5		<1		1-5		1-5		1-3
M14	25-50	25-50	5-10	>10		<1	<1	1-5		<1		
M15	<25	<25	<5	<5		<1	<1	>5		1-5		
M16	<25	25-50	>10	<5		<1	<1	1-5		1-5		
M19	25-50	25-50	<5	>10		<1		1-5		<1		
M20	<25	<25	<5	<5		1-5		<1		>5		
M22	25-50	25-50	>10	<5		<1				<1		
M23	25-50	25-50	<5	>10			<1	<1		<1		
M24	<25	>50	>10	<5		<1				<1		
M25	25-50	>50	>10			<1	<1	<1		<1		
M27	25-50	>50	>10	<5	1-5	<1	<1	1-5		<1		
M28	<25	<25	5-10	5-10	1-5	>5		<1		>5		
M29	<25	25-50	5-10	<5	>5	<1	<1	<1		<1		
M30	>50	25-50	>10	<5				<1		>5		
M31	<25	<25	>10			<1		>5		1-5		
M32	<25	<25	>10	<5		<1		>5		<1		
M33	<25	>50	<5	<5		<1	<1	>5		1-5		
M36	25-50	<25	<5	<5		1-5	<1	<1		>5		
M37	>50	<25	<5	<5	>5	<1	<1	<1		1-5		
M39	<25	>50	<5	<5		1-5		<1		1-5		
M40	>50	<25	<5	5-10	>5	<1	<1			<1		
M43	>50	<25	<5	<5		<1				<1		
M44	<25	25-50	>10	<5		1-5		<1		<1		
M45	25-50	>50	<5	<5		1-5				<1		
M46	<25	<25	<5	>10		<1				<1		
M47	<25	>50	<5			<1				<1		
M48	>50	25-50	<5	<5						<1		
M49	25-50	<25	5-10	5-10		<1				<1		
M81	<25	<25	>10	5-10		<1		<1		<1		
M83	<25	>50	<5			<1				<1		
G9	<25	25-50	5-10	>10		1-5	<1	>5		1-5		<1
G11	>50	<25	<5	5-10	<1	<1		1-5		1-5		
G12	25-50	<25	<5	<5	<1	1-5		<1		>5		
G13	<25	<25	>10	>10		1-5		>5		>5		
G15	25-50	25-50	<5					1-5		1-5		
G16	<25	<25	<5	5-10	>5	<1		>5		1-5		
G17	<25	>50	>10	5-10		1-5		<1		<1		
G18	<25	<25	<5	>10	<1	1-5		>5		1-5		
G19	<25	>50	<5	5-10		<1	<1	>5		<1		
G20	<25	>50	<5	<5		<1		1-5		<1		
G21	<25	>50	<5	>10		<1		<1		<1		
G22	<25	>50	>10	<5		<1	<1	<1		<1		
G23	25-50	>50	<5	>10	<1	<1	<1	<1		1-5		
G24	<25	>50	5-10	>10	<1	<1	<1	1-5		>5		
G25	<25	>50	<5	>10		<1	<1	<1		<1		
G27	<25	>50	>10	<5	1-5			>5		<1		
G28	25-50	>50	<5	<5	1-5	<1	<1	<1		1-5		
G29	25-50	25-50	<5	>10	<1	<1		<1		1-5		
G30	<25	<25	<5	<5		>5	<1			>5		
G31	<25	<25	<5	>10		<1	<1	<1		>5		
G32	<25	>50	<5	>10		<1				<1		
G33	<25	<25	<5	<5		<1	<1	<1		1-5		
G34	<25	>50	<5	5-10		1-5				1-5		
G36	<25	>50	<5	<5	>5	<1		<1		<1		
G37	<25	>50	<5	>10		<1		<1		<1		
G39	<25	25-50	<5	5-10		<1	1-5	>5		<1		
G43	<25	25-50	>10	>10		1-5		1-5		>5		
G45	<25	25-50	5-10	>10		<1	<1	1-5		1-5		
G48	<25	<25	>10	>10	<1	1-5	<1	>5		>5		
G50	25-50	25-50	<5	>10	>5	<1	<1	<1		<1		
G69	>50	<25	<5	<5		1-5	<1	<1		1-5		
G70	>50	25-50	<5	<5		<1		<1		<1		
G71	>50	25-50	<5	<5		<1		<1		1-5		
G72	25-50	>50	<5	<5		<1				>5		
G73	25-50	>50	<5	<5		1-5	<1			1-5		
G74	25-50	<25	<5	>10			<1	<1		>5		
G75	<25	<25	<5	>10			<1	<1		<1		
G76	<25	<25	<5	>10		<1		<1		>5		
G77	25-50	<25	<5	>10		<1				1-5		
G78	>50	<25	<5	>10		<1		<1		1-5		
G97	<25	<25	>10	<5		<1				<1		
G100	>50	<25	5-10	<5			<1	<1		<1		
G159	<25		<5	<5		1-5			1-5	>5	<1	
G160	25-50	<25	<5			1-5			<1	1-5	1-3	
G161	<25	<25				1-5				<1	<1	
G162	25-50	<25			<1	1-5				<1		
G163	<25	<25	<5	<5		>5			<1	1-5	>3	
G164	>50	<25				1-5				<1		<1
G165	>50	<25				<1				<1		
G170	>50		<5			1-5				>5	1-3	
G171	>50	<25		5-10		>5				>5	<1	
G172	25-50			5-10		>5				>5	>3	<1
G173	25-50	<25	<5	<5		>5	<1			>5	<1	
G177	<25		<5			1-5	<1		>5	1-5	<1	>3
G205	<25	>50				<1	<1	1-5		<1		
G206	25-50	<25			>5	<1	<1	>5		<1		
G226	<25	25-50	<5			<1	>5	<1		<1		
G227	<25	>50	<5			<1	1-5			<1		
G236	>50	<25	<5	>10		>5	1-5			<1		
G237	<25		<5	5-10		<1	>5			1-5		
G238	<25		<5	5-10		<1				>5		

