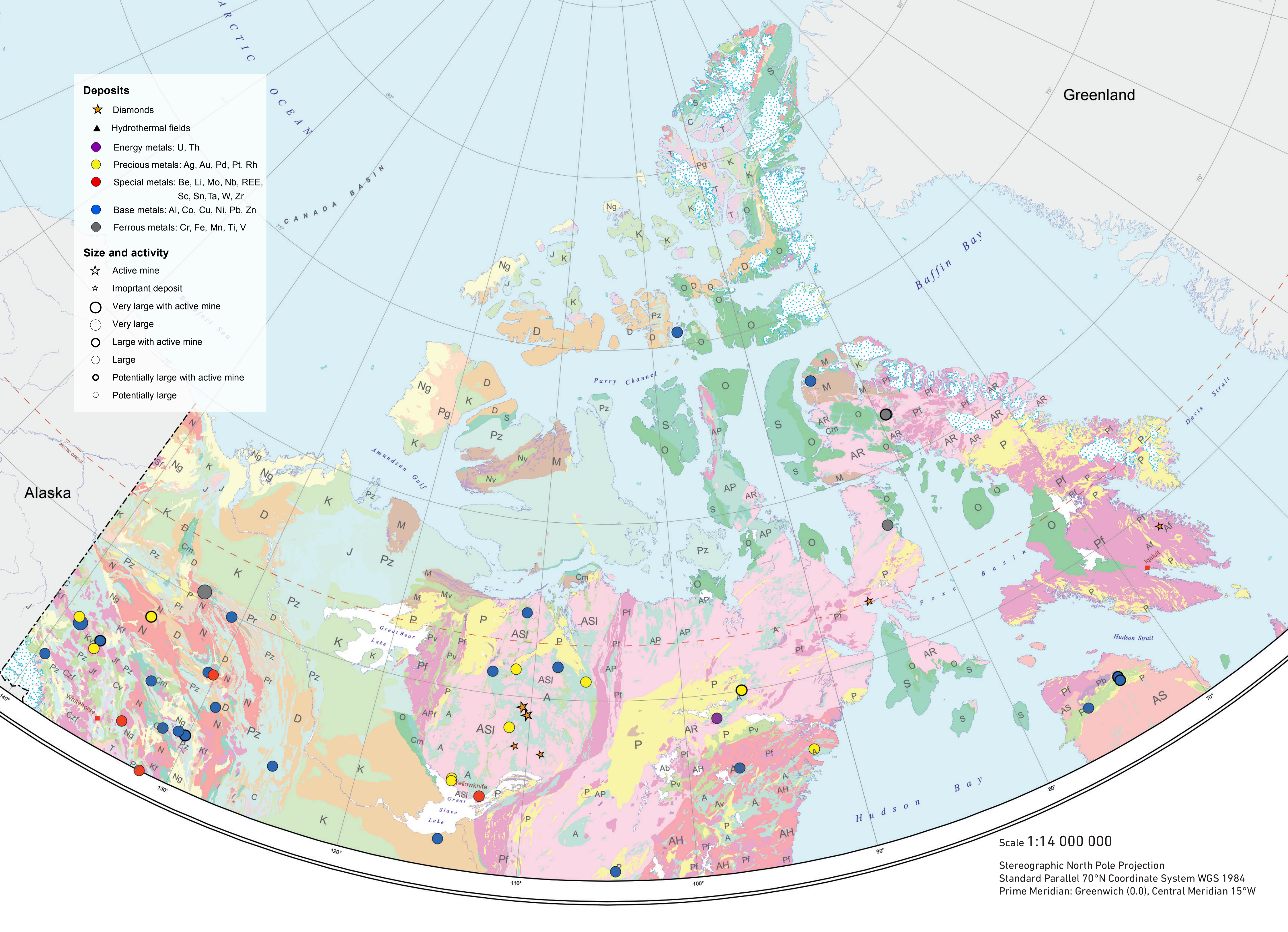

Deposits
Diamonds
Hydrothermal fields
Energy metals: U, Th
Precious metals: Ag, Au, Pd, Pt, Rh
Special metals: Be, Li, Mo, Nb, REE, Sc, Sn,Ta, W, Zr
Base metals: Al, Co, Cu, Ni, Pb, Zn
Ferrous metals: Cr, Fe, Mn, Ti, V
Size and activity
Active mine
Imoprtant deposit
Very large with active mine
Very large
Large with active mine
Large
Potentially large with active mine
Potentially large
Alaska
Greenland
ARCTIC OCEAN
CANADA BASIN
Baffin Bay
Parry Channel
Amundsen Gulf
Davis Strait
Foxe Basin
Hudson Strait
Hudson Bay
Great Bear Lake
Great Slave Lake
Yellowknife
Whitehorse
Iqaluit
Scale 1:14 000 000
Stereographic North Pole Projection
Standard Parallel 70°N Coordinate System WGS 1984
Prime Meridian: Greenwich (0.0), Central Meridian 15°W

CHAPTER 2

CANADA

MINERAL DEPOSITS OF ARCTIC CANADA

Author: J.C. Harrison

Natural Resources Canada, Geological Survey of Canada (GSC)

INTRODUCTION

Geological Setting

This introduction gives a brief overview of the geological setting for the mineral deposits of Arctic Canada (Figure 1). Arctic Canada can be divided into:

- The cratonic roots of the Canadian shield which contains much of the gold, copper, nickel, iron, uranium, rare earth elements and diamonds.

- The bounding Mesoproterozoic to Phanerozoic platform, basins and accreted terrains of the Canadian Cordillera which extend into the High Arctic and contain much of the zinc, lead, gold, silver, copper, molybdenum and tungsten.

Deposits are characterized as small, medium, large, very large and potentially large according to the method described by Eilu et al. (2007) and summarized in the introduction to this volume.

The Canadian shield encompasses four Archean cratons:

The Slave craton is the oldest: it lies to the northwest and is bound by Paleoproterozoic orogens: the Thelon-Taltson orogen to the east and the Wopmay orogen to the west. The Slave craton is divisible into Hadean to Mesoarchean (4.0 to 2.8 Ga) crust primarily located in the west, and Neoarchean crust and supracrustal rocks which dominate the rest of the craton and also unconformably overlie the Mesoarchean and older basement. The Neoarchean is divided into supracrustal rocks consisting of greenstone belts, collectively referred to as the Yellowknife Supergroup, and overlying turbidites. These are succeeded by felsic to intermediate intrusive suites and by mafic dyke swarms that range from 2.2 to 0.73 Ga. The Slave craton is associated with orogenic gold (12 deposits/camps), volcanogenic massive sulphides (VMS: three deposits, all large, Hackett River), five diamond-rich kimberlites (notably the early producers Ekati and Diavik) and a large rare earth mineral deposit (Nechalacho).

The Rae and Hearne cratons lie to the east, underlying most of the remaining parts of the Canadian shield across the Canadian Arctic. These contain Mesoarchean and older roots, and cover and plutonic suites of Neoarchean age, all overprinted by the Paleoproterozoic Trans-Hudson Orogeny. Supracrustal rocks are significant in the Neoarchean Rae craton: they contain important resources of iron (Mary River and Roche Bay), orogenic gold of Paleoproterozoic age (3), uranium, associated with a sub-Paleoproterozoic unconformity (four, including the large Kiggavik-Andrew Lake trend), nickel (1) and commercially significant kimberlites (2). Deposit types in the Hearne craton include Ni-Cu-PGE (2), uranium (1), VMS (1) and one large orogenic gold deposit (Meliadine).

The Superior craton is mostly located S of 60°N but is also exposed in the northern extremity of Quebec. It is bound to the north by the Cape Smith Belt, part of the circum-Superior Trans-Hudson orogen. This belt is noted for its mafic and ultramafic rocks that contain important resources of nickel, copper and platinum group minerals (3 large deposits: Raglan, West Raglan, and Nunavik). The other significant Paleoproterozoic belt is represented by the Wopmay orogen which lies west of the Slave Craton. This features an eastern sedimentary belt and, to the west, the Great Bear Batholith. Important resources in the latter include iron oxide-copper-gold (2 deposits), polymetallic veins (2) and vein uranium (1).

The Precambrian cratons and their cover of Paleoproterozic basins are fringed to the north and west by widespread shelf carbonate deposition that begins in the Mesoproterozoic and continues through the upper Paleozoic. These rocks host Mississippi Valley-type Zn-Pb deposits including large past producers near Great Slave Lake (Pine Point), on northern Baffin Island (Nanisivik) and in the Arctic Islands (Polaris). As yet undeveloped resources are located in the Mackenzie Mountains of the western Northwest Territories (four, of which Gayna River and Prairie Creek are large). Also present in this realm are two iron deposits including the very large Crest deposit in Neoproterozoic strata.

Southwestwards the shelf carbonate succession gives way to Cambrian to Devonian deep water sediments of the Selwyn Basin including shale, chert, carbonate and turbidites. The line of facies change lies in the western Northwest Territories and eastern Yukon. Important resources are represented by sedimentary-exhalative (SEDEX) Zn-Pb mineralization of which there are five deposits in the Yukon (Anvil, Tom and Jason, which are large and Howard's Pass, which is potentially very large). There are also four VMS camps in the Selwyn Basin, including the large Hasselberg deposit and the large Wolverine deposit in the Finlayson camp.

The western part of the Yukon is dominated by Jurassic and Cretaceous accreted terranes and by associated felsic to intermediate intrusive rocks. This is a key realm for gold (14 deposits), polymetallic Ag-Pb-Zn veins (5, notably Keno Hill, large) and Ni-Cu-PGE (1). The gold deposits are classified into epithermal (4, including the large Golden Revenue deposit), intrusion- related (3), orogenic (2, including Coffee (large), manto-type (2) and iron-oxide-copper-gold (3, one of them very large, Minto). There are also deposits associated with Mesozoic intrusives, tungsten and copper skarns (6 deposits, one large: Mactung), and Cu-Mo porphyrys (5, two of them large: Logtung and Red Mountain). Finally, among the many resources of the Yukon, there are eleven gold placer districts of which the Klondike is most significant.

For the purposes of representing ore deposits in the Canadian Arctic on a 1:5 million scale map, selected spatially distinct mineralized zones have commonly been grouped as one deposit (Figure 1). In this context, a deposit is defined as a cluster of genetically related occurrences on a property being investigated by one mineral industry organization (owners, operators, partners) in anticipation of these being mined at a profit as part of a single mine plan. Production and resource figures for these zones have been combined in the database, with a citation given for the source of the resource figures. Added to these deposits, many of which are actively being developed, there are many small, short-lived past producers which are historically well-known but which would not have been mined under the current regulatory environment.

History of Mineral Exploration

The history of mineral exploration in Arctic Canada has its beginnings in the search for placer gold in the Yukon. Although prospecting had uncovered gold along the Yukon River as early as 1883, a report by George Dawson identified the unglaciated areas of west central Yukon as having the greatest potential. Significant gold was discovered in river gravels of Bonanza Creek in August 1896 by George and Kate Carmack, Skookum Jim and Dawson Charlie. This became widely known and by July 1897 there was a major gold rush into the Klondike from the west coast of the USA and from many parts of Canada. In total 30,000 to 40,000 would-be miners entered the region from 1897 to 1899 (Berton, 2001). The rush came to an end when new gold discoveries were reported from the Atlin area of northern British Columbia (in 1898) and from Nome, Alaska (in 1899).

Prospecting activity uncovered new hard-rock gold deposits. In the 1890s this included reconnaissance expeditions by staff of the Geological Survey of Canada. These expeditions and others by prospectors located copper at Carmacks, Yukon by George Dawson (1887) (Kent et al., 2014), polymetallic silver-lead-zinc at Quartz Lake, Yukon (1892), intrusion-related gold at Dublin Gulch (1895) and Lone Star (1897), and silver-lead-zinc at Keno Hill (1901). Further afield, new indications of nickel mineralization were identified by Albert Low in northern Quebec (1898), gold along the Yellowknife River on the north side of Great Slave Lake (1898), zinc and lead sampled by Robert Bell at Pine Point south of Great Slave Lake (1899), and copper, uranium and cobalt at Echo Bay on the east side of Great Bear Lake first noticed by James MacIntosh Bell (1900). The Mississippi Valley-type deposits at Pine Point were low in silver and thus of limited interest to the mining community at that time. It would be sixty-six years before the

Table 1: Overview of the very large and large deposits in Canada north of 60°

Deposit	Status	Size	Genetic type	Main metals	Total tonnage - Mt (Mined)	Grades
Andrew Lake	Not exploited	Large	Unconformity	U	7.67	0.23 % U3O8
Casino	Not exploited	Very large	Porphyry (Cu, Au,Mo, W, Sn, Ag)	Cu, Mo, Au, Ag	2752.6	0.16 % Cu, 0.02 % Mo
Coffee	Not exploited	Large	Orogenic gold	Au	92.95	1.4 ppm Au
Con Mine	Closed mine	Large	Orogenic gold	Au	10.7 (10.7)	17.1 ppm Au
Courageous Lake	Renewed exploration	Large	Orogenic gold	Au	156.448 (0.17)	2.3 ppm Au
Crest	Not exploited	Very large	Stratiform iron	Fe	3200	43.0 % Fe
Faro Mine	Closed mine	Large	Sedimentary exhalative	Zn, Pb, Ag (Au)	58 (53.186)	5.0 % Zn, 3.4 % Pb, 33 ppm Ag, 0.3 ppm Au
Ferguson Lake	Not exploited	Large	Magmatic Ni-Cu-PGE	Ni, Cu (Co, Pt, Pd)	46	0.7 % Ni, 1 % Cu, 0.06 % Co, 1.3 ppm Pd, 0.2 ppm Pt
Gayna River	Not exploited	Large	MVT to Irish type Pb-Zn	Zn, Pb (Ga, Ge, Ag)	50	4.7 % Zn, 0.3 % Pb
Giant Mine	Closed mine	Large	Orogenic gold	Au	15.5 (15.5)	15.8 ppm Au
Golden Revenue	Not exploited	Large	Epithermal gold, plus porphyry	Au, Ag (Cu, Mo)	231.96	0.08 % Cu, 0.02 % Mo, 2.0 ppm Ag, 0.4 ppm Au
Goose	Not exploited	Large	Orogenic gold	Au	24.76	6.4 ppm Au
Hackett River	Not exploited	Large	VMS	Zn, Pb, Cu, Ag (Au)	87	3.8 % Zn, 0.5 % Pb, 0.4 % Cu, 144 ppm Ag, 0.23 ppm Au
Hasselberg	Not exploited	Large	VMS	Zn, Pb, Ag	4.1	6.2 % Zn, 1.8 % Pb, 84 ppm Ag
High Lake	Not exploited	Large	VMS	Zn, Cu, Pb (Ag, Au)	14	3.8 % Zn, 0.4 % Pb, 2.5 % Cu, 84 ppm Ag, 0.2 ppm Au
Howards Pass	Not exploited	Large	Sedimentary exhalative	Zn, Pb	388.5	4.9 % Zn, 1.6 % Pb
Izok Lake	Not exploited	Large	VMS	Zn, Cu, Pb (Ag, Au)	14.6	13.1 % Zn, 1.4 % Pb, 2.3 % Cu, 73 ppm Ag, 0.2 ppm Au
Keno Hill Silver	Active mine	Large	Ag-Pb-Zn veins	Ag (Pb, Zn)	7.214 (4.847)	4.4 % Zn, 5.3 % Pb, 1107 ppm Ag
Kudz Ze Kayah	Not exploited	Large	VMS	Zn, Pb, Cu (Ag, Au)	14.55	5.6 % Zn, 1.5 % Pb, 0.9 % Cu, 121 ppm Ag, 1.3 ppm Au
Logtung	Not exploited	Large	Porphyry (Cu, Au,Mo, W, Sn, Ag)	W, Mo	424.6	0.08 % W, 0.03 % Mo
Lupin Mine	Closed mine	Large	Orogenic gold	Au (Ag)	12.83 (11.73)	10 ppm Au
Mactung	Not exploited	Large	Skarn (Zn-Pb-Ag, Cu, Au, Fe, W)	W	44.886	0.73 % W
Mary River 1	Active mine	Large	Algoma-style iron formation	Fe	631	66.5 % Fe
Mary River 2 & 3	Not exploited	Large	Algoma-style iron formation	Fe	362	65.9 % Fe
Meadowbank Mine	Active mine	Large	Orogenic gold	Au	27.407	3.3 ppm Au
Meliadine	Not exploited	Large	Orogenic gold	Au	48.273	6.5 ppm Au
Minto	Active mine	Large	IOCG to porphyry	Cu (Au, Ag)	110.144 (53.72)	1.7 % Cu, 4.9 ppm Ag, 0.6 ppm Au
Nanisivik Mine	Closed mine	Large	MVT to Irish type Pb-Zn	Zn, Pb (Ag)	17.525 (17.524)	9.0 % Zn, 0.7 % Pb, 41 ppm Ag
Nechalacho	Not exploited	Large	Peralkaline rock-associated rare metals	REE	304.63	2335 ppm Nb, 1.18 % REE, 196 ppm Ta, 1.81 % Zr
Nickel King	Not exploited	Large	Magmatic Ni-Cu-PGE	Ni, Cu (Co)	44.172	0.4 % Ni, 0.09 Cu, 0.02 % Co
Nunavik Mine	Active mine	Large	Magmatic Ni-Cu-PGE	Ni, Cu (Co, Pt, Pd)	27.146	0.9 % Ni, 1.1 % Cu, 0.05 % Co, 2.2 ppm Pd, 0.5 ppm Pt
Pine Point	Closed mine	Large	MVT to Irish type Pb-Zn	Zn, Pb	100.96 (64.26)	5.6 % Zn, 2.5 % Pb
Polaris Mine	Closed mine	Large	MVT to Irish type Pb-Zn	Zn, Pb	20.107 (20.107)	13.4 % Zn, 3.6 % Pb
Prairie Creek	Not exploited	Large	MVT to Irish type Pb-Zn	Zn, Pb (Ag)	11.67	12.8 % Zn, 10.9 % Pb, 0.5 % Cu, 197 ppm Ag
Raglan Mine	Active mine	Large	Magmatic Ni-Cu-PGE	Ni, Cu (Pt, Pd)	42.03 (6.89)	3.2 % Ni, 0.9 % Cu
Red Mountain	Not exploited	Large	Porphyry (Cu, Au,Mo, W, Sn, Ag)	Mo	187	0.1 % Mo
Roche Bay C	Not exploited	Large	Algoma-style iron formation	Fe	567.3	26.4 % Fe, 0.09 % P2O5
Tom and Jason	Not exploited	Large	Sedimentary exhalative	Zn, Pb, Ag	30.99	6.6 % Zn, 3.8 % Pb, 39 ppm Ag
Wellgreen	Renewed exploration	Large	Magmatic Ni-Cu-PGE	Ni, Cu, Pt, Pd (Co, Au)	461.28 (0.17)	0.3 % Ni, 0.3 % Cu, 0.02 % Co, 0.3 ppm Pd, 0.4 ppm Pt
West Raglan	Not exploited	Large	Magmatic Ni-Cu-PGE	Ni, Cu (Pt, Pd)	10	2 % Ni
Wolverine Mine	Active mine	Large	VMS	Zn, Cu, Pb, Ag (Au)	6.154	12.2 % Zn, 1.6 % Pb, 1.2 % Cu, 363 ppm Ag, 1.7 ppm Au