Note: Mineral values are in per cent

LEGEND

Sample point and number M30
Placer gold, milligrams per cubic foot 0.34
Lode gold (milligrams per cubic foot) ***0.24***

Compiled by C.F. Gleeson 1964
To accompany GSC Bulletin 173 by C.F. Gleeson

Road, all weather .... Route
Other roads
Cart track
Trail
Height in feet above mean sea-level 3737

Base-map cartography by the Geological Survey of Canada, 1968 from maps published at 1/50,000 by the Surveys and Mapping Branch, with revisions by the Geological Survey of Canada.

Approximate magnetic declination 1969, 32°09' East, decreasing 3.7' annually

Published, 1969

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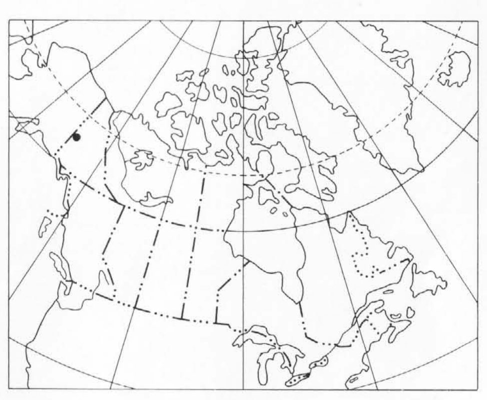

INDEX MAP

Figure 19. Mineral distribution in eluvium, Klondike area, Yukon Territory.

Scale 1:126,720
(1 inch to 2 miles)

Miles 2 0 2 4 6 Miles

Kilometres 2 0 2 4 6 8 10 Kilometres

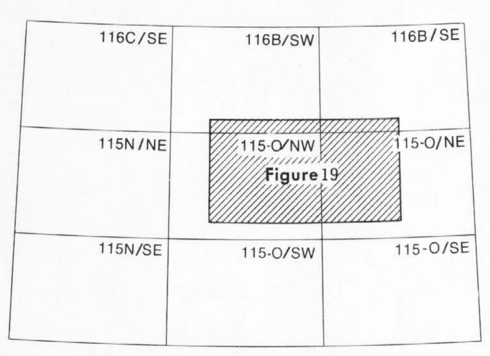

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Figure 19

HEAVY MINERALS IN GULCH, CREEK, RIVER, AND VALLEY GRAVELS

[illegible]

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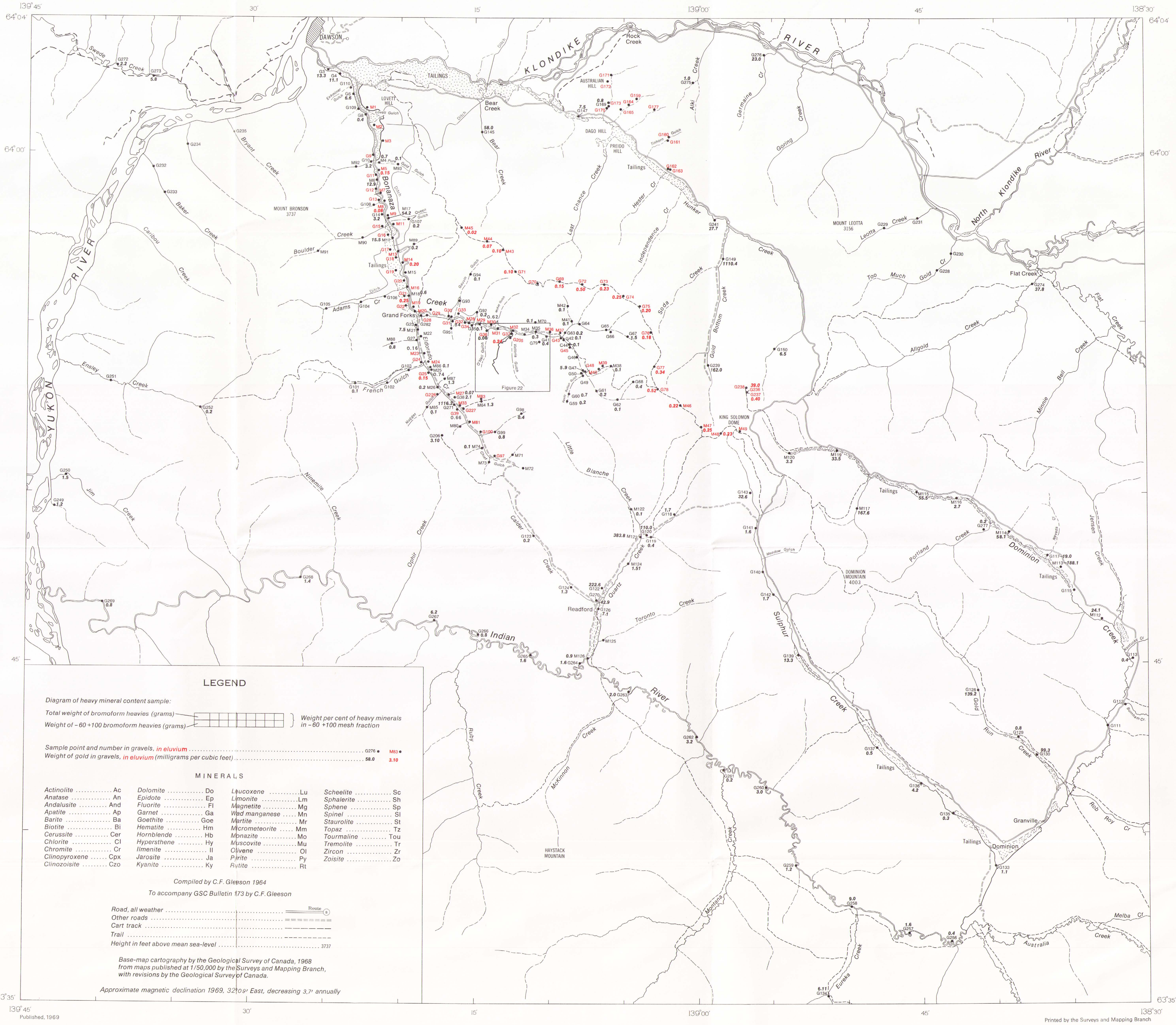


LEGEND

Diagram of heavy mineral content sample:

Total weight of bromoform heavies (grams)

Weight of −60 +100 bromoform heavies (grams)

Weight per cent of heavy minerals in −60 +100 mesh fraction

Sample point and number in gravels, in eluvium .... G276 • M83 •

Weight of gold in gravels, in eluvium (milligrams per cubic feet) 58.0 3.10

MINERALS

Actinolite	Ac	Dolomite	Do	Leucoxene	Lu	Scheelite	Sc
Anatase	An	Epidote	Ep	Limonite	Lm	Sphalerite	Sh
Andalusite	And	Fluorite	Fl	Magnetite	Mg	Sphene	Sp
Apatite	Ap	Garnet	Ga	Wad manganese	Mn	Spinel	Sl
Barite	Ba	Goethite	Goe	Martite	Mr	Staurolite	St
Biotite	Bi	Hematite	Hm	Micrometeorite	Mm	Topaz	Tz
Cerussite	Cer	Hornblende	Hb	Monazite	Mo	Tourmaline	Tou
Chlorite	Cl	Hypersthene	Hy	Muscovite	Mu	Tremolite	Tr
Chromite	Cr	Ilmenite	Il	Olivene	Ol	Zircon	Zr
Clinopyroxene	Cpx	Jarosite	Ja	Pyrite	Py	Zoisite	Zo
Clinozoisite	Czo	Kyanite	Ky	Rutite	Rt		