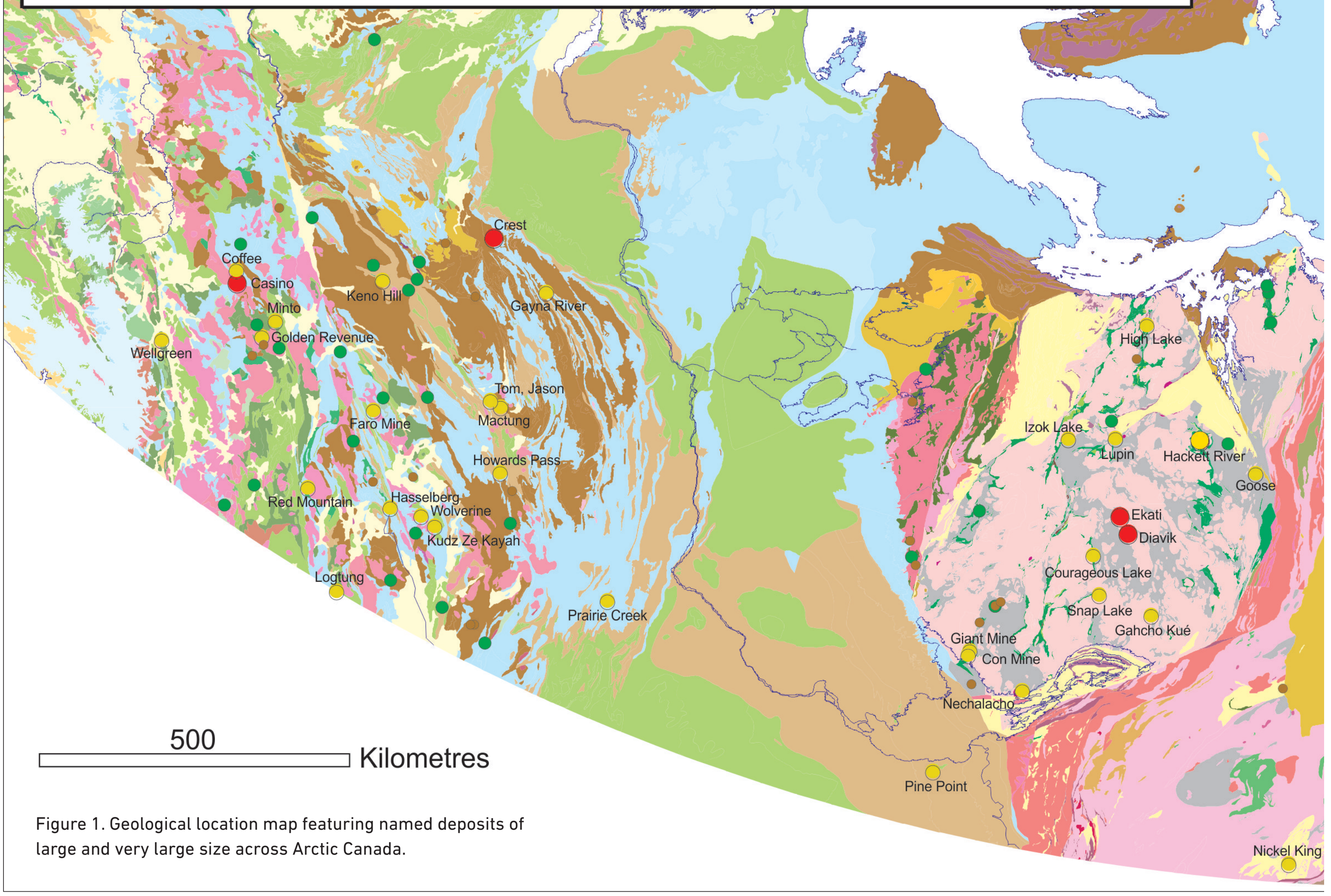
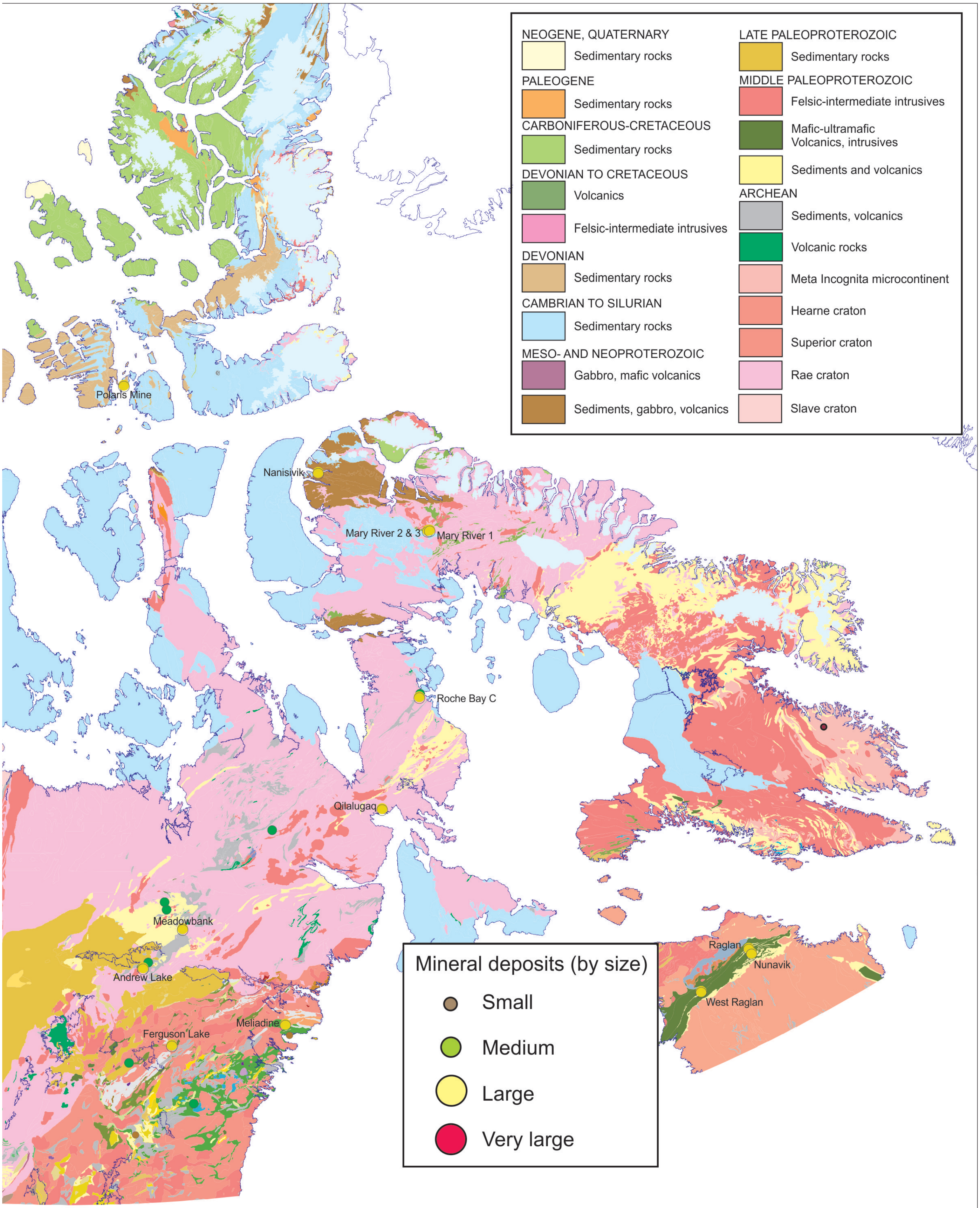


Figure 1. Geological location map featuring named deposits of large and very large size across Arctic Canada.


NEOGENE, QUATERNARY
Sedimentary rocks
PALEOGENE
Sedimentary rocks
CARBONIFEROUS-CRETACEOUS
Sedimentary rocks
DEVONIAN TO CRETACEOUS
Volcanics
Felsic-intermediate intrusives
DEVONIAN
Sedimentary rocks
CAMBRIAN TO SILURIAN
Sedimentary rocks
MESO- AND NEOPROTEROZOIC
Gabbro, mafic volcanics
Sediments, gabbro, volcanics
LATE PALEOPROTEROZOIC
Sedimentary rocks
MIDDLE PALEOPROTEROZOIC
Felsic-intermediate intrusives
Mafic-ultramafic Volcanics, intrusives
Sediments and volcanics
ARCHEAN
Sediments, volcanics
Volcanic rocks
Meta Incognita microcontinent
Hearne craton
Superior craton
Rae craton
Slave craton
Polaris Mine
Nanisivik
Mary River 2 & 3
Mary River 1
Roche Bay C
Qilalugaq
Meadowbank
Andrew Lake
Meliadine
Ferguson Lake
Raglan
Nunavik
West Raglan
Mineral deposits (by size)
Small
Medium
Large
Very large

area would become commercially viable (Siega and Gann, 2014).

The introduction of float-planes from 1925, was a significant boost to the mineral exploration business (Zaslow, 1975). This allowed access to large areas of remote country and was largely responsible for the exploration discoveries of the 1930s. The prospector Gilbert LaBine was the first to investigate the mineral showings on Great Bear Lake: in 1930 this led to the discovery of high grade pitchblende and silver ore at what would become the Eldorado mine (Zaslow, 1975). A small staking rush identified vein uranium at Rayrock, also near Great Bear Lake, in 1934, and of copper-gold mineralization at NICO. Production at the Eldorado Mine began in 1933 followed by the Contact Lake silver mine in 1936. The Eldorado mine was closed in 1940, but was soon reopened to supply uranium to the war effort. It remained mostly active down to 1982.

The discovery of gold near Yellowknife in 1898 was not, at the time, considered significant, partly because of the remote location of the area. However, the success of mine development at Great Bear Lake inspired new prospecting over a wide area of the Northwest Territories. Renewed prospecting took place in the early 1930s, which led to the discovery, in 1935, of the deposits which were developed in the Giant and Con mines (Duke et al, 1991; Goucher, 1991) and to the establishment of the Yellowknife town site from 1936. As many as five mines were operating in the late 1930s. The outbreak of WWII, however, brought much of this activity to an end. The area became a significant mining centre, again, after the war. Gold mineralization was, in 1944 and 1945, discovered along the trend to the north on what would later become the Yellowknife Gold Project. Other gold properties were established elsewhere within the Slave craton in this period, including Courageous Lake (1944), Colomac (1945) and Lupin (1960).

The 1950s were an especially active period for nickel exploration in Arctic Canada. Follow-up of A.P. Low's discoveries in Ungava Quebec, which led to the Raglan deposit (1956) and the Nunavik property (1957) is particularly noteworthy. New prospects were discovered west of Hudson Bay, at Ferguson Lake (1950) and at Nickel King (1952) and in the southwest Yukon at Wellgreen (1952). Additional discoveries of skarn mineralization were made in this period, though skarn-related copper had been found at Whitehorse as early as 1897. However tungsten skarns were delineated near the Yukon-Northwest Territories border at Cantung (1954) (Fitzpatrick and Bakker, 2011) followed by Mactung (1962) and Sa Dene Hes, a lead-zinc skarn (1962). Other noteworthy discoveries include the iron deposits at Snake River, Yukon (1961), at Mary River in the Rae craton of northwestern Baffin Island (1965) and at Roche Bay on Melville Peninsula (1968-1970).

The 1960s and 1970s were notable for the exploration for porphyry copper-molybdenum in the Yukon following on the success of new exploration models in British Columbia (Sinclair, 2007). This led to discoveries at Red Mountain and Casino (both in 1967), which precipitated a staking rush and later the discovery of Cash (1975) and the Logtung tungsten-molybdenum deposit (1976). New properties associated with iron oxide-copper-gold (IOCG) mineralization were discovered in the same period, including the Sue Dianne deposit (1974) which has a noteworthy radiometric anomaly, Pagisteel in the Mackenzie Mountains and the Minto deposit (1971), Yukon, which was staked on the basis of a stream-sediment geochemical anomaly (Mercer et al, 2012). Mississippi Valley type deposits also became commercially viable in this period, notably Pine Point (1965), Polaris in the Arctic Islands (1970) which was discovered by drilling a gravity anomaly (Dewing et al., 2007a), Gayna River (1974), and Nanisivik on Baffin Island (1976). Other noteworthy discoveries included the following sedimentary exhalative (sedex) deposits: the Anvil deposits (1953, 1965), Tom and Jason (1951, 1974) and, especially, the large Howard's Pass deposit (1972) which was discovered during follow-up of stream sediment geochemical results. Announcement of the Howard's Pass discovery precipitated a major staking rush across the central Yukon (O'Donnell, 2009). Volcanogenic massive sulphide deposits were also being discovered in the Yukon, e.g. Hasselberg (1955) and Hart River (1955), and notably, on the Canadian shield, Hackett River (1966).

Other developments in this latest period included the discovery of orogenic gold deposits in the Hope Bay belt in the northeastern Slave craton (1992-1995), Hyland gold (1981) which started out as a lead-zinc property (Armitage and Gray, 2012), new deposits on the Skukum gold property (1982), Brewery Creek (epithermal gold) in the Yukon (1987), Meadowbank (gold) (1987) which arose from the discovery of uranium at Kiggavik (1974) near the Baker Lake Basin (Ruel et al., 2012), Meliadine (gold) (1989),West Raglan (nickel) (2002), and White Gold in the Yukon (2007).

The latest significant development in the mineral exploration of Arctic Canada has been the discovery of commercially significant diamond-bearing kimberlites. This was the vision of two men, Charles Fipke and Stewart Blusson, who tracked kimberlite indicator minerals extracted from eskers and in so doing pin-pointed the favourable kimberlite source in bedrock near Lac de Gras in the central Slave craton. This was an endeavor of ten years ending with drilling of the first diamond-bearing kimberlite in 1991 (Carlson et al., 2015). The announcement of their discovery precipitated one of the biggest staking rushes in Canadian history. As well as the original Ekati property, other kimberlite prospects of economic significance were located in several parts of the Arctic, including Snap Lake (1994) and Diavik (1995) in Northwest Territories and Qilalugaq (2000-2005) and Chidliak (2005) in Nunavut.

NEOARCHEAN IRON

Two Neoarchean iron deposits, each of large dimensions, are located in the Rae craton of northeastern Nunavut. The Mary River deposit (Fig. 1) is located on northern Baffin Island, 160 km S of Pond Inlet, 300 km N of Sanirajak, and 1000 km NW of Iqaluit (the capital of Nunavut). Access is by fixed wing to an airstrip on the property, or by ski- or float-equipped aircraft to nearby Sheardown Lake. The second major deposit is the Roche Bay iron deposit located 60 km SW of the settlement of Sanirajak and immediately west of Roche Bay on eastern Melville Peninsula (Figure 2).

Mary River (Large[1])

Iron ore of commercial significance was proven by drilling at Mary River as early as 1965. There was no new interest until 2004 when additional drilling was completed. A revised estimate of the resource was made available in 2006. The current owner is Baffinland Iron Mines Corporation. The Mary River group is named for a collection of supracrustal outliers in the northwestern part of Baffin Island. The tectonic setting is one in which the Mary River Group (2.74 to 2.68 Ga) and associated deposits occur in west- and northeast-trending synforms overlying older Mesoarchean basement. Jackson (2000) and Johns and Young (2006) have correlated these belts with the Prince Albert and Woodburn groups of Melville Peninsula and with similar rocks in northwest Greenland, a tectonic entity that is identified as the Committee Orogen (Jackson, 1966). However, these relationships are now in some doubt. The Mary River group overlies a basement complex that includes foliated and nebulitic granite and granodiorite (3.0 to 2.8 Ga; Johns and Young, 2006). The contact relationship is thought to be unconformable but in places is also faulted, mylonitic, intrusive and migmatitic. The Mary River Group is succeeded regionally by the Paleoproterozoic Piling Group (central Baffin Island), generally unmetamorphosed Mesoproterozoic strata of Borden Basin, dykes of the Mackenzie (1270 Ma) and Franklin (720 Ma) swarms, and flat-lying or tilted Ordovician carbonates.

The thickness of the Mary River Group in the vicinity of the iron deposits is considered to be of the order of 2000 - 4000 m. The metamorphic grade ranges from greenschist to upper amphibolite facies. Jackson (2000) has identified the following five units within the Mary River Group (from the base upwards): 1) metapelite, mafic metavolcanics; lenses of conglomerate; 2) quartzite; metarhyolite, dacite (2718+5-3 Ma),

1 The sizes of the deposits described in this chapter are grouped according to the criteria described by Eilu et al. (2007).

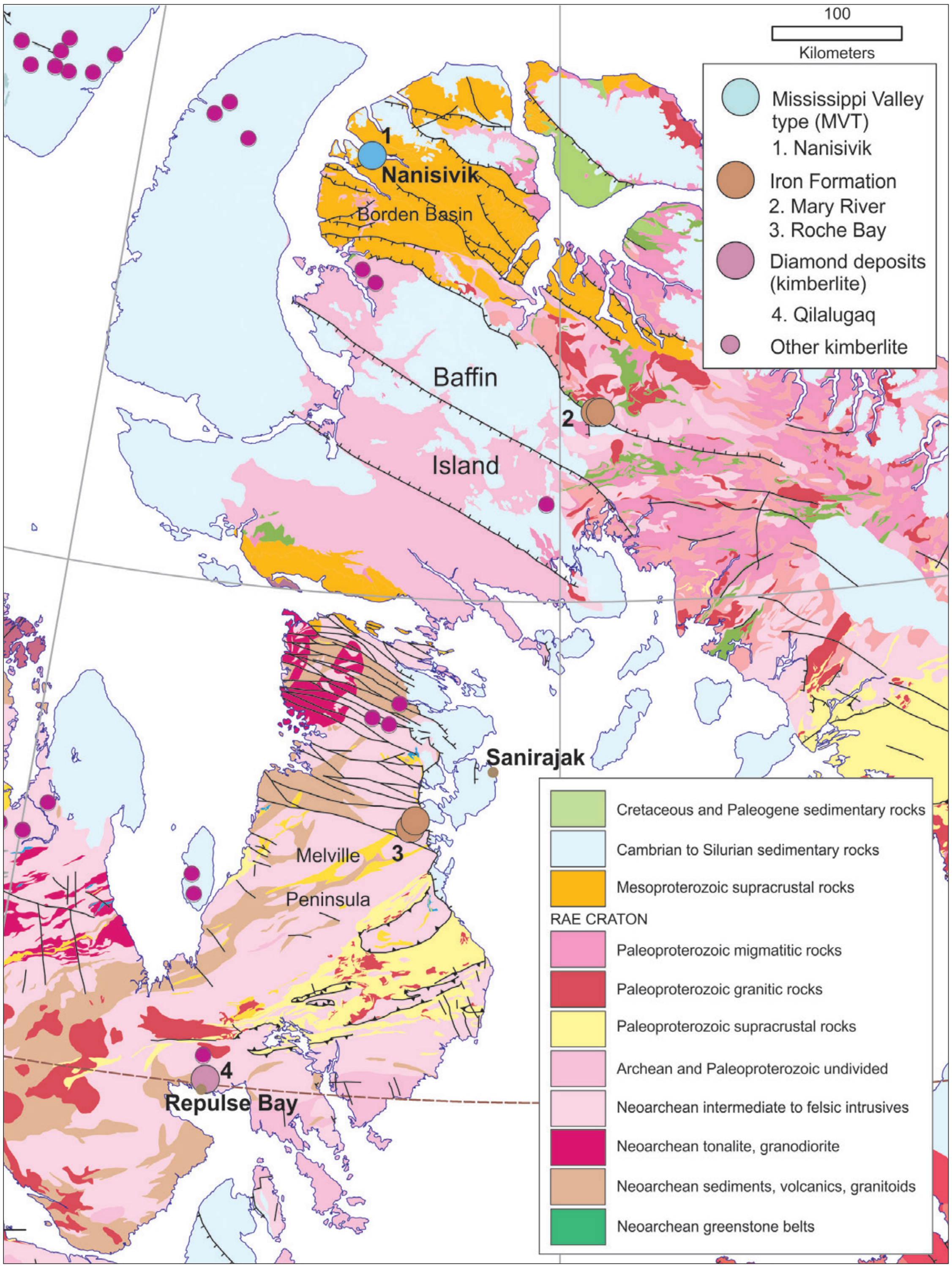


Figure 2. Simplified geology of Melville Peninsula and adjacent northwestern Baffin Island with deposits of iron, kimberlite diamond and Mississippi Valley-type zinc-lead.

mafic metavolcanics; oxide facies iron formation (and ore deposits); 3) conglomerate, breccia; greywacke, metapelite; metavolcanics; pyribolite; iron formation; 4) local conglomerate, breccia; greywacke, metapelite; 5) local conglomerate, breccia; metavolcanics with meta-anorthosite, meta-gabbro, pyribolite.

Local unconformities have been proposed to underlie the conglomerates within each unit. Layering of iron formation with other lithofacies is common and has been attributed to a mixture of both depositional facies variation and tectonic interleaving. Varieties of iron formation include oxide, silicate, pelitic and calcitic/ferroan dolomitic carbonate. Oxide and pelitic facies iron formation also contain small amounts of disseminated pyrite and pyrrhotite. The greatest thickness of iron formation occurs in the vicinity of the ore bodies: 52 - 195 m thick and traceable for up to 3.8 km (Figure 3). The ore zones are, however, generally lenticular in shape. The ore zone mineralogy is mostly hematite-magnetite grading to hematite. Subsidiary phases include grunerite, anthophyllite, clinochlore, quartz, garnet, pyrite, pyrrhotite, chalcopyrite and covellite (Wahl et al., 2011).

Roche Bay (Large)

The Roche Bay deposits are classified as Algoma-type iron formation. Five deposits are located here and labelled as zones A, B, C (Large), D and E. Exploration in the period 2006-2011 focussed on Zone C: its dimensions are 5 km in strike length, 160 m thickness and a dip of 700 to the southwest. The A/B Zone is 1400 - 2000 m long and 120 - 150 m thick.

The oldest rocks of the eastern Melville Peninsula area are granitized paragneisses of the Amitioke Gneiss Complex. These were identified as basement to the iron formation-bearing Prince Albert Group by company geologists (Palmer, 2007), who also recognized an intrusive relationship. The type Prince Albert Group in the Prince Albert Hills of western Melville Peninsula has, more recently, been redefined, and dated to 3.20 to 2.77 Ga (Corrigan et al., 2013), with uncertain correlation to the Archean sediments at Roche Bay. Typical Archean supracrustal rocks near the deposits include metasedimentary and metavolcanic rocks. The metasediments feature iron formation, quartzite (metachert and meta-quartz arenite), biotite schist, argillite and meta-conglomerate (Palmer, 2007, Schau, 1981). The metavolcanics include meta-andesite, meta-rhyodacite, meta-rhyolite, and felsic breccia. Mafic igneous rocks, including metagabbro and "metabasalt" sills of the Tasijuaq Gabbro Complex, intrude the supracrustal rocks.

The metamorphic grade ranges from upper greenschist to lower amphibolite facies. The structure of the area features two phases of folding with the longer wavelength sets being isoclinal. There are two fabric sets: S1, which is parallel to basalt pillows and a younger S2 which is axial planar to regional folds. The iron formation shows a laminar interlayering of magnetite and quartz (metachert) with individual layers averaging 0.5 - 2 cm thick. Host-rock minerals include magnetite, quartz, amphiboles (grunerite, actinolite, hornblende), micas (biotite, muscovite), chlorite, and sulphides (mostly pyrite and pyrrhotite, minor chalcopyrite and arsenopyrite) (Schau, 1981).

Figure 3. Mary River: View to the northwest of the No. 1 deposit. Length of the deposit is 2.5 km and consists of 68.2% average iron as hematite and magnetite. GSC 1995-201A.

NEOARCHEAN VOLCANOGENIC MASSIVE SULPHIDE (VMS)

The Slave craton is an important host for ore deposits in Arctic Canada. Lying in the northwestern part of the Canadian shield, it is bound to the east by the Paleoproterozoic Taltson-Thelon orogen and to the west by the Wopmay orogeny. The Slave craton features a basement of Eoarchean to Mesoarchean granitoid rocks and several supracrustal units (4.0 to 2.83 Ga). Unconformable on these, there are supracrustal units collectively referred to as the Yellowknife Supergroup (2.74 - 2.62 Ga). This contains quartzite and ironstone in the lower part, tholeiitic greenstone, arc rocks, and, in the upper part, turbidites. This package was intruded by a “bloom” of granites at 2.95 to 2.58 Ga and was intensely deformed at 2.64 to 2.58 Ga. The mineral deposits of the Slave craton include volcanogenic massive sulphides in the Yellowknife Supergroup, shear-zone hosted gold and iron-formation hosted gold. Also present are diamond-bearing kimberlites (described near the end of this account) of Cambrian to Eocene age (Bleeker and Hall, 2007).

Three massive sulphide deposits are located in the northern part of the Slave craton of western Nunavut (Figure 4). The large Izok Lake deposit in the northwestern Slave is 265 km S of the community of Kugluktuk (Coppermine) on Coronation Gulf. The Hackett River deposit (large) in the Hackett River greenstone belt of the northeastern Slave is 485 km NE of Yellowknife. The large High Lake deposit in the High Lake greenstone belt is located in the northern Slave craton 40 km S of Coronation Gulf. Elsewhere, the Heninga deposit is located in the Rankin-Ennadai greenstone belt of the Hearne craton W of Hudson Bay (Figure 5).

Izok Lake (Large)

High-grade massive sulphide boulders were discovered in the Izok Lake area by Texasgulf Inc. in 1974. Drilling of the adjacent lake soon led to the discovery of four massive sulphide lenses (Northwest, North, Central West, Central East). A fifth lens (Inukshuk) was discovered in 1992.

Two regional map units are present in the area. The lower of these, the Point Lake Formation, consists of marine mafic tholeiite and felsic calc-alkaline volcanics and volcaniclastic rocks. This is overlain by the Contwoyto Formation which consists of iron formation and greywacke turbidites. These units are intruded by granitoid rocks and by Mesoproterozoic Mackenzie dykes.