Compiled by C.F. Gleeson 1964

To accompany GSC Bulletin 173 by C.F. Gleeson

Road, all weather .... Route 8

Other roads

Cart track

Trail

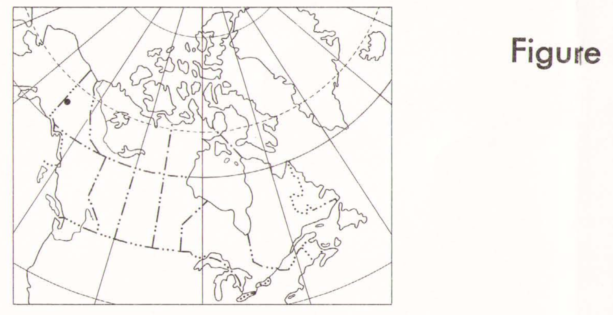
Height in feet above mean sea-level 3737

Base-map cartography by the Geological Survey of Canada, 1968 from maps published at 1/50,000 by the Surveys and Mapping Branch, with revisions by the Geological Survey of Canada.

Approximate magnetic declination 1969, 32°09′ East, decreasing 3.7′ annually

Published, 1969

Printed by the Surveys and Mapping Branch



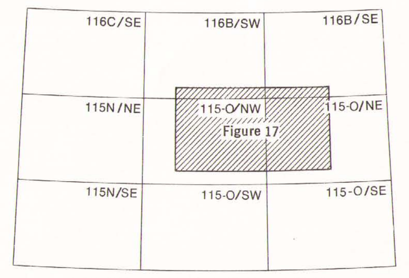
INDEX MAP

Figure 17. Distribution of heavy minerals in gulch, creek, river, and valley gravels, and in eluvium, Klondike area, Yukon Territory.

Scale 1:126,720 (1 inch to 2 miles)

Miles 2 0 2 4 6 Miles

Kilometres 2 0 2 4 6 8 10 Kilometres



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE

HEAVY MINERALS IN ELUVIUM

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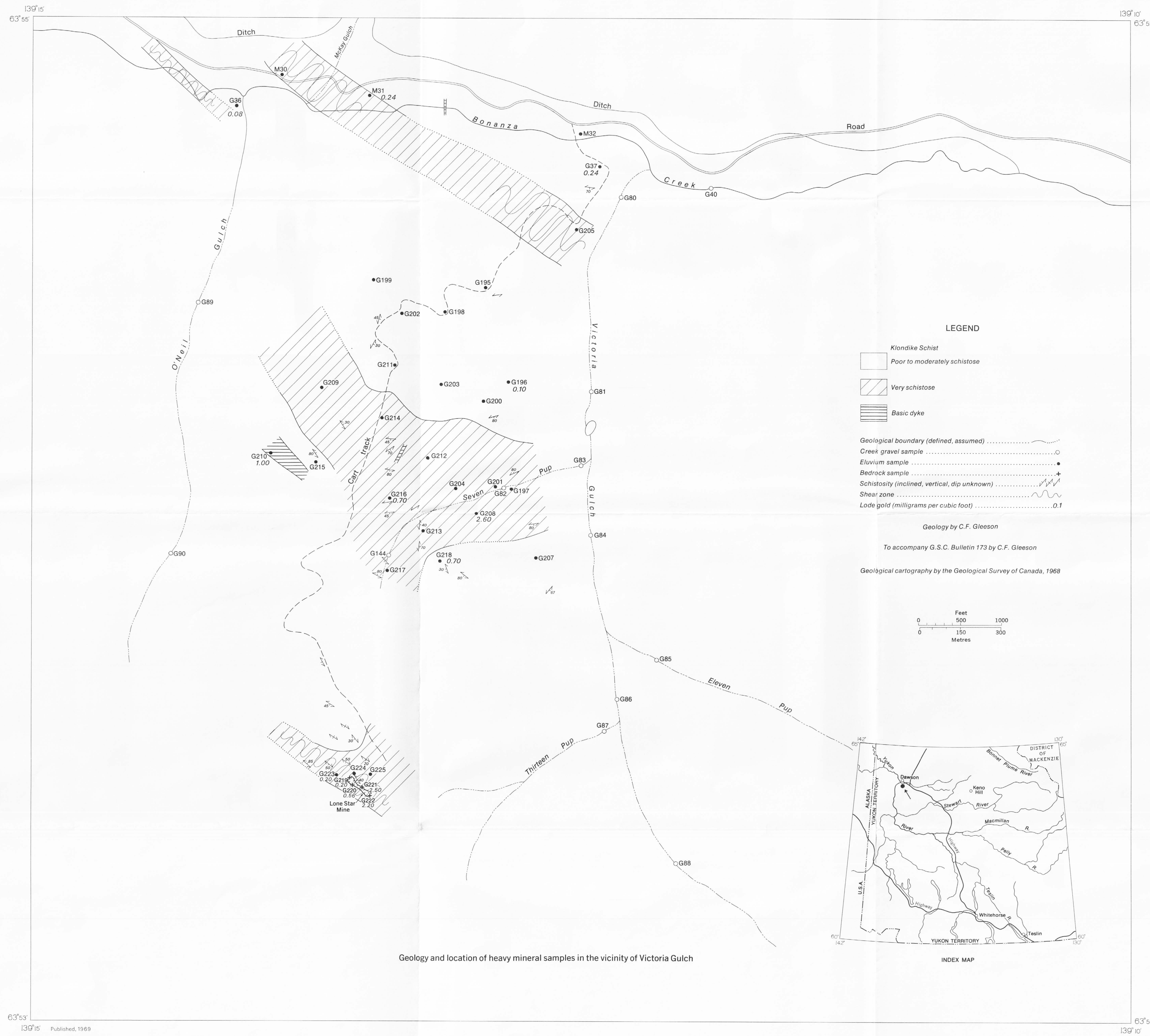