The Point Lake Formation at Izok Lake features felsic to mafic flows and some calcareous metasediments. The felsic volcanics are mostly porphyritic rhyolites, all intensely deformed. Volcanic rocks in the immediate vicinity of the ore lenses include pyroclastic aphyric rhyolite and quartz-phyric rhyolite, often hydrothermally altered. Other significant rock units in the same area include andesite dykes and flows, volcaniclastic rocks, pillow basalt and gabbro dykes and sills. Iron formation is also present and often contains disseminated sulphides (Morrison 2004). Deformation in the area is primarily represented by a layer-parallel strain fabric with a superimposed crenulation cleavage. Metamorphism is typically high temperature and low pressure based on assemblages that contain sillimanite and cordierite-spinel-corundum. Alteration is most intense around the ore deposits and includes sericitization (muscovite), chloritization (chlorite-biotite-cordierite), biotite and silicification (Morrison 2004).

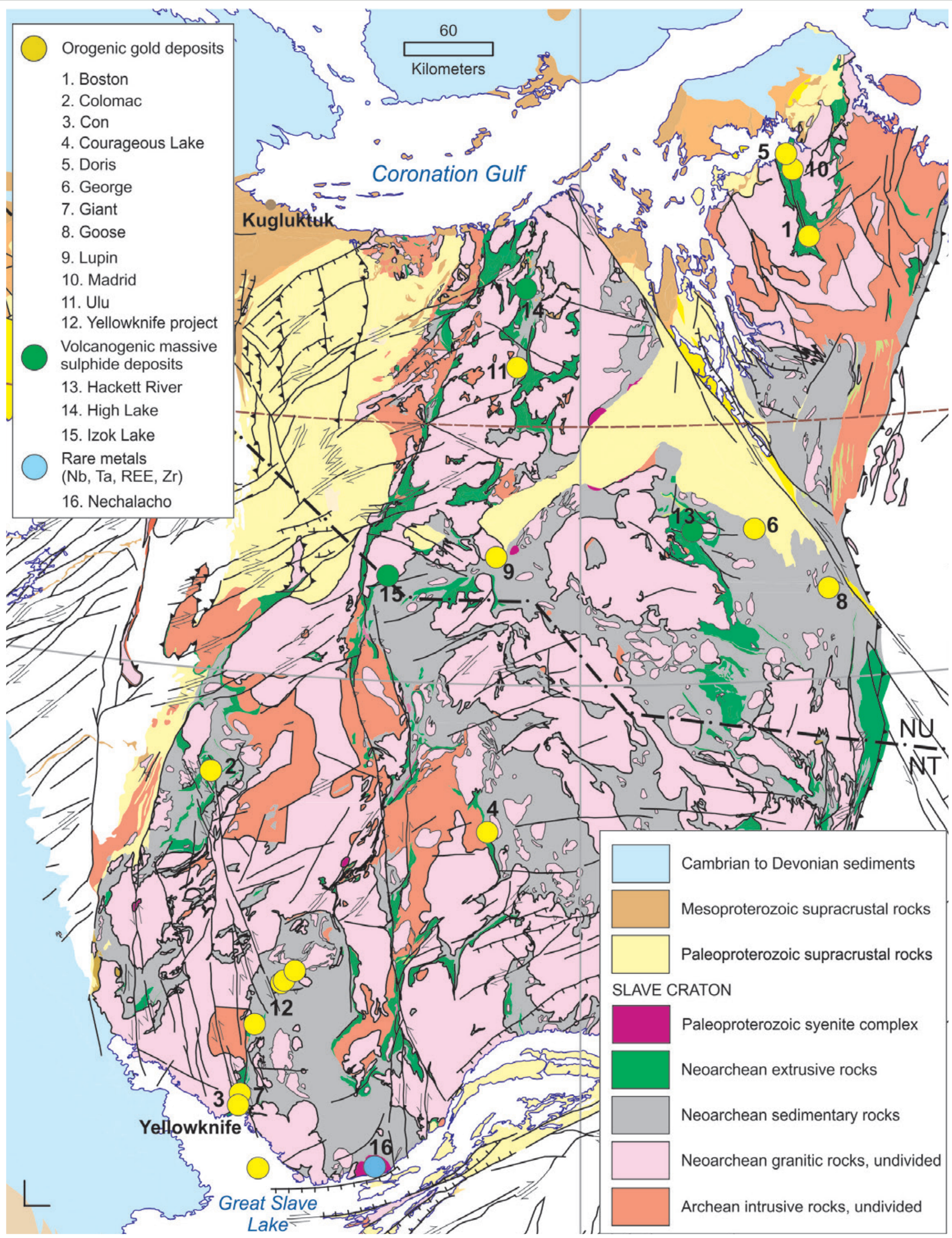
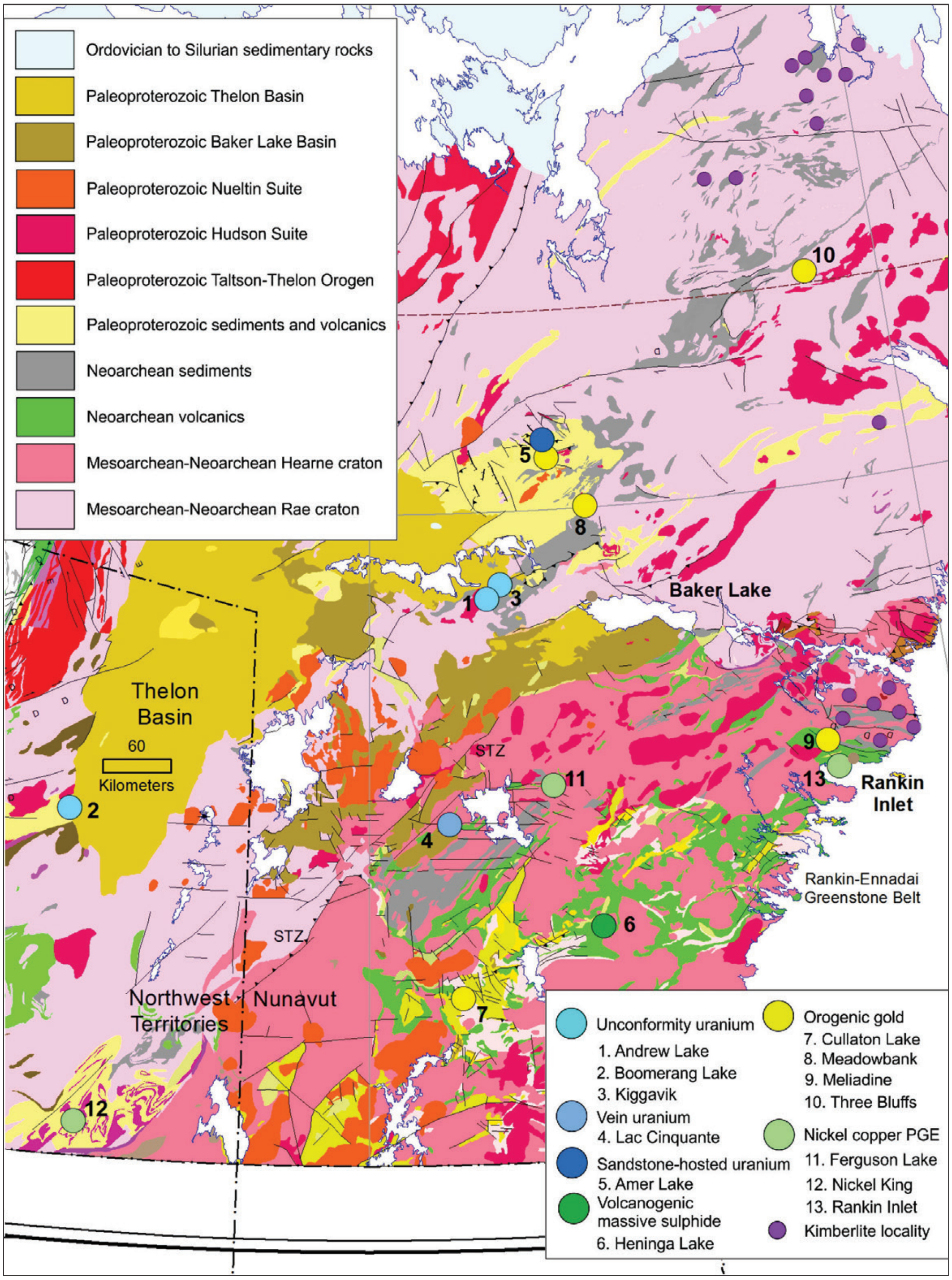


Figure 4. Simplified geology of the Slave craton of Nunavut and Northwest Territories with deposits of orogenic gold, volcanogenic massive sulphides and rare earth elements.

The ore lenses are mineralogically complex and include combinations of the following sulphides: pyrite, sphalerite, chalcopyrite, pyrrhotite and galena. A copper-rich stockwork zone is also present, beneath the massive sulphide ores, for example under the Central West lens. Sizes range up to 570 x 200 m and 125 m thick in the case of the Central lenses (Morrison 2004). The ore deposits have been interpreted as forming in a sub-sea floor replacement setting rather than as a sea-floor mound. This is drawn from the observation that there are no exhalites associated with the ore horizons. Franklin et al (2005) have identified the Izok Lake deposit

Figure 5. Simplified geology of a portion of the Rae and Hearne cratons within Nunavut and Northwest Territories together with deposits of uranium, volcanogenic massive sulphides, orogenic gold and nickel-copper-PGE.



as a bimodal-mafic type volcanogenic massive sulphide.

Hackett River (Large)

The Hackett River property was acquired by Glencore Canada Corporation in 2011. It lies within the Neoarchean Hackett River greenstone belt of the northeastern Slave craton, close to its unconformable contact with the Paleoproterozoic Goulburn Group of Kilohigok Basin. A volcanic-dominated unit, the Hackett River Group dominates the lower part of the section. It is correlated with the Banting Group of the Yellowknife area (Bleeker and Hall, 2007) and is subdivided as follows. At the base is the Siorak Formation (biotite schist, quartzofeldspathic gneiss, sericitic schist, amphibole gneiss) overlain by the Nauna Formation (volcanic flows, in part pillowed, mafic and felsic pyroclastics). This is succeeded by the Ignerit Formation, consisting of dacitic and andesitic flows and pyroclastics (Clemmer et al., 2013). Intercalated with the flows are “white smoker” dolomitic and calcitic carbonates (Bleeker and Hall, 2007), iron formation, and sulphidic volcaniclastic rocks. The Ignerit Formation is the host of the known VMS deposits (Figure 6).

Turbidites of the Beechey Lake Group overlie the sequence described above. Characteristic rocks include greywacke, mudstone and minor carbonaceous mudstone, iron formation, chert and pyroclastic rocks. The Beechey Lake Group is correlated with Burwash Formation turbidites of the Yellowknife area and other widely represented metasediments of the Slave craton (Bleeker and Hall, 2007). Two granitoid suites are present in the Hackett River area. The Mara River complex features granitoid gneiss, migmatite and anatectite derived from the Yellowknife Supergroup. More discrete plutonic bodies are found in the intrusives of the Regan Intrusive suite: granite, granodiorite, tonalite and quartz diorite plutons. These display metamorphic aureoles in the enclosing rocks. Largely post-tectonic, these are probably part of the “granite bloom” of Bleeker and Hall (2007; 2595-2585 Ma).

VMS deposits in the Hackett River belt are spatially associated with synvolcanic intrusions and include the A deposit, East Cleaver, Boot Lake, and Cleaver Low Grade in the north, and the Yava and Musk deposits in the south (Bleeker and Hall, 2007). Alteration associated with the deposits includes 1) sillimanite-biotite-garnet-quartz; 2) sericite-quartz; and 3) anthophyllite- cordierite (Clemmer et al., 2013). Deformation has produced upright and recumbent to over- turned folds. There is also late-stage reverse faulting. Cu-Pb-Zn and Ag ternary plots have been employed to infer an arc-like VMS setting (Bleeker and Hall, 2007). These deposits are classified as bimodal-felsic VMS (Franklin et al., 2005).

High Lake (Large)

The High Lake greenstone belt, 70 km in strike length and 5 - 25 km wide, is divided into a central metasedimentary belt bound to both east and west by volcanic domains. The western domain is dominated by intermediate and felsic volcanic rocks and volcaniclastic rocks with an age range of 2705±1 Ma to 2695±3 Ma (Henderson et al, 1995). Gossans, massive sulphides and gold occurrences are common. The central sedimentary domain comprises mostly slate, siltstone, greywacke, volcaniclastic rocks and chemical carbonate metasediments. It is the host for the Ulu gold deposit and other epithermal arsenide-gold occurrences. Its age range

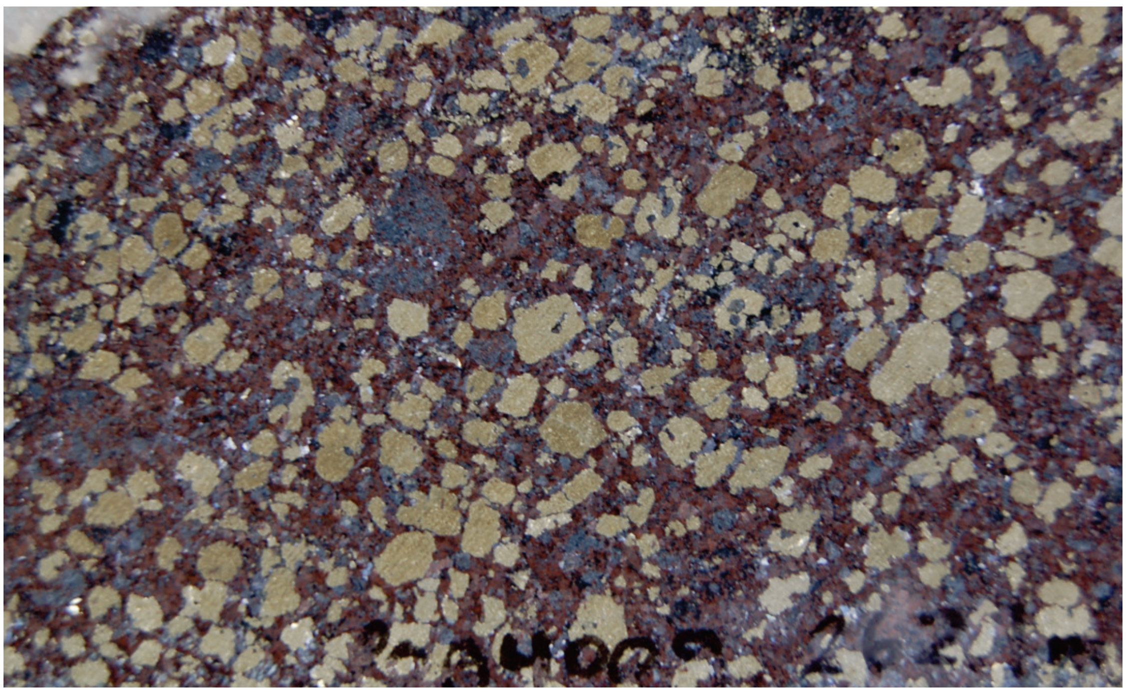


Figure 6. Hackett River: massive sulphide with up to 30 % buckshot pyrite in a matrix of dark red sphalerite and tremolite-altered tuff clasts. GSC 2015-111.

is 2616+-3 Ma to 2612+-3 Ma (Henderson et al, 1995; Henderson et al, 2000). Mafic and intermediate volcanic and volcaniclastic rocks are dominant in the eastern domain. It is geologically and metallogenically similar to the western domain.

Deformation fabrics include a bedding parallel foliation, NNE-striking map scale folds, a ubiquitous, steeply-dipping NNE-striking planar fabric (that overprints folds), and a local crenulation fabric. The metamorphic grade is mostly greenschist, based on the assemblage quartz-sericite-chlorite, but ranges to amphibolite grade in the north and south. Local andalusite and cordierite isograds have been identified and contact metamorphic aureoles are present around granodiorite-tonalite-granite intrusions.

The High Lake property features lenses (AB and D zones), pods (C, E and H zones) and other deposits farther afield (Lake zone, North zone and West zone). The largest deposit is the AB zone, which measures 200 x 600 m (Petch, 2004). It is bound to the east by High Lake and to the west is intruded by granodiorite (2613+-3 Ma; Henderson et al, 1995). Other granitic intrusives in the vicinity of High Lake have been dated at 2605+5/-3 Ma (Henderson et al, 1995).

Rocks in the immediate vicinity of the AB zone include felsic and less commonly intermediate flows, diabase sills and dykes, hyaloclastite, volcaniclastic rocks and carbonate-rich exhalite. Minor units of metasediment include slate, psammite, pelite and argillite. A unit of anthophyllite-magnetite-cordierite is closely associated with the ore bodies. Other alteration assemblages in the vicinity of the AB zone include silicification, chloritization and sericitization. A separate assemblage of cordierite and/or quartz-sericite-chlorite porphyroblasts forms a characteristic “dalmatianite” fabric in the immediate vicinity of the ore deposits and is a useful prospecting tool (Petch, 2004).

Mineralization includes massive to semi-massive and stringer-zone pyrite, pyrrhotite, chalcopyrite, sphalerite and minor galena. Additional phases include magnetite and minor hematite. Local textures include colloform banded pyrite and vugs lined with drusy quartz, pyrite and chalcopyrite. Zoning with respect to copper and zinc is, in the case of the AB deposit, poorly developed (Petch, 2004). A Cyprus-type, bimodal, rift-like environment has been suggested as the setting for the High Lake deposits (Bleeker and Hall, 2007). Franklin et al, however, proposed a bimodal-felsic volcanogenic massive sulphide model.

Heninga Lake (Medium)

The dominant rock types in this central Rankin-Ennadai greenstone belt are dacites with lesser rhyolite, andesite and basalt. Pyroclastic deposits, notably dacitic lapilli tuffs with clasts up to 30 cm in diameter but mostly less than 5 cm, are prominent amongst the felsic volcanics. Minor sedimentary rocks are most commonly grey cherts which occur interbedded in the volcanic rocks. All the rocks have been metamorphosed to lower or middle greenschist facies and have suffered regional deformation, including a northeast-striking foliation associated with isoclinal folds. Later deformation includes a north-trending set of parasitic folds with flattening of volcanic clasts and axial-planar quartz veins. The general pattern is of a northeast-trending volcanic pile with younger strata located to the southeast as indicated by the facing direction of volcanic pillows (King, 1975).

Mineralization is found in exposures near the shores of Heninga Lake. The forms of mineralization include: 1) massive and medium-grained pyrite-chalcopyrite-sphalerite with lesser pyrrhotite and magnetite; 2) coarse-grained and massive pyrite-sphalerite; 3) disseminated blebs and stringers of pyrite-chalcopyrite-sphalerite, and 4) streaks and stringers of pyrite-chalcopyrite. In general, the disseminated mineralization is situated structurally above the massive type. Drilling and geophysics have delineated a zone of 850 m length within which there are separate Cu-Zn-Ag- rich and Zn-Ag-rich sections (King, 1975).

NEOARCHEAN OROGENIC GOLD

Orogenic gold deposits of Neoarchean age, all located in the Slave craton of the Northwest Territories, are considered in this section (Figure 4). The Giant mine (large) lies on the west side of Yellowknife Bay, on the north shore of Great Slave Lake. It is located in the northerly-striking Yellowknife Greenstone Belt. Giant, together with the nearby Con (also large), are the largest gold deposits of the Slave craton (followed in size by Goose Lake, Courageous Lake, George Lake, Lupin, and Colomac, all of which have been mined). Although separated by faulting, the Giant and Con mines are generally considered to be parts of a single ore deposit. The gold zones of the Yellowknife Gold project, 90 km N of the town of Yellowknife are also located in this greenstone belt. Farther afield, in the Slave craton, the Ulu deposits are located in the High Lake greenstone belt, and, to the northeast, in the High Lake belt, the gold deposits of Boston, Doris and Madrid.

Giant (Large)

Gold in this area was discovered by GSC staff who panned the Yellowknife River in 1898. Significant discoveries of lode gold were, however, not made until 1935. This led to the staking of claims on what would become the Giant Yellowknife Gold Mine and to a staking rush in 1936. Significant new discoveries were made in 1944, which precipitated another staking rush. The mine was active from 1948 to 2004 (Figure 7; Moir et al., 2006; Canam, 2006).

The basement of the Yellowstone Greenstone Belt consists of gneisses and plutonic rocks dated at 3.3 - 2.93 Ga, and supracrustal rocks of the Bell Lake Group (>2.8 Ga). Gold-bearing shear zones occur in the Yellowknife Bay Formation (2.71-2.70 Ga) and in felsic tuffs and porphyries of the Townsite Formation. Lode gold also occurs in the younger Jackson Bay Formation (breccia,

Figure 7. Yellowknife Royal Oak Giant Mine head frame. GSC 2015-110.

conglomerate, sandstone, argillite) and in the overlying Banting Group (2.67-2.66 Ga; felsic tuff and mafic volcanics). Younger intrusive rocks include: Defeat Suite granodiorite (2.63-2.62 Ga), Duckfish Granite (2.61 Ga) and Anton Complex (2.64-2.61 Ga) (Cousens et al., 2006).

In general, the Giant deposit is bound on three sides by faults and to the east by the Banting Group and Jackson Bay Formation. The Giant Mine is classified as a quartz-carbonate, shear-zone-hosted vein deposit. Schist envelops the ore zones and is closely associated with alteration as follows: Sericite-carbonate schist grades outwards to chlorite-sericite schist and finally chlorite schist. Ore-hosting schist is associated with shear zones and is also folded into antiforms and synforms. Schistose zones are known to transect bedding. The regional-scale folds are therefore not the product of simple folding of primary stratigraphic units. Four deformation phases are documented at Giant: layer-parallel fabrics (S1), east-west compression to form the main phase of deformation (S2), folding of S2 (D3), and brittle faulting of Proterozoic age (D4). The ore of the Giant Mine (and of Con Mine) is considered to be synchronous with D2 deformation and post-date the Defeat Suite (Martel and Lin, 2006). A Re-Os isochron age on pyrite has provided an age of 2.59 Ga for sulphides in the Con Mine (Ootes et al., 2011).

Mineralization occurs as: 1) bands of quartz and sulphides alternating with sericite-carbonate schist; 2) sericite-carbonate schist with matrix of quartz and sulphides, and; 3) folded and boudinaged quartz-carbonate veins. Ore minerals include: pyrite, arsenopyrite (closely associated with gold), sphalerite, chalcopyrite, stibnite, sulphosalts and pyrrhotite (Canam, 2006).