Geology and location of heavy mineral samples in the vicinity of Victoria Gulch

Published, 1969

SAMPLE NUMBER	TYPE OF SAMPLE	TOTAL WEIGHT OF BROMOFORM HEAVIES GRAMS	WEIGHT OF −60+100 BROMOFORM HEAVIES (GRAMS)	GOLD milligrams per cubic feet	Goethite	Muscovite	Epidote	Apatite	Magnetite	Ilmenite	Actinolite	Clinopyroxene	Hypersthene	Hornblende	Martite	Pyrite	Barite	Garnet	Sphene	Biotite	Dolomite	Anatase	Monazite	Rutile	Zircon	Chlorite	Jarosite	Tremolite	Scheelite	Galena	Native Copper	ROCK TYPE	REMARKS
					WEIGHT PER CENT OF HEAVY MINERALS IN −60+100 MESH FRACTION																												
G195	ELUVIUM	123.9	15.1		26.0	67.0		3.9	0.2	1.1		tr.	0.1	tr.	tr.		1.3	0.4							tr.							Klondike schist	Moderately schistose
G196		33.8	4.6	0.1	53.3	4.9	3.3	4.3	4.3	2.5	0.7	tr.	19.8		0.2		0.4	0.3	1.6						tr.								
G198		45.9	6.9		55.0	31.5		0.8	0.6	0.2		tr.	3.2	5.7	tr.		2.2		0.8						tr.								
G199		20.6	5.2		12.6	17.3	0.6	1.7	3.1	2.6	3.3	tr.	23.0	31.5	tr.		0.4	0.3	3.6						tr.								
G200		40.6	8.0		39.7	52.7		1.7	0.5	1.4		tr.	2.4	1.5	0.1																		
G202		42.1	3.8		54.7	35.5		2.5	1.1	0.8	0.3	0.2	1.8	tr.	0.1		2.5	tr.	0.4	0.1					tr.								
G203		74.6	12.6		34.2	39.1	1.4	2.7	2.3	0.8	tr.	0.1	12.4	5.3	0.1		0.9		0.7														Moderately schistose
G207		104.6	7.2		23.8	40.5	0.5	17.1	0.9	0.2		tr.	3.9	tr.		tr.		tr.		tr.						10.4	2.7					Klondike schist	Moderately schistose-chloritic
G210		62.2	12.5	1.0	10.4	7.6	0.7	12.7	6.0	5.0	0.4	0.2	51.5	3.0				0.3	1.9			0.3			tr.							Basic dyke in Klondike schist	
G211		70.8	4.8		42.3	24.2	0.6	25.6	4.3	0.3	0.6	0.2	1.3	0.3					0.3						tr.							Klondike schist	Moderately schistose
G215		373.5	13.5		4.2	37.2	0.3	15.6	0.3	0.2	22.4	tr.	0.2	3.2					16.4	tr.													
G218		65.9	3.3	0.07	30.5	17.5	0.3	39.9	0.6	1.0	0.3	0.1	4.1	3.9			0.4		1.4	tr.													
G36		45.6	10.4	0.08	0.9	70.2	0.6	tr.	0.2	tr.			tr.	tr.			0.1		0.8			0.1		0.1	tr.		27.0						
G37		91.3	23.7	0.24	2.9	62.7	29.3	1.8	0.6	0.9	0.1		0.3				0.2			0.3					0.1	0.8							
M32	ELUVIUM	114.8	5.4		9.0	9.5	0.3	19.0	0.4	0.5	tr.		0.3				57.8		3.1	0.1					tr.								
Average of 14 samples (G210 not included)		89.1	8.9		27.8	36.4	2.7	9.8	1.4	0.9	2.0	tr.	5.2	4.0	tr.	tr.	4.7	0.1	2.1	tr.		tr.		tr.	tr.	0.8	2.1						Moderately schistose
G197	ELUVIUM	78.6	12.1		39.2	39.0	2.1	12.7	0.5	0.8	2.5	tr.	1.7	tr.	tr.			tr.	1.5						tr.								Very schistose
G201		7.2	1.8		39.1	23.4	0.8	33.2	0.6	0.5	0.8		tr.	1.1				tr.	0.3														
G204		144.2	11.6		29.8	38.8	0.9	28.1	0.3	0.1	0.6	tr.	0.7	tr.	tr.				0.7														
G205		39.6	19.0		2.8	93.0			tr.	0.7			tr.		tr.	tr.	3.5																
G208		72.0	9.2	2.60	36.2	19.1	4.6	21.1	1.1	0.2	4.4	tr.	1.2	1.0		tr.			9.9	tr.							1.2						
G209		41.8	6.1		50.2	5.7	0.8	27.6	1.4	0.5	1.5	tr.	7.3	3.1			0.7		1.2	tr.					tr.								
G212		61.8	9.4		41.1	19.9	0.3	25.6	1.3	0.4	0.6	0.1	3.9	5.3					1.5	tr.													
G213		17.5	3.4		47.9	34.0		11.0	1.2	3.3	0.3	tr.	2.0	tr.						0.3					tr.								
G214		45.5	8.9		85.8	6.6		6.3	0.1	0.9			0.3	tr.																			
G216		85.2	6.8	0.70	36.5	37.4		17.2	1.3	0.3	3.6	tr.	1.6	1.0		tr.			1.1														
G217		21.7	2.3	43.0	20.8	15.7	1.8	8.2	8.5	3.7	0.3	tr.	16.0	2.8	0.1		19.8		1.9						0.4								
M30		11.4	1.3		52.5	28.5	2.1	10.5	5.2	tr.	0.3					tr.	0.3								0.6								