Con (Large)

Gold production has taken place from the following, named shear zones: Campbell, Con and Rycon-Negus. The first gold was poured in 1938. Production from the prolific Campbell shear commenced in 1946 and was continuous to 2002.

The metamorphic grade in the vicinity of the ore zones is either amphibolite grade or greenschist transitional to amphibolite facies. The mineralization is associated with an eastward excursion of the hornblende isograd and with granite plugs (several containing molybdenite), lamprophyres and breccias. One lamprophyre is a gold host rock. The following comments are specific to the Campbell zone but to varying extent also apply to Con and Rycon-Negus. The primary host rock at Campbell is a shear zone consisting of chlorite-carbonate and sericite-chlorite-carbonate schist. The Con mine is classified as a quartz-carbonate, shear-zone-hosted vein deposit (Figure 8). The ore is associated with intense quartz- ankerite veining and alteration which is enveloped by sericite-ankerite schist. There are two types of ore: free-milling and refractory (i.e. finely divided). Sulphides comprise a minor component of the ore (1-3 %) and include pyrite, arsenopyrite, lesser sphalerite, galena, chalcopyrite and sulphosalts. Other notable phases include scheelite and tourmaline, the latter in quartz veins or in tourmalinite breccias (Hauser et al., 2006). The ore of the Con mine (and Giant mine) is considered to be synchronous with D2 deformation and to post-date the intrusive Defeat Suite (2.62 Ga). A Re-Os isochron on pyrite yields 2.59 Ga for sulphides in the Con mine (Ootes et al., 2011).

Yellowknife Gold project (Medium)

The Yellowknife greenstone belt, traceable for 50 km north from Yellowknife Bay, is bound to the east by Burwash Formation sediments. In general, the stratigraphic units strike N50°E. Graded beds indicate that tops are to the southeast. The Yellowknife Formation is part of the Kam Group, a 10 km section of tholeiitic basalt including massive, pillowed and variolitic flows, and flow breccias. There are four contained formations of which the Townsite Formation is most distinctive (dacitic flows, breccias, felsic tuff). Two intervals of pillow basalt form distinctive markers in the Yellowknife Bay Formation. The top unit in the Kam Group is the Kamex Formation: pillowed and volcaniclastic rocks with interbedded tuffs and tuffaceous sediments. N-/NW- striking gabbro dykes of multiple generations occur in the Yellowknife Greenstone Belt (Hauser et al., 2006).

The first claims were staked in 1944 on a visible gold discovery in quartz veins near Giauque Lake. Further gold discoveries were made in

1945. A shaft was sunk in 1946 followed by mine development in 1948 - 1949. Mining commenced in 1950 and by 1960 had reached a depth of 1237 m. The mine was closed in 1969. The interest of Tyhee Development Corp. in the Yellowknife Gold project dates to 2001.

The Ormsby Nicholas area is the northernmost of three mineral zones within the Yellowknife Gold project. Garnet amphibolite metavolcanic rocks within a "sea" of Burwash Formation metasediments are associated with this zone. Above the metavolcanics there is a transitional facies in which metasediments are intercalated with thin amphibolite beds. A high-strain zone referred to as the Discovery Shear Zone is associated with the mineralization. The host rocks at Ormsby are actinolite-albite-carbonate schists, commonly brecciated and derived from calc-alkalic to tholeiitic basalt. Gold occurs in folded quartz veins along with 1-10 % pyrrhotite, lesser pyrite, arsenopyrite and rare chalcopyrite, sphalerite and galena (Pratico, 2009). At Nicholas the host quartz veins are located within a shear adjacent to a small pluton of granodiorite or within Burwash Formation metasediments. The sulphide phases are the same as at Ormsby. The granodiorite also contains scheelite.

Ulu (Small)

The Ulu deposit was discovered by BHP Minerals in 1989. WPC Resources is the most recent owner. The Flood zone, the largest of 16 gold showings, strikes at 118° and dips 70-80° south. Within this zone there are 15 distinct veins, of which the largest is 500 m long and 1.5 to 18m wide and is traceable to a depth of at least 600 m. From its margins inwards it shows the following alteration assemblages: 1) biotite-titanite-tourmaline; 2) silicification (actinolite-carbonate-sericite-clinopyroxene), and 3) silicification (quartz) with arsenopyrite+-K feldspar and gold. Ore zone sulphides, in descending order of significance include arsenopyrite (closely associated with gold), loellingite, pyrrhotite, pyrite, chalcopyrite, and rare sphalerite and galena (Graham and Wahl, 2011).

Hope Bay: Boston, Madrid, Doris (Medium)

Three significant gold deposits and 75 smaller showings are located in the northeastern part of the Slave craton of western Nunavut within the northerly-trending Hope Bay greenstone belt. A port is planned to provide access by way of the Northwest Passage. The potential for gold was recognized soon after the mapping of greenstones in the area in 1962. The Boston deposit was discovered in 1992 followed by Madrid in 1994 and Doris in 1995. These properties are currently worked by TMAC Resources Inc.

Volcanic rocks in the five known extrusive suites range from iron-rich tholeiitic rhyolite in the oldest succession (Flake Lake suite of rift affinity: 2716 - 2697 Ma) to calc-alkaline dacite to rhyolite in the four overlying packages (arc affinity: 2690 - 2662 Ma). These are succeeded by fluvial conglomerates containing detrital zircons, dated at 2715 - 2664 Ma and sourced from the underlying volcanic suites. These, in turn, are invaded by gabbros (2663 - 2262 Ma) and by four phases of granitoids (including tonalite, granodiorite and monzogranite) ranging in age from 2672 - 2608 Ma (Sherlock, 2012). Showings and deposits are closely associated with iron-rich tholeiites in the lower part of the volcanic succession. There is also a close association with iron carbonate alteration and pyrite-bearing quartz veins.

The Doris deposit, located in the northern part of the greenstone belt, is hosted in three quartz vein systems. The mineralogy of the veins includes quartz, sericite, chlorite, tourmaline and gold. The host rocks are overprinted by a hydrothermal assemblage including ankerite, ferroan dolomite, sericite, pyrite and other minor phases. Structural interpretation indicates that the lode gold-quartz veins were emplaced in a saddle-reef structure during D2 strain (Sherlock, 2012). The Madrid deposit, in the same part of the greenstone belt, has a different character. The gold ore occurs in sulphidized iron-rich tholeiite. Hydrothermal alteration at Madrid is associated with a quartz-carbonate stockwork and features sericite, magnesite and ankerite. The gold ores are more explicitly associated with secondary albite, paragonite, ankerite and pyrite, and with hematite alteration (Sherlock, 2012).

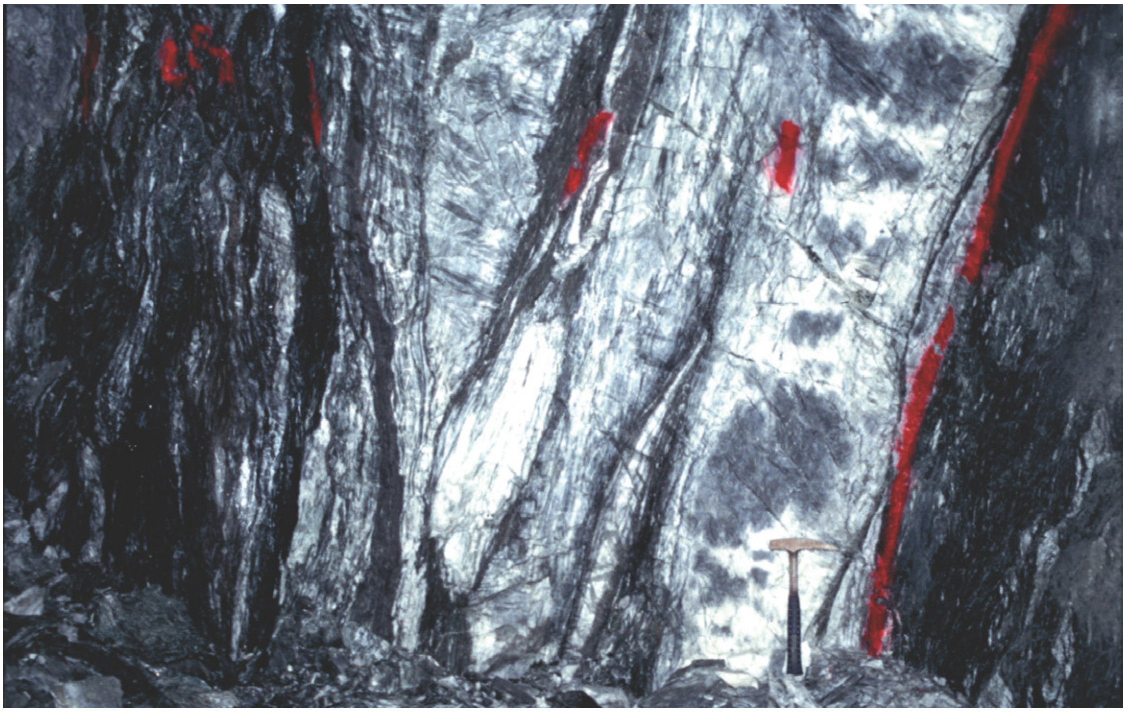


Figure 8. Con Mine stope 59202 (D-006): Section view showing laminated gold-bearing fault-fill quartz-carbonate veins hosted in a ductile shear zone. GSC 2015-109.

The Boston deposit is located in the southern part of the greenstone belt, in association with a belt of ankerite, quartz and sericite alteration that has been traced for 9 km. The ore occurs in a high strain zone in mafic pillow basalt (tholeiite and iron-rich tholeiite) that is gradational to overlying argillite and siliciclastic sediments (Sherlock, 2012).

Colomac (Medium)

The Colomac property is located 220 km NW of Yellowknife. Gold was discovered in this area by prospectors in 1938 and near Baton Lake (N of Indin Lake) in 1945. Five companies were attracted to the area and staked claims on the Colomac site. Prospecting soon led to the discovery of gold at both the East Zone and the West Zone. In 1986 Neptune Resources Corp. optioned the Colomac property and demonstrated that the deposit was amenable to open pit mining. A production decision was made in 1987 and the deposit was brought to production from 1990 to 1997. The current operator is Nighthawk Gold Corporation.

Colomac lies within the larger Indin Lake property, which has 20 known gold deposits and showings. The Colomac property is underlain by mafic to felsic volcanics and intermediate intrusives. These are bound to east and west by metasediments including argillite, greywacke and siltstone. Lenses of pyrite-pyrrhotite iron formation and sulphide-bearing argillite are also present. The volcanic rocks are intruded by a multiphase subvolcanic sill complex consisting of diorite, quartz diorite and gabbro. Part of this is identified as the Colomac Sill (2671 ±10 Ma), a differentiated quartz-albite porphyry of tonalite-trondjhemite composition with up to 2% pyrite and pyrrhotite. It is 40 - 200 m thick and traceable for 6 km (Trinder, 2013). The Colomac ore zones feature quartz veins with gold commonly associated with pyrite, chlorite, pyrrhotite, tourmaline, arsenopyrite, magnetite and sericitic alteration (Trinder, 2013).

Courageous Lake (Large)

The Courageous Lake property is located 240 km NE of Yellowknife near a winter road linking Yellowknife to Diavik and Lupin. Gold was first discovered by prospecting in the 1940s and specific deposits were found in 1944 (Tundra) and 1947 (Salmita). New deposits (the FAT and Carbonate zones) were uncovered by Noranda in 1980 and a shaft was sunk in 1988. However, results were not encouraging and the excavated gold mineralization was stockpiled at the surface. The property was purchased in 2002 by Seabridge Gold Inc (Huang et al., 2014).

The Yellowknife Supergroup within the Courageous-Mackay greenstone belt, 3 - 7 km wide and extending along strike for 70 km, is host to the mineralization. These rocks have attained mid-greenschist facies. The supergroup rocks include early tholeiites and later calc-alkaline volcanics forming a single dominant mafic to felsic cycle. Greywacke and siltstone are increasingly prominent in the upper part of the sequence. Four phases of deformation have been identified - two ductile phases producing foliation fabrics and cleavage, and two late stages of brittle faulting.

The FAT deposit consists of 13 discrete zones collectively 1900 m in length, 800 m wide and known to a depth of at least 800 m. The host rocks are felsic volcanic rocks that range from dacite to rhyolite with textures including lithic lapilli tuff, welded tuff, ash tuff and agglomerate. The deposits show sericitic, silicic, carbonate and potassic alteration. Associated sulphides include pyrite, pyrrhotite, arsenopyrite (closely associated with gold), sphalerite and chalcopyrite. An epithermal origin, involving a hydrothermal system for the gold mineralization at Courageous Lake is favoured by Seabridge Gold (Huang et al., 2014).

Lupin (Medium)

Gold was discovered in the Lupin area by Canadian Nickel Company (Canico) staff in 1960, and was mined by Echo Bay Mines Limited from 1984 to 2004. The latest owner is WPC Resources Inc.

The host unit is the Neoarchean Contwoyto Formation, a turbidite- and iron formation-dominated part of the Yellowknife Supergroup of the Slave craton. The Contwoyto Formation is succeeded by the Itchen Formation, another turbidite unit with carbonate concretions but no iron formation. There is some indication that the Contwoyto Formation may grade laterally into the volcanic flows and tuffs of the Point Lake Formation. Above this there are six plutonic suites of Archean age, all cut by Proterozoic gabbro dykes. Metamorphic isograds in the vicinity of the Lupin property are related to local granodiorite plutons and include sillimanite-in and cordierite-in isograds. Lupin lies almost entirely below the cordierite isograd. The emplacement of the ore is linked to intrusion of the granodioritic Contwoyto Batholith (2.585-2.580 Ga) and related metamorphism and hydrothermal activity in the late Neoarchean (Bullis, 1991).

Figure 9. Lupin: iron formation-hosted stratabound gold. Arsenic-rich gold-bearing sulphide iron formation showing sulphide-arsenide megacrysts distributed along bedding. Scale bar is 1 cm. GSC 1995-201A.

The ore is hosted by Contwoyto Formation turbidites. In the immediate vicinity of the ore deposits there is a unit of greywacke and quartzite overlain by Lupin banded iron formation (Lupin BIF) which is succeeded by phyllite. The five known ore zones (West, Central, Eastern, M1 and M2) are confined to amphibolitic iron formation and the deposit is identified as being of iron-formation-hosted lode gold type (Figure 9). Types of iron formation found include silicate, sulphide and oxide (Greusebroek and Duke, 2005).

There are three deformation phases. S2/S3 include an axial planar cleavage. A major ductile shear zone is mapped at the mine (D3) and is labelled as the Lupin Deformation Zone (LDZ). Gold ores occur where the LDZ penetrative shear fabric is located on the west and central limbs of an F2 dome. Lupin BIF has been traced for 3 km and to a depth of 1500 m (Greusebroek and Duke, 2005). The host rock contains quartz-grunerite±magnetite, where unmineralized, and the ore zones consist of hornblende-quartz-chlorite-native gold ± pyrrhotite, arsenopyrite, loellingite. In general, there are 5-30% sulphides the mineralized zones. Quartz veins ranging from a few cm to 1m wide and traceable for up to 12m are also present. The gold can be seen, in polished sections, to be closely associated with arsenopyrite and loellingite. Accessory minerals include scheelite, chalcopyrite, chlorite, pyroxene, graphite, epidote and ilmenite. Arsenopyrite also occurs as coarsely crystalline haloes around quartz veins (Harron, 2012).

Characteristic dimensions for the ore zones are: West zone: 220 m long x 2.5 m thick, West zone - South: 300 m x 2.0 m, Central zone: 225 m x 5 m thick. The M1 and M2 zones are largely mined out but down dip potential remains (Harron, 2012).

George Lake and Goose Lake (Medium, Large)

The Back River Joint Venture was established in 1982. Surface discoveries were presumably made before 1985 as drilling began in that year. These properties are currently held by Sabina Gold and Silver Corp.

Volcanic-turbidite rocks of the Yellowknife Supergroup are dominant in the Hackett River and Back River areas. These are subdivided into Hackett River (felsic to mafic volcanic), Back (felsic to intermediate volcanic), and Beechey Lake (turbidite) groups. Mineralized iron formation occurs in the Beechey Lake Group (turbidites). Facies of iron formation include oxide (magnetite-chert-grunerite) and silicate (chert-grunerite-chlorite). Both contain iron carbonate. There are indications that three folds in the iron formation represent a repetition of a single iron formation bed.

Three deposits are recognized at Goose Lake: Goose Main, Llama, and Umwelt. The following description is specific to Umwelt but to varying degrees also applies to the others. The bulk of the mineralization occurs in oxide-facies iron formation (chert-grunerite-magnetite) with lesser amounts in silicate-facies iron formation and in clastic sediments (greywacke, siltstone and mudstone). There is also a close association with quartz-carbonate veining, sulphidization, brittle faulting and folding. Mineral species include pyrite, arsenopyrite, pyrrhotite, rare chalcopyrite and free gold (Kent et al., 2013).

At George Lake, mineralization variously occurs in oxide-facies iron formation with less in silicate iron formation. There is a spatial relationship to shear zones in some deposits at George Lake, but a genetic relationship has not been proved. The gold is associated with sulphides in iron formation and with quartz veins. Minerals present include pyrrhotite, pyrite, arsenopyrite, loellingite, gold and minor chalcopyrite. The dominant amphibole is hornblende. Gold-mineralized quartz veins are also present (Kent et al., 2013).

These ore bodies are banded iron-formation hosted gold deposits with similarities to Lupin.

Nechalacho (Thor Lake) (Large)

Uranium claims were first registered on the Thor Lake property in 1970: it was then acquired by Bluemount Minerals Ltd. Niobium (Nb) and tantalum (Ta) were subsequently found in 1976 by Highwood Resources Ltd. Property work and drilling from 1976 to 1979 resulted in the discovery of Nb, Ta, Y (yttrium) and REE (rare earth elements). Active companies on the property since then have included Placer Development Ltd., Hecla Mining Co., Conwest Exploration Co. Ltd., Royal Oak Mines Ltd., Dynatec Corp., Beta Minerals Inc., and (to date) Avalon Rare Metals Inc.

The large Nechalacho deposit is located within the Blatchford Lake Complex, which is intrusive into the Slave craton north of the East Arm of Great Slave Lake (Figure 4). Named intrusive phases include (early) western lobe: peridotite, pyroxenite, layered gabbro, leucoferrodiorite, anorthosite, quartz syenite, and granite, and eastern lobe: peralkaline granite, and (late) syenite. Nepheline syenite is also present, intrusive into the Thor Lake syenite which is host to the Thor Lake deposit. Based on cross-cutting relationships, three distinct late phases of intrusion are documented in the immediate vicinity of the deposits: Grace Lake granite, Thor Lake syenite, and the Nechalacho layered suite. The age range of the Blatchford Lake Complex is 2185±5 Ma to 2175±5 Ma, whereas the ages of the Thor Lake and Nechalacho phases are 2176.8±1.6 Ma and 2164±11 Ma respectively (Mumford, 2014; Ciuculescu et al., 2013).

The Grace Lake granite is an arfvedsonite-aegirine-perthite granite with ca. 25 % quartz. It is gradational to the Thor Lake syenite which suggests that these two phases are synchronous and not intrusive into each other. The Thor Lake syenite consists variously of leucosyenite, fayalite-aegirine syenite and arfvedsonite-aegirine syenite (Mumford, 2014). The Nechalacho layered suite features nepheline and sodalite as primary rock-forming minerals. There is also a cumulate zone containing agpaitic phases such as eudialyte and a so-called "basal zone" which hosts the mineral deposits (Figure 10).

Mineralization in the basal zone includes 4.6 - 9.1 % ore minerals including allanite, monazite, bastnaesite and synchysite (sources of LREE), fergusonite (for Y, HREE, Nb, Ta), ferro-columbite (Nb) and zircon (HREE, Nb, Ta, Zr). Gangue minerals include quartz, plagioclase, microcline, biotite and iron oxides (Ciuculescu et al., 2013). The Nechalacho deposits have been compared to other peralkaline intrusions, notably: Strange Lake, Labrador; Illimaussaq in Greenland, and; Lovozero on the Kola Peninsula in Russia. These are intrusions formed by igneous differentiation, crystal fractionation and crustal assimilation. REE are concentrated in the residual liquid and the eutectic point is depressed by elevated fugacity of gases such as fluorine and carbon dioxide.

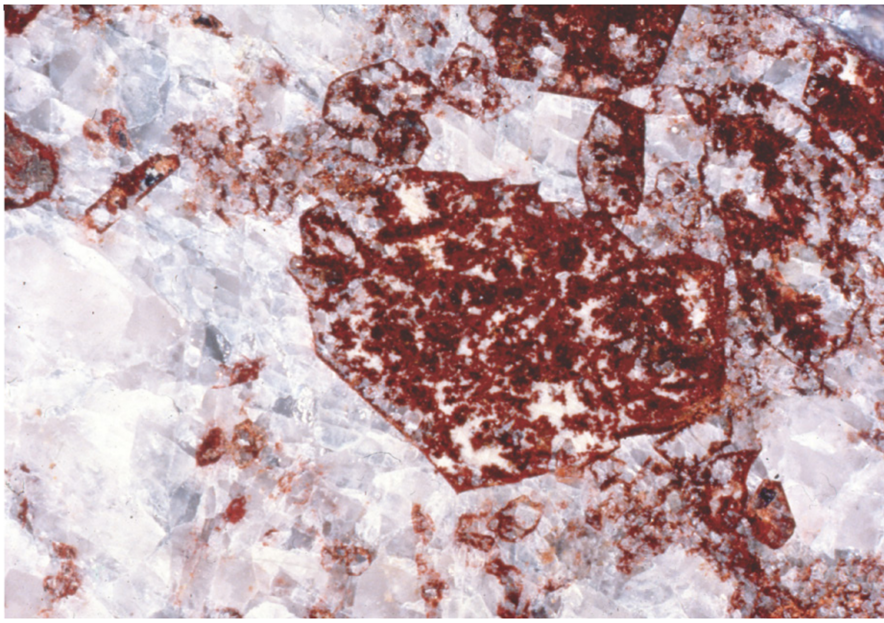


Figure 10. Nechalacho: Eudialyte pseudomorphs in foyaite (Basal Zone) (V. Moeller, McGill University).

GABBRO-HOSTED NICKEL-COPPER PGE

Two large Ni-Cu-PGE deposits of uncertain Paleoproterozoic age, spatially associated with the 2800 km long Snowbird Tectonic Zone (STZ), (Figure 5) are included in this group. This major tectonic break follows the boundary between the Rae and Hearne cratons in the southeast Northwest Territories (Nickel King deposit) and southwest Nunavut (Ferguson Lake deposit). The age and significance of the STZ remains controversial with interpretations including: intracontinental shear zone at 2.6 Ga; intracontinental rift at 2.55 Ga, and; a plate boundary suture at 1.9 Ga (PEG Mining Consultants Inc., 2010).

Nickel King (Large)

Canico (now Vale Inco) discovered nickel at Thye Lake in 1952. The property has been held by Strongbow Resources since 2004.

The Nickel King property is part of the Rae craton and is located 20 km NW of the Snowbird Tectonic Zone. Dominant features on the property include Neoarchean to Paleoproterozoic pelitic to psammitic paragneiss with mafic to ultramafic intrusive rocks. The psammites consist of biotite, garnet, sillimanite, quartz and feldspar. Rare meta-conglomerate preserves primary sedimentary clasts. The range of mafic to ultramafic intrusive compositions includes norite, gabbro and pyroxenite. Norite is the principal ore host. The mineralogy of the norite includes enstatite, clinopyroxene, hornblende, plagioclase and phlogopite.

The metasediments are dominated by a bedding-parallel gneissosity defined by alignment of biotite. Other features in these rocks include tight to isoclinal folds, and younger upright folds. Gabbro/norite bodies are grossly devoid of deformation fabric. However, there is petrographic evidence for strain, and there is evidence to indicate that some gabbro sills have been isoclinally folded, like the enclosing gneiss.

Five ore zones, all hosted by norite, have been identified at Nickel King. The largest, the Main Zone (2600 m in strike length), is interpreted to form a tight recumbent syncline (with upper and lower mineralized sills) which has been refolded in an open fold. The richer mineralization is net-textured to semi-massive and 2-14 m thick. Disseminated zones are mostly 60-80 m thick but range up to 120 m. The typical sulphide assemblage is pyrrhotite with inclusions of pentlandite and chalcopyrite. Grain size ranges from 0.5 - 7 mm (PEG Mining Consultants Inc., 2010). Nickel King has some resemblances to the gabbro-norite hosted Ni-Cu- PGE deposits of the Limpopo metamorphic belt of eastern Botswana, and the Las Aguilas Ni-Cu deposits in Argentina (PEG Mining Consultants Inc., 2010).

Ferguson Lake (Large)

Canadian Nickel Company Ltd. (Canico; now wholly owned by Vale Inco) discovered nickel at Ferguson Lake in 1950. The East and West zones were tested by drilling from 1950 to 1955, resulting in the discovery of significant resources to depths of 240 m. Ore zones were uncovered east and west of Ferguson Lake as well as under the lake.

The Ferguson Lake property is located in the Hearne craton southeast of the Snowbird Tectonic Zone; part of the Yathkyed greenstone belt (~2.71 to 2.66 Ga) consisting of Archean supracrustal and intrusive rocks metamorphosed to upper amphibolite facies, Paleoproterozoic plutons and younger dykes. The supracrustal rocks are identified as mafic volcanics, chert iron formation, lesser intermediate to felsic volcanics and clastic metasediments. The Archean intrusives include granodiorite, quartz monzonite, diorite and gabbro (2.66-2.63 Ga). Host rocks in the vicinity of the Ferguson Lake property include east- to northeast-striking sills (?) of amphibolites and gabbro, sulphide- oxide- and silicate-banded iron formation, quartz-feldspar-biotite gneiss and paragneiss, all intruded by Archean tonalite, granite and pegmatite. The host gabbro/hornblendite displays compositional layering including pyroxenite to leucogabbro (in the West zone) and mesocratic to leucocratic gabbro and anorthosite (in the East zone) (Campos-Alvarez et al, 2012). Three generations of deformation are recognized. Antiforms and synforms have developed in gneisses and metagabbros. Mineralization, hosted by hornblendite, is located in the south limb of a recumbent, doubly-plunging synform, subsequently modified by shear zones and faults.

The host of the magmatic Ni-Cu-PGE mineralization is gabbro and hornblendite. This same body is 10 - 600 m thick and traceable from East to Central to West zones, a distance of 12 km. Better grades occur in lenses, pods and stringers (two to tens of metres thick) of massive to semi-massive ore consisting of 80-90% pyrrhotite, lesser chalcopyrite, pyrite and pentlandite. Platinum group minerals identified include two palladium tellurides, three palladium bismuthinides, and palladium and platinum arsenides. Other textures include brecciated ores (gabbro clasts in a sulphide matrix), and net-textured ores noted in stringer and fracture-filling zones. The Ferguson Lake ores have been identified as tholeiitic intrusion- hosted nickel-copper ores (associated with differentiated intrusions) (Clow et al., 2011).

ULTRAMAFIC-HOSTED NICKEL-COPPER PGE

Large Ni-Cu-PGE deposits of commercial significance are located in Paleoproterozoic ultramafic rocks in the Cape Smith belt of northern Ungava (province of Quebec; Figure 11). The Cape Smith belt (2.04 - 1.86 Ga) has been interpreted as a stack of southerly transported klippen consisting of quartzite, semipelite, ironstone and gabbro-peridotite in the lower part (Povungnituk Group) and basalt, and gabbro-peridotite in the upper part (Chukotat Group). These rocks accumulated on a long-lived north-facing rifted margin.

The age of the mineralized ultramafic rocks is 1.883 Ga. The host rock is the volcano-sedimentary Povungnituk Group consisting of the Nituk Fm. at the base (conglomerate, sandstone, siltstone, silicate iron formation); the Beauparlant Fm. (tholeiitic basalt, phyllite); the Cecilia Fm. (alkaline basalt, andesite, minor rhyolite, pyroclastics, sediments), and the Nuvilic Fm. (deep marine sediments including exhalative sulphides). The Nuvilic Formation is intruded by the Lac Esker Suite ultramafic intrusions, which host the West Raglan deposits. The overlying Chukotat Group is largely volcanic (komatiitic to tholeiitic basalts) and is coeval with the Lac Esker Suite (also intrusive into the Chukotat Group). The Lac Esker Suite consists mainly of subvolcanic ultramafic sills, predominantly composed of wehrlite but ranging from dunite to peridotite and pyroxenite. Individual intrusions are <150 m thick and traceable for 1 - 10 km. Overlying this there is a mostly volcanic island-arc accretionary complex, the Watts Group.

The Ni-Cu-PGE deposits are located primarily in Chukotat peridotite (Lesher, 2007). The Raglan, West Raglan and Nunavik deposits are described below. Neoarchean nickel mineralization also occurs in ultramafic rocks in the vicinity of Rankin Inlet, Kivalliq region, southwestern Nunavut.

Raglan (Large)

Low-grade showings were first discovered in 1898, in the western part of the Cape Smith Belt by A.P. Low of the Geological Survey of Canada. Sporadic exploration has taken place in the Cape Smith Belt and in the Raglan deposit area since the 1930s with the first high-grade showings being discovered by prospectors in 1956. Mining was first attempted by New Quebec

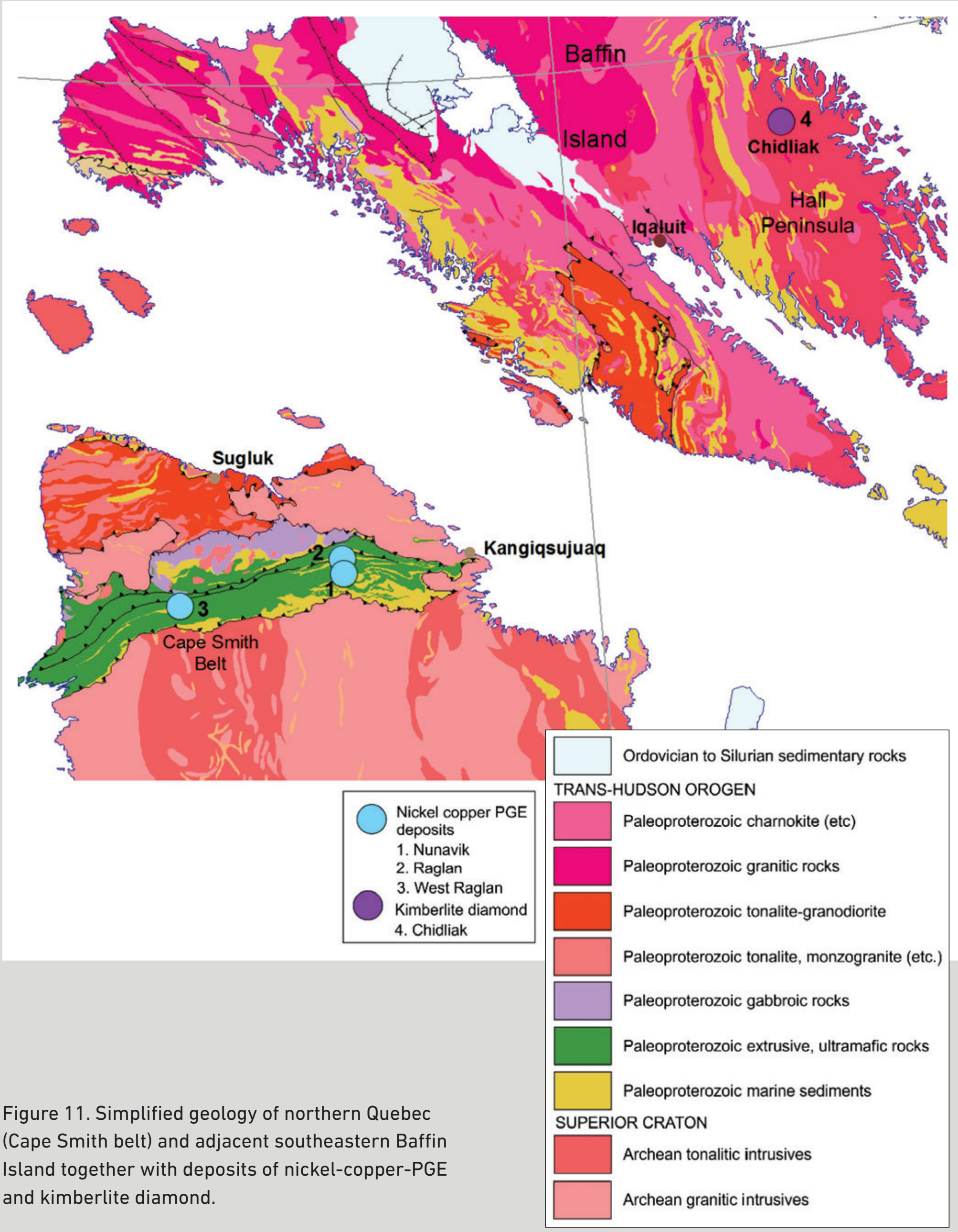


Figure 11. Simplified geology of northern Quebec (Cape Smith belt) and adjacent southeastern Baffin Island together with deposits of nickel-copper-PGE and kimberlite diamond.

Raglan Nickel Mines from the 1960s to 1970s but was then abandoned due to low metal prices. Mining was renewed from December 1997 when Falconbridge Ltd. Xstrata acquired Falconbridge Ltd. in 2006. A merger in 2013 led to formation of the current mine owner, Glencore Xstrata.

The dominant mineralization at Raglan is footwall-contact type composed of disseminated, net-textured and massive pyrrhotite, pentlandite and chalcopyrite, contained in over 140 lenses located from the surface to a depth of 750 m (Figure 12). Lens tonnages range from 0.01 to 5.2 Mt, averaging 0.2 Mt. The basal layer in each lens is typically massive, overlain by net-textured ore that grades into disseminated mineralization. Massive to semi-massive brecciated ore also occurs and consists of a mixture of footwall sediments and ultramafic rock. Another feature is injection of sulphides into host rock sediments. The “up” direction at the time of sulphide emplacement was to the north, in sill (or dyke) rocks that are considered to have been subvertical. Ore lenses typically occur in embayments at the base of ultramafic sheets. Similarly, canoe-shaped intrusions feature “keels” of sulphide, tens to hundreds of metres in length. The ore zones occur in linear clusters that collectively define the channel in which they occur (Desharnais, et al., 2014).

West Raglan (Large)

The West Raglan property (owners: True North Nickel Inc. and Royal Nickel Corp) is located in the western part of the Cape Smith Belt, which consists mainly of 1.88 Ga-old magmatic rocks associated with the Chukotat Large Igneous Province. Three types of ore lens have been identified: contact, hanging-wall and vein-type mineralization. Seven zones have been delineated at West Raglan. In general, the mineralization occurs at contacts between ultramafic intrusive sills (Desharnais, et al., 2014).

Nunavik (Large)

The Nunavik Nickel mine is located 80 km W of Kangiqsujuaq (Wakeham Bay) and 30 km ESE of the Raglan Mine in the Nunavik region of northern Quebec. Disseminated sulphides were first discovered in the area in 1957. The current owner is Jilin Jien Nickel Industry Co. Ltd.

The Ni-Cu deposits in the Cape Smith belt lie in the Raglan Trend in the north and in the South Raglan Trend located 20 km to the south. Although in many ways similar, there is a contrast in Ni/Cu ratios: 3:1 in the Raglan trend and closer to 1:1 in South Raglan. The host rock for the deposits in the Nunavik Nickel property, located in the South Raglan Trend, is the Expo Intrusive Suite, a 500 m wide intrusive complex, consisting of gabbro dykes, ultramafic bodies, dunite pipes and sill-like peridotites. These have been emplaced into the Povungnituk Group and are collectively traceable for 50 km in an east-northeasterly direction. Host-rock ultramafic bodies have a dyke- or channel-like (or trough-like) geometry, individually 100-200 m wide and traceable along strike for several kilometres. In general, the sulphides occur in the basal part of various ultramafic sheets with massive sulphide lenses at the base grading up into net-textured (25-75%) sulphides and a wider halo of less significant disseminated sulphides (Armstrong et al., 2010).

Seven mineralized zones have been defined within the Expo Intrusive Suite. The following description applies to one of these, the Allammaq zone. The deposit is hosted in peridotite that varies in attitude from a dip of 20°N to near vertical and has been emplaced into metabasalt and metasediment of the Beauparlant Formation (part of the Povungnituk Group). Drilling indicates the presence of four distinct units within the host intrusion: 1) pyroxenite-peridotite, 2) hornblende gabbro; 3) sparsely mineralized pyroxenite-peridotite, and 4) heavily mineralized pyroxenite. Sulphides occur as disseminations, blebs, net-textured ores, and vein-like massive sulphides.

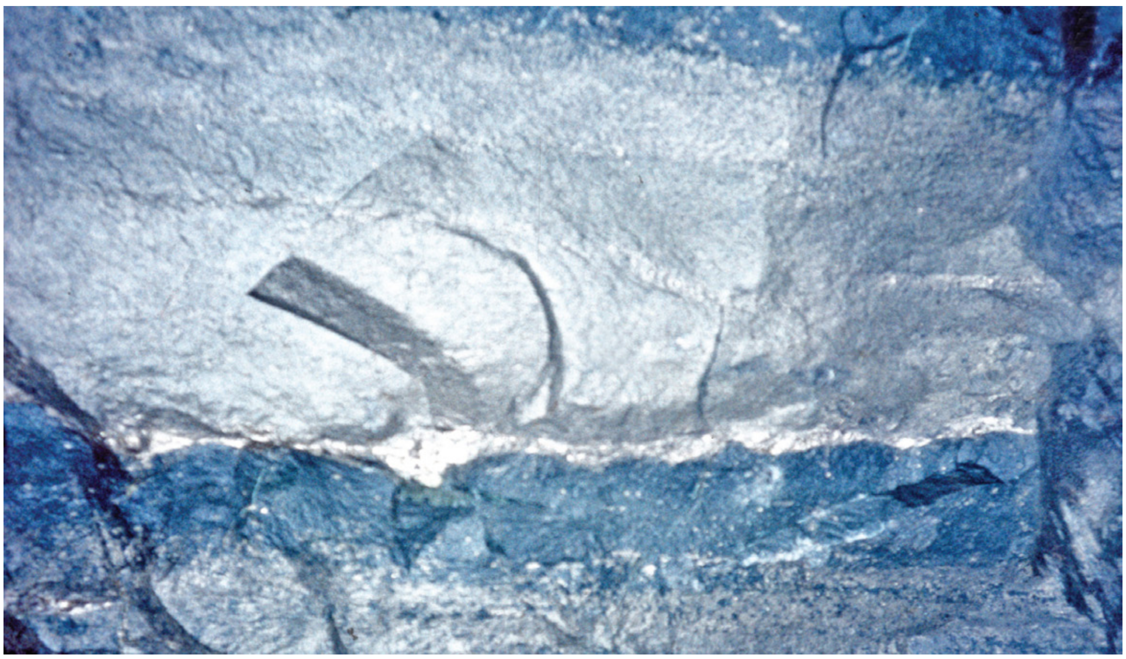


Figure 12. Raglan (Katinniq mine): from base, net-textured Fe-Ni-Cu sulphides, disseminated sulphides, massive sulphides (metallic band) and disseminated sulphides (at top) (C.M. Lesher, Laurentian University).

In descending order of significance the sulphide mineralization includes pyrrhotite, pentlandite (major carrier of cobalt), chalcopyrite and accessory galena, sphalerite, cubanite and cobaltite. Platinum group minerals include sudburyite (lead antimonide), PGE tellurides including michenerite (a palladium bismuth telluride), merenskyite (a palladium telluride), moncheite (a platinum telluride), kotulskite (a palladium telluride), and sperrylite (platinum arsenide); gold is carried in electrum (Armstrong et al., 2010).

Rankin Inlet (Small)

The deposit is located on the west shore of Hudson Bay near the community of the same name (Figure 5). It was discovered in 1928, grade and tonnage figures were obtained in 1929 and the deposit was mined by North Rankin Nickel Mines Ltd. from 1957 to 1962. The deposit is located in the Rankin Inlet Greenstone Belt which is subdivided into a lower volcanic cycle, a clastic sedimentary horizon and an upper volcanic cycle. The lower volcanic cycle consists of a mixed assemblage of volcano-sedimentary rocks dated at 2663±3 Ma (Tella et al., 1996). The upper cycle consists of thick, pillowed flows and minor interflow sediments with a date of 2629±14 Ma (Tella et al., 1996).

The mineralized sill has been emplaced along the contact between greywacke sediments, tuffs and quartzites (below) and upper cycle volcanics (above). It consists of pyroxenite and serpentinized talc-rich peridotite. Mineralization occurs in depressions along the base of the host-rock sill. Massive sulphides at the base grade upwards into net-textured and disseminated ores. Metallic phases include pyrrhotite, pentlandite, chalcopyrite, magnetite, pyrite, gersdorffite, violarite and marcasite.

PALEOPROTEROZOIC OROGENIC GOLD

Gold deposits of presumed or established Paleoproterozoic age are hosted in Neoarchean iron formation in the Rae and Hearne cratons of southwestern Nunavut (Figure 5). The Cullaton Lake (not described), Meadowbank, Meliadine (large) and Three Bluffs deposits are considered here. The Meadowbank deposits are located 70 km N of Baker Lake community in the Rae craton. The Three Bluffs deposit is also located N of Baker Lake. The Meliadine property is located in the Hearne craton 25 km NW of Rankin Inlet on the west shore of Hudson Bay: it is connected to Rankin Inlet by all-weather road.

Meadowbank (Large)

The Meadowbank deposit, currently owned by Agnico-Eagle Mines Ltd, is primarily hosted by iron formation of the Neoarchean Woodburn Lake Group. The stratigraphy of the Group includes quartzite (at the base), conglomerate, ultramafic metavolcanics (talc-chlorite-amphibole) and intermediate volcaniclastic rocks with wacke, mudstone and Algoma-type iron formation (Sherlock et al., 2004). Felsic volcanics in the Woodburn Lake Group are dated to 2.735 - 2.71 Ga ((Sherlock et al., 2004; Ruel et al., 2012). Detrital zircons in quartzite are dated at 3.0 - 2.81 Ga. There is widespread intrusion of granitoids dated to 2.62 - 2.60 Ga. The metamorphic grade ranges up to granulite facies regionally, but the grade near the deposit is upper greenschist to lower amphibolite facies. Geologic relationships and geochronology indicate that the gold mineralization was introduced during D2 deformation (isoclinal folds, axial planar foliation and shear zones) in the Paleoproterozoic (1.9 - 1.8 Ga; Sherlock et al., 2004). All these units are overlain by Paleoproterozoic strata of the Baker Lake Basin.

Meadowbank has four significant ore zones: Portage, Goose, Vault and Bay. The Portage and Vault zones are currently being mined (Agnico-Eagle, 2016). The largest, Portage, is 1.85 km x 100-230 m wide and 6-8 m thick. Goose is 750 m x 500 m wide and 3-20 m thick. Vault is 1100 m long and 8-18m thick (Ruel et al., 2012). The Portage and Goose deposits are identified as iron- formation-hosted lode gold type. Vault is a lode-gold deposit of disseminated/replacement type. The primary mineralogy of the iron-formation host rock is magnetite, quartz and amphibole, in layers 0.2 to 5.0 cm thick. The deposits are associated with widespread sulphide and native-gold replacement of magnetite. Sulphide minerals include disseminated to semi-massive pyrrhotite and pyrite with minor chalcopyrite and arsenopyrite. Gold also occurs in quartz-sulphide veins.

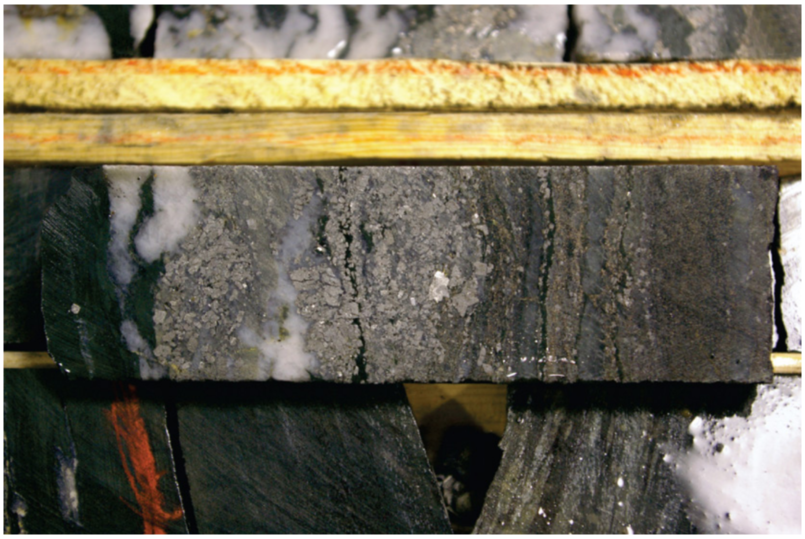


Figure 13. Meliadine: chloritized and sulphidized silicate facies iron formation at Tiriganiaq showing coarse arsenopyrite crystals and chlorite clots oriented sub-parallel to the foliation. GSC 2015-114.