M31		43.0	2.0	0.23	23.8	17.1		13.9	3.0	0.1	19.9		tr.			tr.	18.2					3.8			0.2								
G223		8.7	1.7	0.20	50.3	32.6	3.0	6.7	2.3	2.0			tr.			2.3		tr.	0.8														
G224		64.7	5.7		26.2	59.4		9.8	2.7	0.6			tr.		0.2	tr.	0.4	0.4	0.3						tr.								
G225	ELUVIUM	24.7	2.5		46.5	37.8		7.7	0.3	0.1			tr.		tr.	7.6				tr.													
Average of 16 samples		48.0	6.5		39.3	31.7	1.0	15.0	1.9	0.9	2.2	tr.	2.2	0.9	tr.	0.6	2.7	tr.	1.2	tr.		0.2			0.1		0.1						Very schistose
G219	BEDROCK	19.9	0.9	0.20	21.4	63.7	1.4	4.2	0.6	1.8		tr.	0.3	tr.		3.9			1.5	0.8					0.4								Very schistose from open cut Lone Star mine
G220	BEDROCK	462.9	62.3	0.50	2.6	35.2		6.7	tr.	tr.		tr.	tr.	tr.		51.4		tr.			4.1												
G221	BEDROCK	72.1	14.3	2.50	27.9	63.6		0.9	0.2	2.4						5.0				tr.										tr.			
G222	BEDROCK	54.2	5.0	2.20	29.8	45.0		4.8	0.3	2.3			tr.	tr.	0.1	7.9	9.2						0.6										
Average of 4 bedrock samples		152.3	20.6		20.4	51.9	0.3	4.2	0.3	1.6		tr.	0.1	tr.	tr.	17.1	2.3	tr.	0.4	0.2	1.0		0.1		0.1					tr.		Klondike schist	Very schistose from open cut Lone Star mine
*G206	QUARTZ PILE	104.7	13.9	3.1	31.1	2.3			0.3	0.3		tr.	0.5	0.4		tr.	47.8			tr.					tr.		17.3			tr.		Quartz-barite	Rubble from quartz-barite vein cutting Klondike schist (poorly schistose), Violet deposit open cut
*G236	QUARTZ PILE	855.5	77.9	39.0	54.0	14.3	10.9	0.7	0.3	5.3		5.2	0.7	0.2		4.0			0.4	1.7							2.2			tr.	tr.	Quartz	Rubble from quartz vein, Mitchell deposit-shaft
*G237	SCHIST PILE	380.7	38.5	0.4	10.3	0.2	8.4	7.3	3.4	0.6	0.3	2.5				20.8				0.3	2.0					43.9					tr.	Chlorite schist	Rubble from quartz-chlorite schist, Mitchell deposit-shaft
*G238	BEDROCK	842.1	49.9			8.4	8.0	1.8	14.4	0.5	0.3									60.5						6.1						Quartz-biotite-chlorite schist	Trench, Mitchell deposit - 775 feet north of shaft
G40	CREEK GRAVEL	580.8	69.1	2.75	13.1	7.2	14.6	6.5	23.0	0.3	29.5		2.2				1.4		tr.	0.3				tr.		0.9	0.7	0.3					Bonanza Creek
G80		188.9	3.8	0.42	43.8	4.7	2.8	4.4	13.3	2.5	0.4		8.0			1.2	16.5			0.5						1.9							Victoria Gulch
G81		152.8	5.6	1.25	37.7	16.8	2.5	8.1	10.3	0.7	0.6		7.0				12.1			0.4						3.8							Victoria Gulch
G83		103.6	3.6	7.32	33.9	6.6	6.1	9.2	16.8	1.1	1.0		11.4	1.0			7.6		5.3						tr.				tr.				Seven Pup Victoria Gulch
G82		89.2	12.0	15.47	18.9	9.2	7.3	21.0	5.9	1.2	2.2		22.3	2.0			3.4		3.7	2.5					tr.	0.4							Seven Pup Victoria Gulch
G144		39.1	4.2	12.64	66.6	12.1	3.1	2.8	1.2	1.3	1.8	2.7	3.6			0.2	3.0	0.1						tr.	tr.	1.5			tr.	tr.			Seven Pup Victoria Gulch
G84		271.8	2.9	7.89	38.5	5.9	4.5	9.7	19.8	2.6	0.2		8.0			0.2	7.3		3.3					tr.									Victoria Gulch
G85		88.9	1.9	0.19	43.0	10.1	19.2	7.8	8.6	0.7	tr.		2.6			0.1	4.8	0.2	2.6					0.1	tr.	0.2							Eleven Pup Victoria Gulch
G86		166.2	3.5	8.17	57.5	6.0	4.6	5.4	4.7	0.2	0.1		5.0			1.7	10.8		2.5	0.9						0.6	tr.						Victoria Gulch
G87		39.0	3.6	1.11	37.4	37.9	2.0	5.6	2.5	0.2	tr.		1.0			3.9	5.0		2.1					0.1	0.3	0.5	1.5						Fifteen Pup Victoria Gulch
G88		117.2	4.8	3.33	36.3	25.9	7.3	7.8	1.9	1.3	3.0		7.2			3.9	1.7		2.2	tr.						1.5							Victoria Gulch
G89		343.2	14.1	0.93	42.5	28.6	1.4	7.7	1.6	0.2	1.0		1.4				12.0		1.8					0.2			0.6	1.0					O'Neil Gulch
G90	CREEK GRAVEL	56.1	3.5	0.25	13.0	2.1	43.1	4.5	4.6	1.7	7.0		17.2	1.0		tr.	3.3	0.5	1.0					tr.	1.0								O'Neil Gulch

* For location see Figure 17

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Figure 20. Heavy mineral content of eluvium and creek gravels; and in bedrock from the Lone Star, Violet and Mitchell deposits in the vicinity of Victoria Gulch, Yukon Territory.

GEOLOGICAL SURVEY OF CANADA
DEPARTMENT OF ENERGY, MINES AND RESOURCES

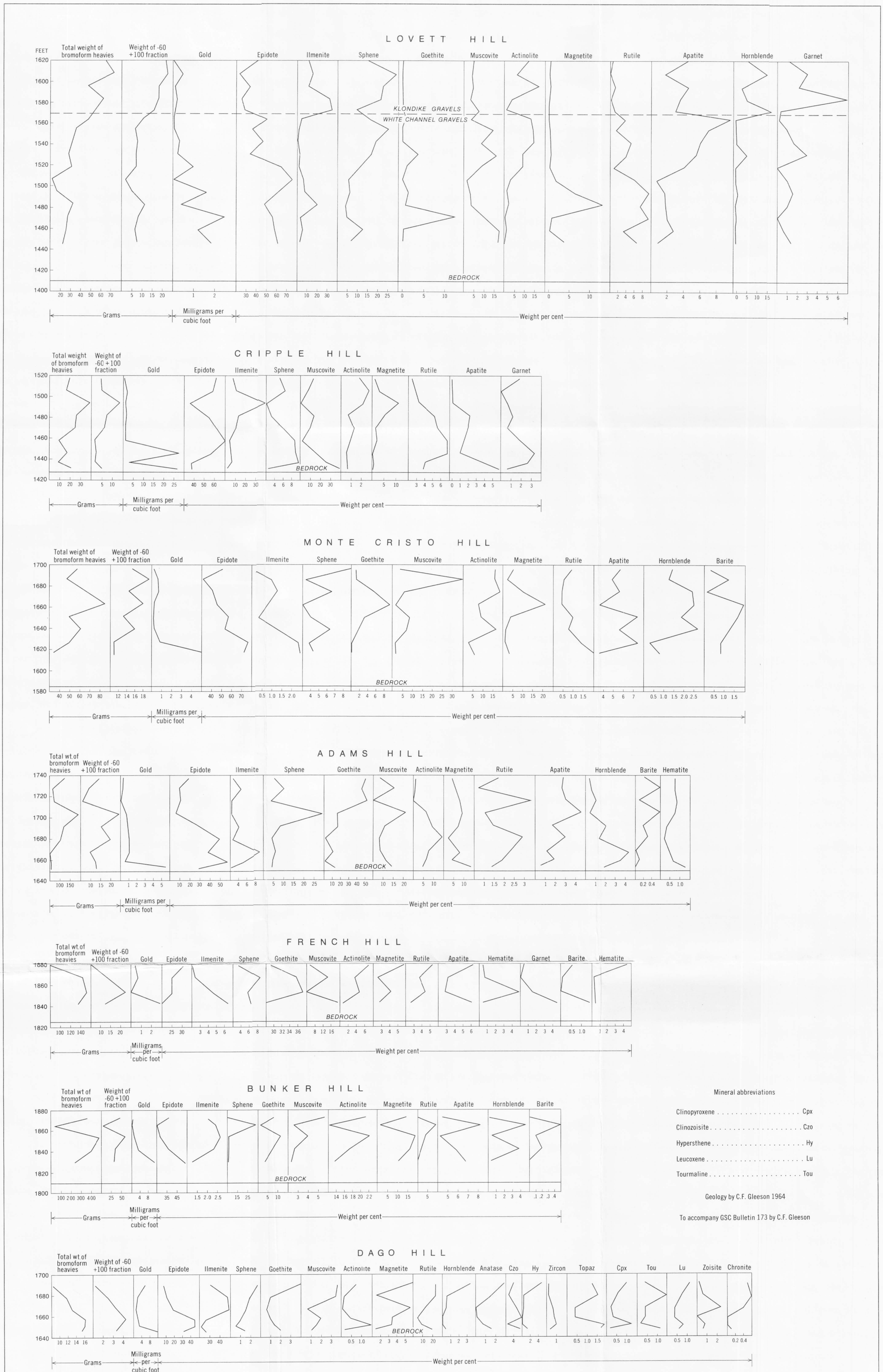

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Figure 18. Graphical representation of the heavy mineral content of the high level gravels, Klondike area, Yukon Territory.

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