Meliadine (Large)

The Meliadine deposits (Agnico Eagle Mines Ltd.) are located within the Rankin Inlet greenstone belt, part of the Hearne craton. Supracrustal rocks encountered in the greenstone belt include mafic volcanics, felsic pyroclastic rocks, sediments and gabbro sills. The gold deposits and showings are closely associated with the Meliadine trend, a W-NW-trending belt of supracrustal rocks that includes a major structure, the Pyke Break. The Pyke Break is a several kilometres wide high-strain zone that is spatially associated with the known gold deposits. The Meliadine trend includes seven ore zones: Tiriganiaq, Discovery, Normeg, Wesmeg, F zone, Pump and Wolf. Ore emplacement is considered to have occurred during the third deformation phase in the Paleoproterozoic, but is postdated by crenulation.

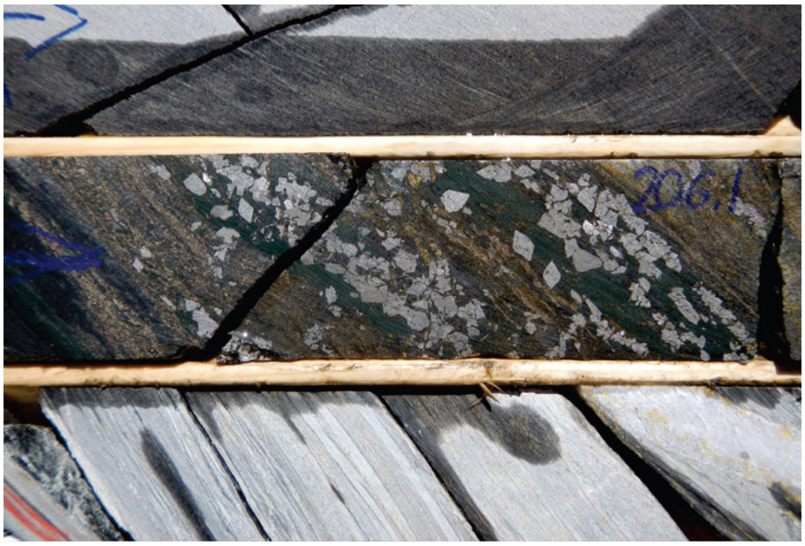


Figure 14. Meliadine: hydrothermally altered oxide facies iron formation adjacent to a cryptic and arsenopyrite-rich quartz vein. GSC 2015-115.

The stratigraphic setting of the Tiriganiaq deposit features the following units: turbidites (Sam Formation), iron formation with chert, chloritic mudstone and greywacke (Upper Oxide Formation), siltstone (Tiriganiaq Formation) and basalt, gabbro dykes and interflow sediments (Wesmeg Formation). The oldest gabbros feed mafic volcanics while the youngest are post-tectonic and are associated with ore emplacement. The ore horizons are spatially associated with the Upper Oxide Formation but in other deposits (Wesmeg, Normeg) they extend into the Wesmeg Formation. The gold mineralization is, in general, associated with shearing and quartz veining during the Paleoproterozoic (Orosirian) Trans-Hudson orogeny (1.9-1.8 Ga). Re-Os ages on arsenopyrite yield ages of 2.27 and 1.90 Ga (Lawley et al., 2015). This suggests phases of mineralization that are coincident with the Arrowsmith and early Trans-Hudson orogenies.

Gold-hosting quartz occurs as veins several metres thick but ranging downwards in size to erratic quartz stringers and stockwork. Typical vein mineralogy includes quartz, and quartz-ankerite. In contrast, quartz-calcite veins are barren. Primary sulphides introduced during mineralization occur in iron formation and argillite as wispy discontinuous laminae of pyrrhotite, pyrite, chalcopyrite and arsenopyrite (Figures 13, 14). Late-stage sulphides include galena and sphalerite. In general, sulphides are not a reliable prerequisite for high gold grades. Ore-deposit types include orogenic-greenstone and banded iron-formation-hosted gold mineralization (Larouche et al., 2015).

Three Bluffs (Medium)

The Three Bluffs gold deposit (North Country Gold Corp) is also hosted by Archean iron formation. The age of the mineralization is Paleoproterozoic. These iron formations lie within the Committee Bay belt (2.73 - 2.69 Ga), which consists of komatiite-quartzite-iron formation that has been metamorphosed to amphibolite and granulite facies and intruded by diverse granitoids (2.61 - 2.59 Ga). Younger granitoids include granite, granodiorite and monzogranite (1.82 Ga) (Davies et al., 2010).

The gold mineralization at Meadowbank, Meliadine and Three Bluffs is associated with multiply deformed rocks and, at Three Bluffs, with major shear zones. These include splays off the Walker Lake shear zone, and are associated with F2 fold hinges (1.85 - 1.82 Ga). The highest gold grades are associated with silica-rich intervals (tectonized quartz veins) and with muscovite-rich intervals (metamorphosed hydrothermal alteration) in sulphide-facies iron formation. Sulphides associated with the mineralization include pyrrhotite, pyrite, arsenopyrite, chalcopyrite and loellingite (Davies et al., 2010). The age of the gold mineralization is 1.86 - 1.82 Ga, roughly synchronous with the TransHudson Orogeny and Three Bluffs D2 deformation, but predating 1.78 Ga metamorphism.

POLYMETALLIC VEINS

Host rocks for uranium and silver arsenide vein deposits lie within the Great Bear magmatic zone (1.87 to 1.84 Ga), part of the western domain of Wopmay orogen, a magmatic and collisional belt that brought together the Slave craton located to the east and the Hottah terrane to the west. Included in this category of deposits are the Eldorado, Echo Bay and Terra Silver mines near Port Radium on Great Bear Lake (Figure 15). The belt also includes iron oxide copper gold deposits (IOCG: NICO, Sue-Dianne).

Port Radium (Medium)

Silver and uranium deposits near Port Radium are located along the eastern shore of Great Bear Lake, Northwest Territories (Figure 16). These include the former Eldorado uranium and silver mine and the Echo Bay silver deposit. The first record of iron, copper, uranium and cobalt near Echo Bay was made by J.M. Bell of the Geological Survey of Canada in 1900. High-grade pitchblende and silver ores were discovered in 1930 by the prospector, Gilbert LaBine. Mineral production began at Eldorado in 1933, but closed briefly in 1940, reopening in 1942 to supply uranium to the war effort. Production was maintained, more or less continuously, to 1982. The Echo Bay deposit was brought into production for silver and copper from 1964 to 1975.

Host rocks in the area include the Port Radium Formation of the LaBine Group (sandstone with lesser carbonate), Cobalt porphyry and andesite of the Surprise Lake Member. These are intruded by quartz monzonite and granite of the Great Bear magmatic zone, and by diabase of the Cleaver and Western Channel swarms. Studies have shown that two types of granite are present. One of these is associated with high heat flow and may be a source for uranium in the Port Radium area (Somarin and Mumin, 2012).

Ore deposit metals are associated with steep northeast-striking faults in andesitic deposits of the Great Bear magmatic zone. The earliest

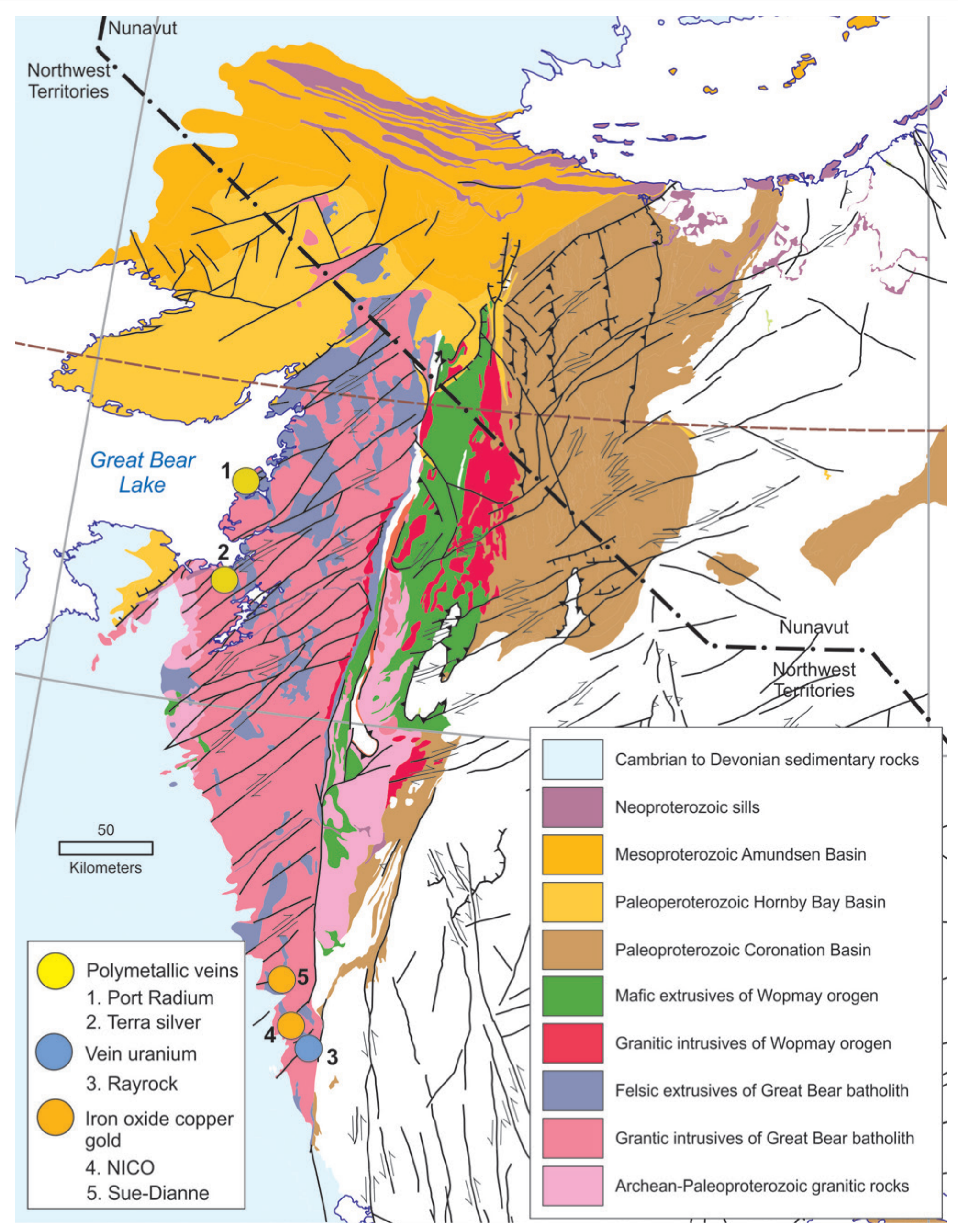


Figure 15. Simplified geology of Wopmay orogen and Great Bear batholith in Nunavut and Northwest Territories with deposits of polymetallic veins, vein uranium and iron oxide copper gold.

mineralizations, sparse chalcopyrite and pitchblende in quartz, are seen to heal these brittle faults. These are then cut by Cleaver diabase dykes dated at 1.74 Ga (Gandhi et al., 2013). Post-Cleaver fault reactivation led to a total of five stages of mineralization as follows.

Stage 1: pitchblende with chlorite, fluorite, carbonates; Stage 2: arsenides, nickel sulphides, native silver, native bismuth. These first two stages precede 1.66 Ga Narakay Islands volcanics. Stage 3: polymetallic sulphides, silver tellurides; Stage 4: carbonates, native bismuth, minor native silver. These stages are intruded by Western Channel Diabase at 1.59 Ga. The fifth and final stage, post-Western Channel diabase, produced additional native silver and bismuth (Gandhi et al., 2013).

Terra Silver (Small)

The Terra Silver property is located on the southeast side of Great Bear Lake in the Northwest Territories. Although there were

Figure 16. Aerial view looking east of the Port Radium mine site on Great Bear Lake. GSC 2015-119.

staking rushes for nickel, uranium and silver in the area from 1929, little was accomplished until the 1960s. High-grade silver and copper intersections were reported by Terra Mines Ltd from the drilling campaign of 1967. Mining occurred from 1969 - 1985. Historic production at Terra Silver includes high-grade silver plus cobalt, bismuth and nickel arsenides hosted in a gangue of quartz, albite and carbonate. The veins are located in the Terra Formation of the Labine Group which is identified as caldera-fill of fluvial and lacustrine sediments. Ten percent of the host sediments contain banded and disseminated sulphides including pyrite, pyrrhotite, chalcopyrite, arsenides, native silver and bismuth. Native silver-bearing pods in the host veins are enveloped by an alteration assemblage that includes quartz, hematite, chlorite and carbonate. Minor minerals include skutterudite, safflorite, rammelsbergite, matildite and sphalerite (Webb, 2003).

VEIN URANIUM

Vein uranium is commercially significant at Rayrock in the southern Great Bear magmatic zone and at Lac Cinquante in the Hearne craton W of Hudson Bay in southwestern Nunavut.

Rayrock (Small)

The Rayrock uranium mine is located at the southern end of the Great Bear magmatic zone, 40 kilometres N of the north arm of Great Slave Lake. Pitchblende was first identified in the area by Geological Survey of Canada staff in 1934. Intensive prospecting in the 1950s led to the discovery of the Rayrock deposit which was mined from 1957 to 1959. The mineralization at Rayrock features uranium and copper in giant quartz veins in brittle fractures that post-date Great Bear magmatic activity. The ore-bearing veins are up to 60 m wide and traceable for 5 km. The host rock is gneissic granodiorite that has been mylonitized and altered. Alteration assemblages up to 10 m wide include silicification, chloritization, epidotization and hematization. Most of the quartz veins are barren but some contain hematite, copper sulphides, pyrite and pitchblende. Study of the paragenesis indicates early pitchblende followed by bornite, chalcocite, covellite and hematite. Lead isotopic ages on pitchblende indicate an age of 517+-80 Ma, which suggests a genetic association with transgressive Cambrian strata (Gandhi, 1994).

Lac Cinquante (Medium)

The discovery of polymetallic showings and a uranium deposit at Lac Cinquante dates to the 1960s. Independent of their uranium potential many of the showings are enriched in copper and silver. Most uranium-related work ended in 1981. Renewed interest in uranium and in iron oxide-copper-gold potential arose in 2007. The property is held by Kivalliq Energy Corporation. The nearest settlement to Lac Cinquante is Baker Lake, 225 km to the northeast (Figure 5).

The Lac Cinquante deposit is located in the Angikuni Greenstone Belt of the Chesterfield Block, part of the Hearne craton. It is close to the unconformity below the transtensional Paleoproterozoic Baker Lake Basin (1.84 - 1.79 Ga). Other Paleoproterozoic depocentres include the Wharton (1.76 - 1.74 Ga) and Thelon (1.72 - 1.54 Ga) basins. Contemporaneous intrusives include the Hudson (1.85 - 1.81 Ga) and Nueltin (1.76 - 1. 75 Ga) granitoids (Bridge et al, 2013).

The deposit is hosted by Archean graphitic-tuffaceous metasediments. Typical strata of the overlying Baker Lake Basin near Lac Cinquante include a discontinuous fault-related basal breccia overlain by conglomerate with granitoid clasts and an arkose that grades laterally to trachyte (Christopher Island Formation) (Bridge et al, 2013). The deposit is fracture-controlled, brecciated and associated with alteration phases including veins of hematite, chlorite, quartz, carbonate and pitchblende. Ore shoots lie within the plane of the host tuff and have been traced along strike for 3.5 km, and to a depth of 400 m. The mineralogy of the host includes pyrite, chalcopyrite, molybdenite, galena, sphalerite, pitchblende, coffinite and a variety of other uranium phases (Figure 17; Dufresne et al., 2013). The pitchblende has been dated to 1.83 Ga (U-Pb), coinciding with the Hudson granitoid suite and deposition of the Baker Lake Group (Bridge et al, 2013).

The deposit type has been compared to the basement- and structure-hosted uranium vein type, not unlike that found in the similar age Beaverlodge district of Saskatchewan (1.9 to

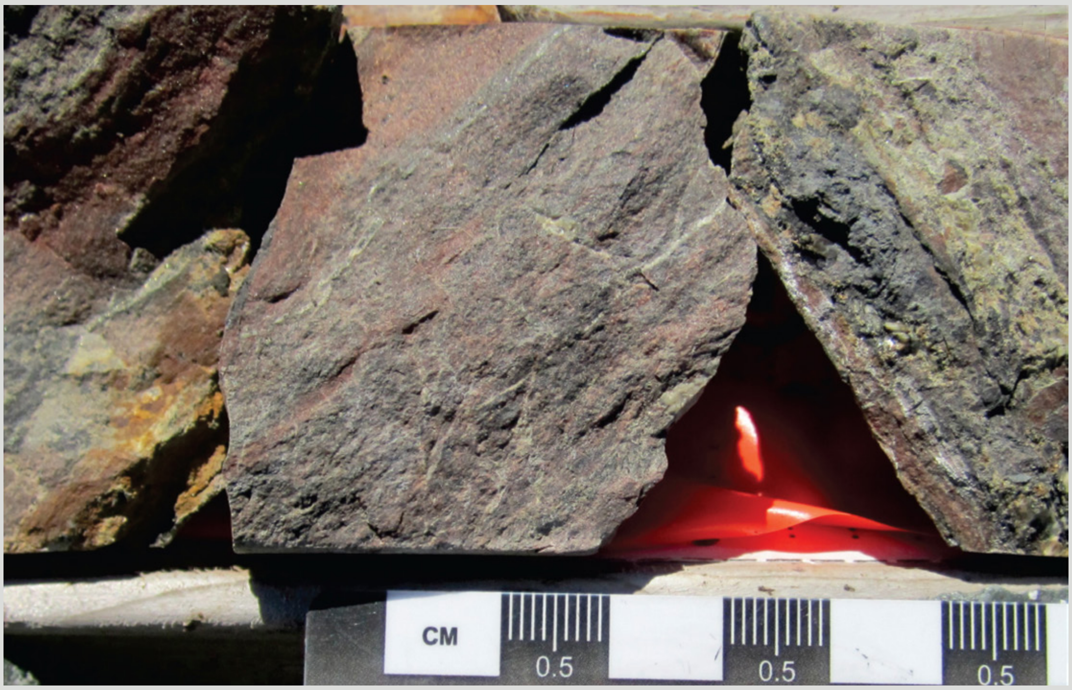


Figure 17. Lac Cinquante Main Zone: foliated graphite chlorite sulphide tuff; pervasive hematite alteration and quartz pitchblende veinlets and breccia. GSC 2015-113.

1.8 Ga). Two theories have been proposed for the origin of Lac Cinquante. The first is that the uranium is derived by leaching from Baker Lake Basin and the Hudson granite and concentrated in basement graphitic rocks which acted as a reductant; the second is that the uranium derives entirely from Baker Lake strata and was concentrated in a hydrothermal system associated with emplacement of the Hudson granite (Bridge et al, 2013).

UNCONFORMITY URANIUM

Three deposits in this category are closely associated with the unconformity below Paleoproterozoic strata of the Thelon Basin in Northwest Territories and Nunavut (Figure 5). These include the Boomerang Lake deposit (Small, not described) in southeast Northwest Territories, the Kiggavik deposit W of Baker Lake in southwestern Nunavut, and the Andrew Lake deposit (not described) near Kiggavik, also in Nunavut.

Kiggavik-Andrew Lake trend (Medium)

The Kiggavik deposits are located 80 km W of Baker Lake in the Kivalliq region of Nunavut. Exploration in the area has been ongoing since the 1970s. The Kiggavik Main Zone (KMZ) and two other deposits were discovered in 1974 by lake/water geochemical methods and by airborne radiometrics. The project consists of five uranium deposits, three at Kiggavik and two at a separate location (Sissons site). Four of the deposits are to be mined by open pit, and one by underground methods. Other discoveries were subsequently made at Andrew Lake and Endgrid 15-17 km SW of Kiggavik. In 1993, controlling interest in the property passed from Urangesellschaft to COGEMA Inc. (Areva) who undertook a pre-feasibility study in 1997.

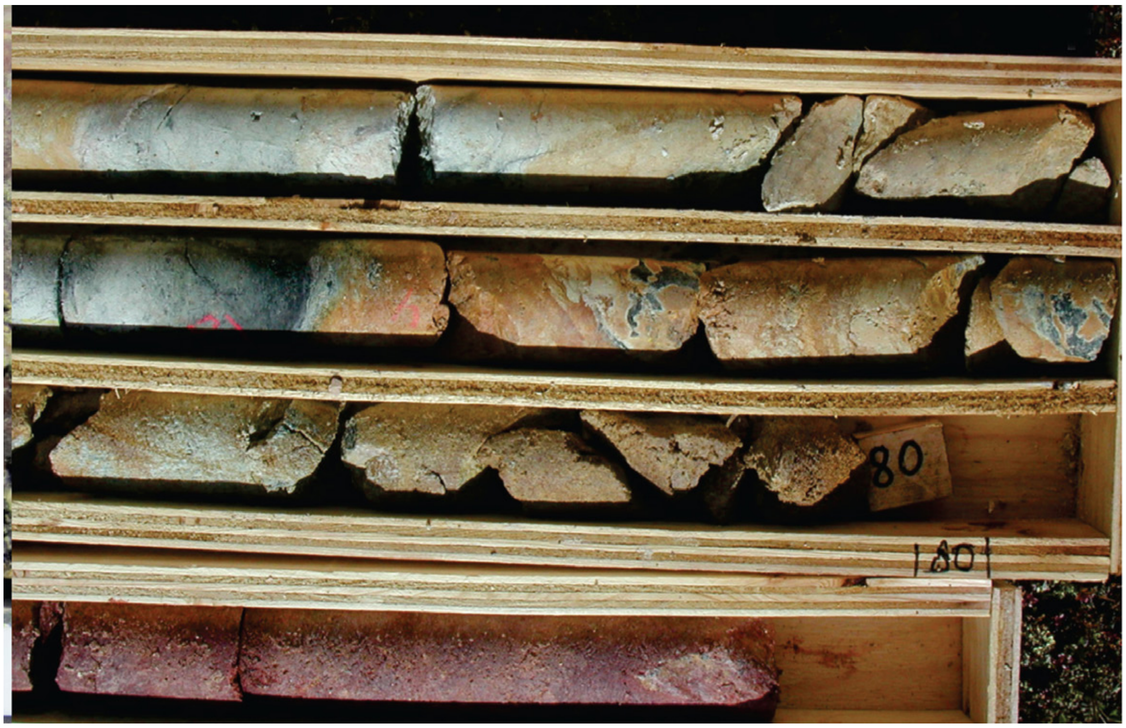


Figure 18. Kiggavik Main Zone: showing vermiform texture (irregular roll front like feature) and graded density of uraninite in remobilized uranium zones. GSC 2015-112.

The deposits lie just outside the Paleoproterozoic Aberdeen Sub-basin of the northeastern Thelon Basin. The deposits lie in basement and are separated from the Thelon Basin by the Thelon Fault. The basement consists of highly deformed but weakly metamorphosed Neoarchean to early Paleoproterozoic metasediments, metavolcanics and intrusive rocks. These were intruded by Hudson Suite granite and by ultrapotassic mafic to felsic dykes, all dated at 1.83 Ga. The basal unit of the overlying Dubawnt Supergroup is the Baker Lake Group: conglomerate, sandstone, ultrapotassic volcanic rocks, syenite, microsyenite and lamprophyre.

The middle unit of the Dubawnt Supergroup is the Wharton Group; associated with the 1.75 Ga Kivalliq Igneous Suite (KIS: volcanic and epiclastic rocks, Nueltin granite, anorthositic gabbro, and diabase in two swarms (Robinson et al., 2014). This is overlain by the Thelon Formation pink sandstone.

The host rock at Kiggavik is Neoarchean quartzofeldspathic metagreywacke with minor iron formation and metapelite, unconformably overlain by 2.6 Ga rhyolite (ore host) and early Paleoproterozoic quartzite (barren) (Robinson et al., 2014). The three ore zones discovered to date are: the East (EZ), Main (KMZ) and Centre (CZ) zones. The largest is KMZ, hosted by greywacke and KIS granite. Ore is also enclosed by alteration and features desilicification and conversion of feldspar to sericite and illite. The ore minerals include uraninite, coffinite and minor uranophane as fine disseminations, veinlets parallel to foliation and fracture fillings (Figure 18). Other minerals in trace quantity include galena, copper sulphides, gold and electrum, molybdenite, bismuth minerals, iron oxides and others (Robinson et al., 2014).

SANDSTONE-HOSTED URANIUM

Amer Lake (Medium)

The Amer Lake property is located 150 km N of Baker Lake and 70 km N of the Meadowbank gold deposit in southwestern Nunavut (Figure 5). Interest in the area dates to 1969, when an airborne radiometric survey by Aquitaine led to the discovery of uranium mineralization in sandstone. The Main and Faucon zones were outlined by drilling in 1970. Significant lateral continuity of mineralization was proven by Uranerz in 1978. The property has been held by Adamera Minerals since October 2015.

The geological context includes Archean basement (>2.7 Ga) of the Rae craton infolded with supracrustal rocks of the Woodburn Lake Group (2.72 Ga), all intruded by granitic and dioritic rocks (2.6 Ga). These are overlain unconformably by the Paleoproterozoic Amer Group (2.45-2.1 Ga) which underwent deformation, intrusion and regional metamorphism associated with the trans-Hudson orogeny (1.91-1.80 Ga). Overlying this orogen there are generally unmetamorphosed Paleoproterozoic sediments of the Baker Lake (1.85-1.79 Ga), Wharton Group (1.75 Ga) and Thelon (1.72 Ga) basins (Armitage, 2009).

The uranium mineralization at Amer Lake is associated with exposures of the Amer Group E of Thelon Basin. Host formations consist of arkose, feldspathic sandstone, quartz arenite, mudstone and minor dolostone. The target for exploration is sandstone-hosted uranium as for other deposits of this type located in Australia, southwestern US, South Africa and Kazakhstan. Ore minerals of the Main zone at Amer Lake include uraninite, lesser brannerite and a secondary phase, uranophane (Armitage, 2009).

These deposits include the NICO and Sue Dianne deposits of the Great Bear batholith, part of the Wopmay orogen W of the Slave craton (Figure 15). Also considered in this group are the Wernecke breccia deposits (Pagisteel) located in the Ogilvie Mountains of northern Yukon, and the younger Minto (large) and Carmacks copper deposits located in the Canadian Cordillera of central Yukon (Figure 44).

NICO (Medium)

The NICO property is located in the vicinity of Mazenod Lake, 160 km NW of Yellowknife. Mineralization was discovered in the area in the 1930s. The first property work on known Co-Bi-Cu arsenide showings was by New Athona Mines Ltd, from 1968 to 1970. Drilling uncovered the additional occurrence of gold. New discoveries were made by Fortune Minerals Ltd who acquired NICO in 1994, and recognized favourable similarities to the Olympic Dam deposit in Australia. Delineation drilling and pre-feasibility studies were carried out in 1998 and 1999, and bulk sampling in 2007.

The NICO deposit occurs in the Great Bear magmatic zone (GBMZ), part of the Wopmay orogen.

Figure 19. NICO: Stratabound to vein-type magnetite-group IOCG ore, dominated by cobalt-rich arsenopyrite and magnetite replacing pervasive and intense amphibole-magnetite-biotite alteration of metasedimentary rocks. GSC 2015-116.

The GBMZ extends northwards from Great Slave Lake to eastern Great Bear Lake and consists of calc-alkaline volcanic and plutonic rocks (1.88 to 1.84 Ga; Goad et al., 2000). It occupies the orogenic suture between the Coronation platform margin of the Slave craton (to the east) and the Hottah terrane (to the west). The GBMZ consists of low-titanium oxide and high-alumina calc-alkaline volcanic and plutonic rocks. Volcanic rocks of the Faber Group, varying from felsic to intermediate, are prominent in the southern GBMZ. Rhyodacite, ignimbrite, flows, tuffs, breccias and volcaniclastic rocks are found and are associated with granodiorite, monzogranite, rapakivi granite and feldspar porphyry (Burgess et al., 2014).

The strata of the Coronation platform margin include shelf and slope deposits of the Snare, Akaitcho and Epworth groups. The Snare Group (now referred to locally as Treasure Lake Group and as cover of the Hottah terrane) is exposed on the NICO property: arenite, dolomite, siltstone, shale. The host rock of the NICO deposit is the Treasure Lake Group (TLG) that is brecciated and altered by iron- and potassium metasomatism, and is close to the sub-Faber Group unconformity. The contacts between metasediments and granites are mylonitic. The proximal host is biotite-amphibole-magnetite schist in the Treasure Lake Group. Other TLG rocks include subarkosic wacke, arenite, minor siltstone and carbonate. The Faber Group on the property (1851+18/-16 Ma) includes rhyolite, rhyodacite, sub-volcanic intrusive equivalents and volcaniclastics. GBMZ granites are found nearby and the TLG is hornfelsed along the contacts. Breccias along the contact with Faber Group volcanics are interpreted as hydrothermal diatreme breccia bodies. The breccias have TLG and felsite clasts in a matrix of iron oxides, biotite, amphibole, chlorite and potassium feldspar (Burgess et al., 2014).

The NICO deposit is mostly contained within magnetite ironstone, schist and subarkosic wacke containing 3-10% sulphides (Figure 19). The ore minerals include cobaltite, cobaltian arsenopyrite, bismuthinite, chalcopyrite, a gold bismuth telluride and native gold. Gangue minerals include pyrite, pyrrhotite, magnetite, hematite and silicates (Burgess et al., 2014). NICO is classified as an iron-oxide- copper-gold deposit of either Olympic Dam or Cloncurry sub-type.

Sue-Dianne (Small)

Early mapping in the region was carried out in the period 1936-1939 by Geological Survey of Canada staff. A radiometric survey by the GSC uncovered significant anomalies north of Mazenod Lake and resulted in staking of the Sue and Dianne claims in 1974. New work included extensive staking, geology, geophysics and airborne gravity. Drilling by Fortune Minerals commenced in 1997.

The Sue-Dianne breccia complex features an outer zone of intense shearing and alteration, with cross-cutting veins, stockwork, breccia, silicification and epidote "flooding". The veins are parallel to the ENE-striking Dianne Lake fault. Zoning around the deposit includes: 1) quartz-epidote veining, stockwork and gouge; 2) potassic altered and iron-rich breccia, sparsely mineralized with malachite, pitchblende and uranium oxides, 3) mineralized diatreme breccia with a matrix of magnetite and hematite (Figure 20), and 4) a breccia cap rock. The deposit occurs in a diatreme breccia body 600 m long, 500 m wide and at least 350 m deep; the deposit itself is 450 m x 300 m x 350 m deep. Copper sulphides include chalcopyrite, bornite, chalcocite and covellite. Silver and gold are associated with bornite and chalcopyrite but are not seen as independent phases (Hennessey and Puritch, 2008).

Pagisteel (Small)

Iron-oxide-copper±gold±uranium±cobalt (IOCG) mineralization occurs in breccia bodies within the Wernecke Supergroup of the Ogilvie Mountains of northern Yukon. The Wernecke Supergroup consists of three units: the Fairchild Lake, Quartet and Gillespie Lake groups.

Wernecke breccia bodies occur throughout the Wernecke Supergroup but preferentially in the Fairchild Lake Group. Individual breccia bodies range in dimensions up to several kilometres. The breccia matrix consists of rock fragments and hydrothermal precipitates: feldspar, carbonate (calcite, dolomite, ankerite), quartz and more locally hematite, magnetite, chalcopyrite, biotite, muscovite, barite, fluorite, minor tourmaline and actinolite (Figure 21; Hunt et al., 2010). In total there are 65 known breccia occurrences, all associated with copper, iron and uranium mineralization. Associated minerals of economic interest include chalcopyrite, magnetite, hematite, pitchblende and brannerite (an Fe-Ti oxide containing uranium and cerium) (Hunt et al., 2010). The origin of the Wernecke breccia remains uncertain but it may be related to overpressured conditions, and transport and dissolution of evaporites from the upper Fairchild Lake Group.

Figure 20. Sue Dianne: Iron oxide breccia with intense K-feldspar alteration of fragments forming the magnetite-to-hematite group IOCG ore. GSC 2015-120.

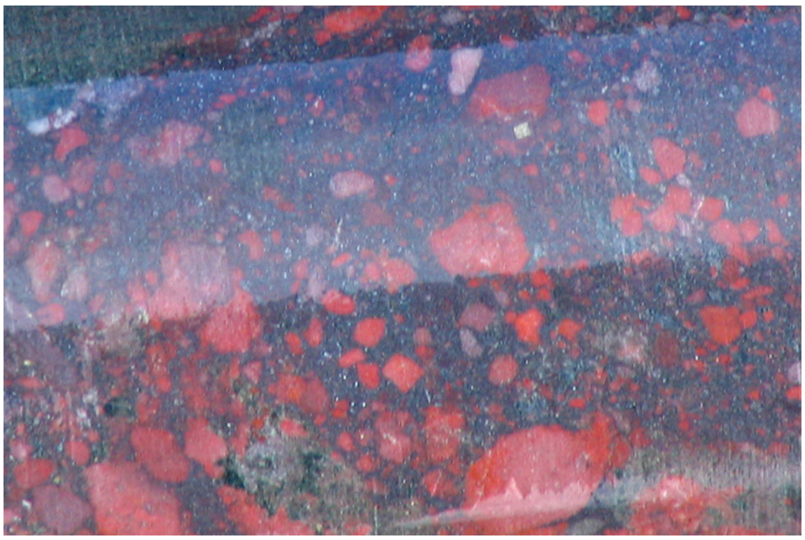


Figure 21. Hematized clasts in breccia at the Yukon Olympic occurrence (Wernecke breccia), Yukon. The matrix is mostly composed of specular hematite (Yukon Geological Survey).

Figure 22. Supergene mineralization (malachite) in altered amphibolite gneiss, Carmacks Copper deposit (Yukon Geological Survey).

Minto (Large)

The deposit (owner: Capstone Mining Corp) is accessible on the Klondike Highway via Carmacks and Minto to Minto Landing on the Yukon River. The Minto deposit lies within the Yukon-Tanana terrane, host of the Carmacks Copper Belt and of several intrusion-related Cu-Au hydrothermal systems. Major features include meta-igneous and metasedimentary rocks of Permian age lying on pre- Late Devonian basement. The Minto deposit is located in the Granite Mountain batholith which intrudes the Yukon-Tanana terrane. The batholith is overlain by Late Cretaceous Tantalus Formation sediments, and by andesite and basalt of the Carmacks Group, also Late Cretaceous. The batholith is flanked to the E of Minto by mafic volcanic rocks thought to be of Triassic age.

The mineralization occurs in rocks that have a strongly developed fabric, all of which are considered to be variant facies of the primary granodiorite. The possibility that the deformed rocks are metasedimentary or metavolcanic rafts has been ruled out. The primary mineralization consists of chalcopyrite, bornite, chalcocite, minor pyrite, magnetite and accessory covellite, hessite, native gold and electrum. Textures include disseminations and sulphide veinlets parallel to the foliation. Grades increase in zones of intense folding. There are also massive and semi-massive sulphide zones which obliterate primary host-rock fabrics. In the Minto Main deposit there is a zonation from bornite-rich (up to 8%) in the west to chalcopyrite-rich but lower grade mineralisation in the east. Precious-metal grades are higher in the bornite zone. These zonation trends are also observed in other parts of the deposit (Mercer et al., 2012). The supergene assemblage, present at depths of 30 - 90 m, includes chalcocite, malachite, azurite and rare native copper. Supergene gangue phases include limonite, hematite and clay-altered feldspar.

Carmacks (Medium)

The Carmacks deposit is located in the Dawson Range, 220 km N of Whitehorse. Geologic components of the region include the Whitehorse Trough, the Yukon Crystalline Terrane and the Yukon Cataclasite Terrane. The rocks of the Whitehorse Trough, E of the Carmacks property, include the Late Triassic Povoas Formation (intermediate to mafic volcanics), carbonate reefs of the Jurassic Lewes River Group, and Early Jurassic greywacke, shale and conglomerate of the Laberge Group. The Yukon Cataclasite Terrane consists of the Granite Mountain granodiorite with screens and pendants of strongly foliated gneiss. These latter rocks are the host of the Carmacks copper deposit. The Yukon Crystalline Terrane, exposed SW of the deposit, consists of early Paleozoic mica schist, quartzite, marble and amphibolite intruded by Jurassic and Cretaceous granite and syenite. Younger strata, not included in the trough and terrane successions, include the Late Cretaceous Carmacks Group and the Mount Nansen volcanics (Kent et al., 2014).

The deposit is underlain by intrusive and meta-intrusive rocks of the Granite Mountain intrusion, ranging in composition from granodiorite to diorite and with textures varying from porphyritic to massive and foliated. Rock types associated with the ore zones include biotite gneiss, quartzofeldspathic gneiss, amphibolite and biotite schist. Siliceous ore is also found. Aplite and pegmatite dykes up to 3 m wide postdate the mineralization.

The No.1 zone is 700 m in strike length, and open to depth below 450 m. The supergene zone extends to 250 m and has been the principal focus of exploration. Drill holes were historically terminated at the base of the metal oxide zone. The mineralogy of the oxidized ore includes malachite, cuprite, azurite, tenorite and minor amounts of covellite, digenite and djurlite (Figure 22). Primary metallic phases include magnetite, rare molybdenite, native gold, native bismuth, bismuthinite, arsenopyrite, pyrite and pyrrhotite in a gangue of carbonate (Kent et al., 2014).

STRATABOUND IRON AND BASE METAL DEPOSITS

Stratabound deposits of the Canadian Cordillera of Yukon and Northwest Territories lie in outer shelf and deep-water basin strata of Neoproterozoic to Carboniferous age (Figure 23). These include iron deposits of Neoproterozoic and Jurassic ages, Mississippi Valley-type (MVT) deposits hosted by Mesoproterozoic to Devonian shelf carbonates, sedimentary exhalative deposits (SEDEX) found in deep-water sediments of Cambrian to Devonian age, and volcanogenic massive sulphide deposits that formed in Paleoproterozoic to Mississippian volcanic rocks.

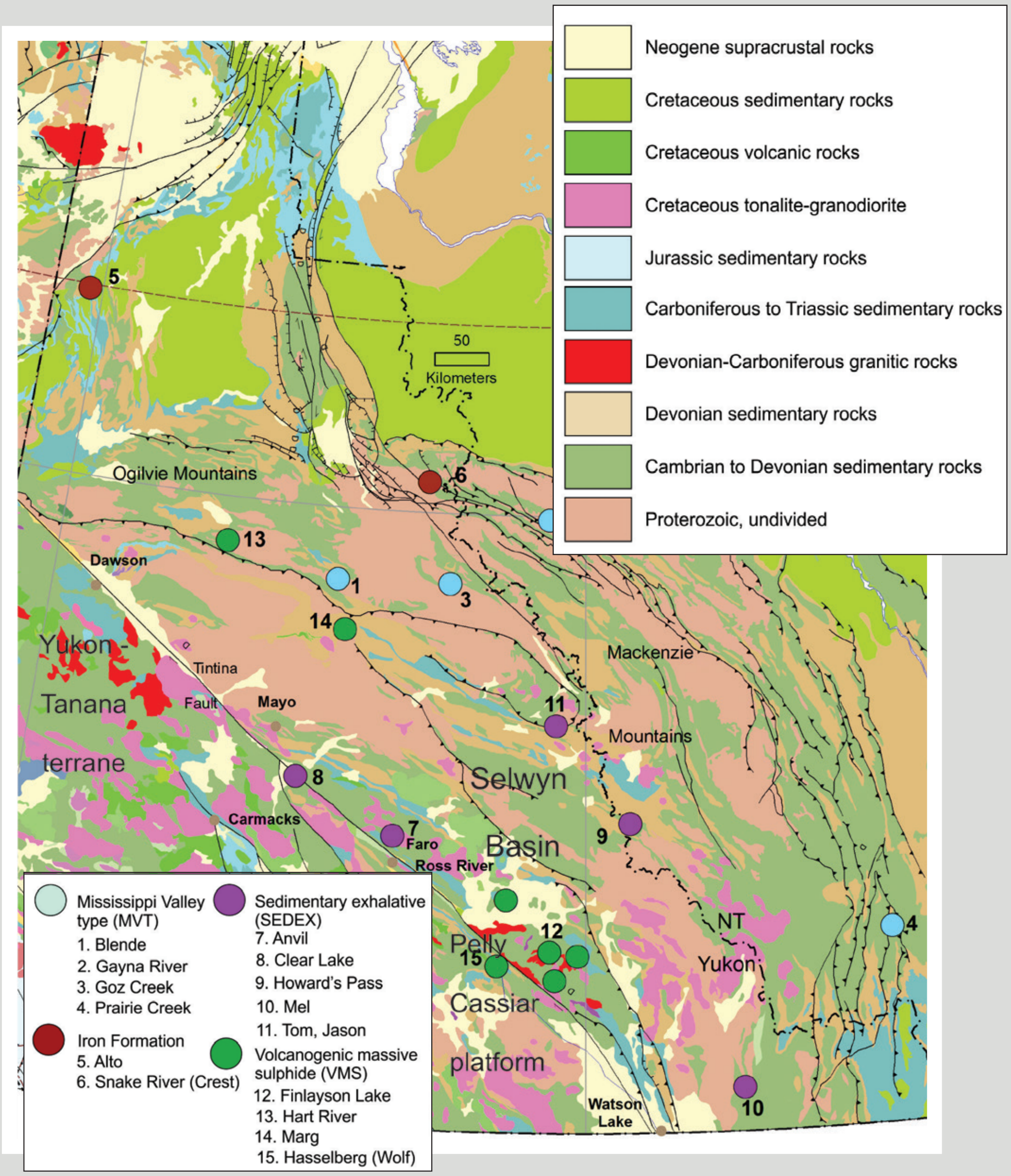


Figure 23. Simplified geology of Yukon and western Northwest Territories also showing deposits of Mississippi Valley-type zinc-lead, iron formation, sedimentary exhalative mineralization and volcanogenic massive sulphide.

NEOPROTEROZOIC AND YOUNGER IRON DEPOSITS

The (very large) Neoproterozoic Crest iron deposit is located in the headwaters area of the Snake and Bonnet Plume rivers of the Mackenzie Mountains of northern Yukon. This is a remote area, 580 km N of Whitehorse and close to the border with the Northwest Territories. This group also includes the (medium-sized) Alto deposit, of presumed Jurassic age (Figure 23).

Crest (Snake River) (Very large)

The deposits were discovered in 1961 by Standard Oil Company geologists who identified 10 - 30 m thick sections of jasper hematite iron formation. Crest Exploration acquired the deposit in 1962. Subsequent reconnaissance determined that the deposit might contain 15 billion tons of iron ore. However, evaluation showed that the deposit could not compete with iron from Australian sources. Evaluations by Kaiser Engineers in 1976, 1991 and 1998 again showed that the deposits were sub-economic because of their remote location. The present owner is Crest Exploration Ltd, a subsidiary of Chevron Canada Resources.

The deposit is located in a westerly-trending portion of the Mackenzie Mountains within a package of folded, mostly carbonate-dominated, Upper Cambrian to Upper Devonian strata. The deposit is bound to the south by Precambrian and lower Paleozoic strata. The Snake River iron formation occurs in the lower part of the Rapitan Group of Neoproterozoic age. The host clastic rocks are conglomerate and siltstone ≥2000 m thick, maroon-coloured in the lower 610-915 m and highly ferruginous, with iron formations present at several levels in the lower 305 m of the formation.

The Crest deposit consists of fine-grained specular hematite with alternating jasper-rich bands. It has been traced for 51.5 km. Iron formation that is economically significant occurs up to 305 m above the sub-Rapitan contact. This zone attains a maximum thickness of 120 m of which 85-105 m is iron formation. Interlayered lithologies include hematite, dolostone, ankeritic carbonate, shale, sandstone, shaly conglomerate, and conglomerate. Shaly conglomerate is the most significant lithology between the iron formation layers. Types of iron formation include nodular, banded, and irregular intergrowths of hematite and jasper (Figures 24, 25). The average iron content is 43%, the main impurity being apatite (McBean, 2006).

Alto (Medium)

The iron deposits at Alto were discovered in 1973 and staked in 1975-76 by a joint venture including Inexco Mining Co., Amoco Canada Petroleum Co. Ltd., Arrow Inter-America and Husky Oil Ltd. Rio Alto performed road building, trenching and mapping in 1983. The ground was restaked by Eagle Plains Resources Ltd. in 1996. Oolitic magnetite iron formation is exposed in a 46 m thick bed at the contact between the Permian Jungle Creek Formation and the Jurassic-Lower Cretaceous Kingak Formation. The exposure has a strike length of 366 m (Anonymous, 2013a).

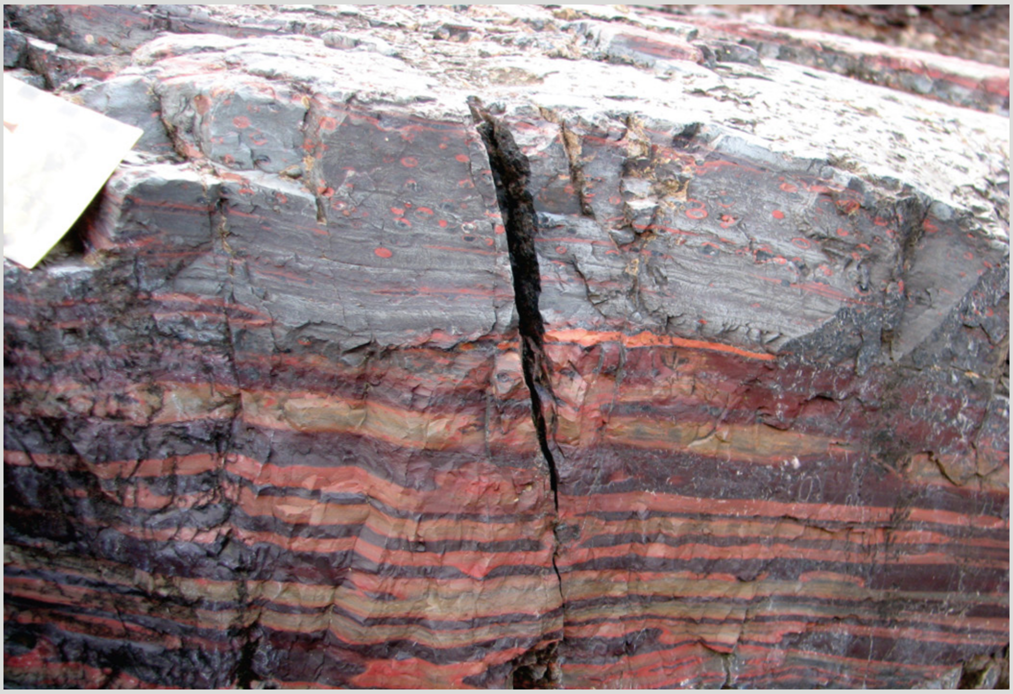


Figure 24. Crest deposit: Boulder of banded jasper and specular hematite. Nodular hematitic layer at the top. (Yukon Geological Survey).

Figure 25. Crest deposit: Outcrop of banded jasper and specular hematite (Yukon Geological Survey).

MISSISSIPPI VALLEY-TYPE (MVT) DEPOSITS

Carbonate hosted zinc-lead deposits range from Mesoproterozoic to Devonian in age and are located in the Canadian Arctic Islands (Polaris and Nanisivik deposits, both large), along the northern edge of the Western Canada Sedimentary Basin (Pine Point deposit, large) and in the Mackenzie Mountains (Figure 23: Blende, the large Gayna River deposit, Goz Creek (not described) and the large Prairie Creek deposit).

Blende (Medium)

The property is located 115 km N of Mayo, Yukon. Although there was active staking and prospecting in the area from the 1920s, mineralization was not discovered on the Blende property until 1961 which led to further staking by Cyprus Anvil Mining Corp. in 1975. Blind Creek Resources acquired an option on the Blende property in 2006 and a 100% interest in 2008 from the previous owners, Eagle Plains Resources Ltd.

The stratigraphy of the property is dominated by the Gillespie Lake Group, part of the Mesoproterozoic Wernecke Supergroup. The lower part of the Gillespie Lake Group consists of greenish-grey to brownish-orange laminated dolomitic siltstone with a well-developed cleavage. The central units of the Gillespie Lake Group consist mostly of orange-tan dolomitic siltstone. These strata host the mineralization on the property. Columnar stromatolites, 3-15 cm wide, rare oolitic layers, and intraclast conglomerates are also found. The highest part of the Gillespie Lake Group consists of thick bedded dolostone weathering to a reddish-orange colour.

The ore zone host rock is the Mesoproterozoic Gillespie Group, in the upper part of the Wernecke Supergroup and in close proximity to a presumed ESE-striking fault of Mesoproterozoic age. Mineral occurrences follow the fault zone for 6000 m. They occur as sulphides in discordant veins, in fault-related breccias and as high grade concentrations in stromatolitic units. The vein mineralogy is mostly sphalerite and galena with lesser pyrite. Anglesite, covellite and smithsonite are found in weathered materials. Zoning in the deposit ranges from spotty copper- and silver-bearing (chalcopyrite, freibergite, tetrahedrite) in the lower part in the west through lead-rich (galena and anglesite) in the middle and upper parts. Zinc enrichment (as sphalerite altering to smithsonite) occurs in the eastern part of the deposit (Price, 2011). Pb/Pb isotope model ages of mineralization are in the range of 1490 - 1430 Ma which indicates an early Mesoproterozoic age (Moroskat et al., 2015). The mineralization has been identified as fault-hosted breccia of carbonate-hosted Irish type.

Gayna River (Large)

This property is located in the headwaters of Gayna River, Northwest Territories, 186 km W of Norman Wells and 298 km E of Mayo, Yukon. The property was first staked by Rio Tinto Canadian Exploration Ltd (Rio Canex) in 1974. Property evaluation and drill hole testing occurred from 1975 to 1979. The claims were allowed to lapse in the 1980s. The property was restaked in 2000 and is now 100% owned by Eagle Plains Resources.

Zinc-lead mineralization of Mississippi Valley-type (MVT) is located in the Little Dal Group, part of the Neoproterozoic Mackenzie Mountains Supergroup. Although mineralization occurs in many units, the better showings are in the Grainstone formation. The mineralogy of the showings is sphalerite (with high gallium and germanium contents) and galena with a silver association. The claim block lies at the hinge of an anticline. The bedding dips 5-100 to SW or NE. Dolomitization and mineralization appear to be unrelated to local thrust faults or other structures (Hewton, 1982).

The Grainstone formation has four members of which the first and third from the base are host for sphalerite and galena mineralization (Figure 26). Both of these units contain cavity-filling calcspar, dolospar and barite. The lower host features these phases in bedding-parallel veins while the upper host unit has breccia matrix spar. Sphalerite is more concentrated in the lower host unit whereas the upper unit has more showings.

Alteration in the lower and upper host units of the Grainstone formation takes the form of early-generation fine-grained dolomite that is grey-black, grey-white or red-brown. A white variety of calcspar with barite and fluorite fills early dolomitization porosity and is closely associated with sphalerite and galena. Most mineralization-related dolomite at Gayna River has obliterated primary carbonate textures, is present as pore- and cavity-filling cement, and acts as a substrate for sulphide deposition.

Nanisivik (Large)

Nansivik was mined from 1976 to 2002. The nearest settlement is Arctic Bay which is accessed from the mine and airport by an all weather gravel road. Concentrate was removed by ship from a purpose-built port in the immediate vicinity of the mine.

The Nanisvik deposit is located in Mesoproterozoic rocks of the Borden Basin on northern Baffin Island. Borden Basin is interpreted to have formed by rifting from approximately 1270 Ma, with episodic extensional faulting occurring during basin evolution. Sedimentation was terminated by inversion at ca. 1000 Ma. The host of the Nanisivik deposit is the Society Cliffs Formation: a dolostone (>1000 m thick) featuring deep-water laminates and deep water carbonate mounds in western Borden Basin. In the eastern Borden Basin the Society Cliffs is dolostone forming peritidal cycles, in total 250 m thick. Pb-Pb dating indicates an age of 1199 Ma (Dewing et al., 2007).

Local features of the ore body include a laminated dolostone host rock. The orebody occurs in a horst block; part of a zone of east-striking normal faults. The ore body is 3 km long, 100-200 m wide and 10 - 30 m thick. In addition, there is an ore zone keel 65 m deep and 5-30 m wide. The ore is mostly pyrite with zones rich in sphalerite, galena and dolospar. The age of the orebody is unresolved but determinations range from 1095 Ma (paleomagnetic dating of hydrothermally altered dolomite) to 461 Ma (dating of feldspathic alteration). The latter age is unlikely as the deposit is cut by a Franklin dyke (dated at 723 Ma) (Dewing et al., 2007).

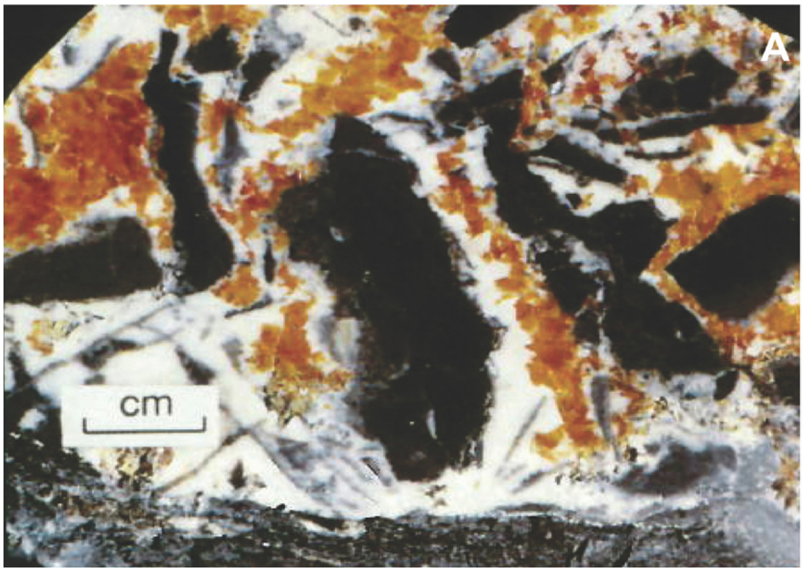


Figure 26. Gayna River: dolomite breccia formed by solution-collapse processes has been infilled with sparry calcite (white) and coarsely crystalline sphalerite (orange). GSC 1995-086B.

Early genetic models emphasized a void-filling karst-related origin for the Nanisivik deposit. Later models emphasize staged replacement of host rocks involving a gas cap trapped beneath the overlying Victor Bay Formation shale, with only minor, initial karst-related porosity in the Society Cliffs.

Pine Point (Large)

The Pine Point properties are located 800 km N of Edmonton near the south shore of Great Slave Lake. Occurrences of lead and zinc at Pine Point were first discovered here in 1899 by Robert Bell of the Geological Survey of Canada. Shipment of high grade ore by Cominco Ltd was initiated in 1965. Production continued until mine closure in the late 1980s. The property is now held by Tamerlane Ventures Inc.

The Pine Point district lies within the Western Canada Sedimentary Basin, which in this area comprises 350 - 600 m of sediments ranging from Ordovician to Devonian in age and limited to the east by the Canadian Shield. In the Middle Devonian, a carbonate barrier (the Presqu'ile Reef) formed along a SW-trending basement ridge with open marine conditions to the north and restricted back reef facies (the Elk Point lagoon) to the south. These restricted conditions led to deposition of gypsum, anhydrite and rock salt. Carbonate deposition continued into the Late Devonian with a phase of uplift and karsting marking the end of barrier reef development. In modern nomenclature, the Presqu'ile facies is thought to be a diagenetic alteration superimposed on a variety of primary reef-associated depositional units.

The mineralization is genetically linked to mineralizing brines and diagenetic alteration forming in karst-induced porosity in the host rock. The host stratigraphy is limited to six named Middle Devonian units to a maximum of 200 m of section. In total there are 97 known deposits within three northwest ore trends, distributed over a strike length of 68 km and a width of 6 km. Forty eight of these deposits were mined by Cominco Ltd. before 1990. The deposits have the form of vertical pipes (karst chimneys), and tabular bodies that lie along former subsurface stream channels (Siega and Gann, 2014).

The mineralization occurs as sphalerite, galena, marcasite and pyrite and as a replacement of karst-fill sediments, breccia, open-cavity fillings (Figure 27) and as peripheral disseminations. Better grades are associated with karst structure and replacive Presqu'ile dolomite. Sphalerite occurs in colloform masses. Galena is present in a nested form inside sphalerite. Other ore-related phases include marcasite, pyrite, minor pyrrhotite, celestite, barite, gypsum, anhydrite and fluorite. Bitumen and pyro-bitumen are also found, particularly in trap settings above the ore bodies. Hydrogen sulphide gas has also been reported (Siega and Gann, 2014). The Pine Point deposits are classic Mississippi Valley-type lead-zinc deposits, possibly the best example of its kind in Canada.

Polaris (Large)

The Polaris zinc-lead district spans an area of 450 km (N-S) by 130 km (E-W) coinciding with the Late Silurian-Early Devonian Cornwallis Fold Belt and the Boothia Uplift in the central Canadian Arctic Islands. Within this area there are eighty zinc, lead and some copper showings and the Polaris deposit on western Little Cornwallis Island.

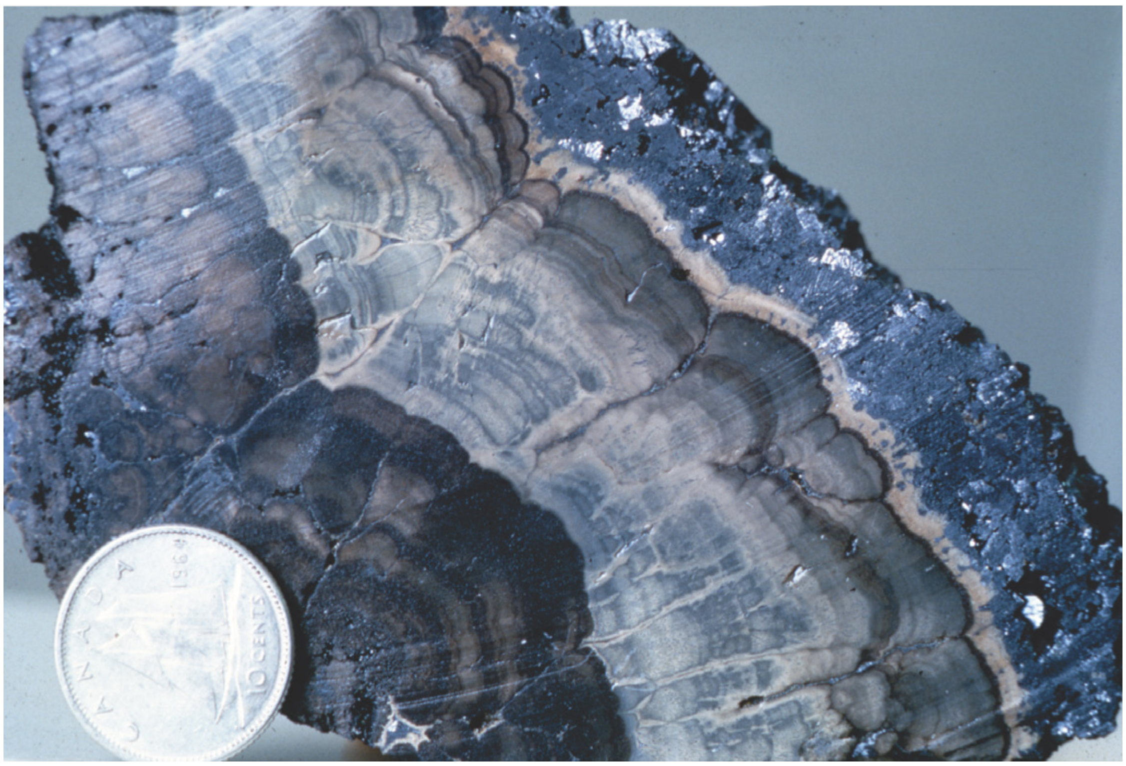


Figure 27. Pine Point: typical botryoidal textured sulphides; layered sphalerite (dark brown and white) is overlain by coarse grained galena (steel blue). Sulphides were precipitated in a cavity, beginning at lower right. The last deposited sulphide was galena. Coin is 1.5 cm in diameter. GSC 1995-214.

The surface showing at Polaris was discovered in 1960. A gravity anomaly was drilled in 1970, which led to the discovery of the deposit, which was mined from 1982 until reserves were exhausted in 2002. The Polaris deposit occurs in the upper part of a Cambrian to Upper Ordovician carbonate shelf succession that notably includes evaporites in the Lower and Middle Ordovician. The host rock is the upper Thumb Mountain Formation of Upper Ordovician age. Other small showings are found in carbonate units as high in the stratigraphy as the Middle Devonian.

Specific host rocks within the upper Thumb Mountain Formation include, from the base: 1) burrow-mottled skeletal wackestone with chert nodules; 2) wackestone with algal colonies; 3) burrow-mottled skeletal wackestone; 4) macrofossil-rich fossiliferous wackestone, and; 5) argillaceous nodular wackestone. The Thumb Mountain Formation is succeeded by green shale with limestone interbeds (Irene Bay Formation), and by black shale with lime mudstone, chert and siltstone (Cape Phillips Formation).

The dimensions of the Polaris deposit are 800 m x 300 m x 20-100 m thick. There are two distinct parts to the deposit: the Panhandle zone (two ore types, in the upper part of the deposit) and the Keel zone (three ore types, in the lower part). The Panhandle (P1) ore type includes massive, carbonate replacement, breccia-fill and vein sulphides. The P2 ore consists of a vein network with veins up to 1m thick of sphalerite, marcasite and galena. Below this, in the Keel zone is K3 ore, consisting of a vein complex with disseminated sulphides. Deeper still is K2 ore, which is mostly fracture- and vein fill with minor replacement ore and breccia. Deepest in the deposit is K1 ore, comprising low-grade fracture and vein fill (Dewing et al., 2007a).

In general, the mineralization features colloform sphalerite, also occurring in disseminated form and as aggregates (Figures 28, 29). Galena occurs in dendritic and skeletal forms and in polycrystalline veins. Other minor phases include pyrobitumen, barite, spar calcite and pyrite. The age of the Polaris ore body is 366±15 Ma (Rb/Sr). This coincides with the Ellesmerian Orogeny, which brought sedimentation in the Franklinian basin to a close (Dewing et al., 2007a).

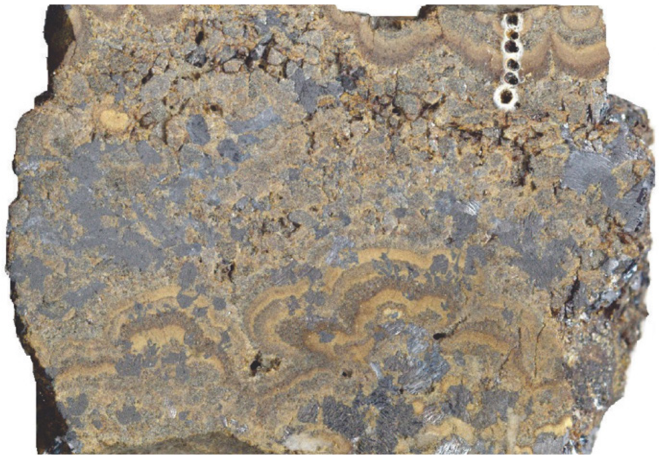


Figure 28. Polaris mine: sphalerite-galena vein showing banded ore on either side and crystalline galena and sphalerite in the centre. GSC 2015-117.

Figure 29. Polaris mine: marcasite-rich ore showing collapsed fragments of banded sphalerite. GSC 2015-118.

Prairie Creek (Large)

The Prairie Creek deposit is located 500 km W of Yellowknife in the Mackenzie Mountains. The property was discovered by a trapper in 1928 and was first staked in 1956. The period of exploration up to 1970 included extensive surface drilling and underground testing.

A decision to put the deposit into production was made in 1980. A winter road was completed from the Liard River Highway, and a mill and concentrator were moved to the site between 1980 and 1982. At this point Cadillac, the principal operator, went bankrupt and the assets were taken over by Procan Exploration Co.Ltd. By 2004 Canadian Zinc Corporation had earned a 100% ownership in the property.

The stratigraphy on the property ranges from Ordovician to Devonian in age and includes the Whittaker, Road River (graptolitic dolomite), Cadillac (grey siltstone and shale) and Arnica (black dolomite and limestone) formations. The Whittaker Formation, the host of the ore deposit, has been divided into nine members. The compositions of these include massive dolostone, bioclastic dolostone (two units), mottled dolostone (ore host rock), chert nodular dolostone (three units) and interbedded chert and dolostone.

The mineralization on the property is diverse and includes: a 16 km long mineralized quartz vein system, in part linked to mineralized stratabound zones, other vein systems extending 4 km to the N and 10 km to the S, subsurface mineralization referred to as the Main Zone, subsurface stockwork and stratabound mineralization, and Mississippi Valley type (MVT) mineralization of which there are six named showings in the northern part of the property.

The vein mineralization contains galena and sphalerite with lesser pyrite and tetrahedrite-tennantite in a matrix of quartz, calcite and dolomite. The largest vein has a probable length of 2.1 km. In other localities vein mineralization occupies tension fractures in competent strata such as the lower Road River and Whittaker formations. Some of these have an "en echelon" geometry. Stratabound mineralization, discovered by drilling, has been traced over a distance of 3 km. It consists of massive sphalerite, coarse galena, disseminated to massive pyrite, but little or no copper or sulphosalts. It occurs mainly in mottled dolomite of the Whittaker Formation. MVT mineralization occurs as colloform sphalerite with pyrite, marcasite and minor galena. It is associated with open cavities in biohermal reefs of the Root River Formation (above the Road River Formation only in the northern part of the property)(Paradis, 2007; Shannon et al., 2012).

To summarize, the main ore deposit types include hydrothermal veins, Mississippi Valley-type deposits (like Pine Point) and deposits of the carbonate-hosted Irish type.

SEDIMENTARY EXHALATIVE (SEDEX) DEPOSITS

SEDEX deposits are an important resource in the Yukon (Figure 23). These include the large deposits in the Anvil area (Early Cambrian Faro, DY, Grum, Swim, Vangorda), Clear Lake (Devonian Mississippian), the potentially very large Howard's Pass (Early Silurian), Mel (Cambrian or Ordovician), and the large Tom and Jason deposits (Late Devonian).

Anvil (Large)

The Anvil mining camp is located 200 km NE of Whitehorse near the town of Faro (Figure 30). The Faro deposit is one of five significant deposits located in the Anvil Mining Camp of the central Yukon. The others are the Grum, Vangorda, Dy and Swim deposits. The Vangorda deposit was the first to be discovered by conventional prospecting, in 1953. Systematic exploration in the area (by Prospectors Airways Co. Ltd) began in 1956. The property changed hands several times until the Faro claims were established in 1964 by Dynasty Exploration Ltd which entered into a joint venture with Cyprus Exploration Ltd. in 1965. The Faro orebody was discovered in June 1965. Mining began in 1969 and continued until the ore was exhausted in 1991. Production was entirely shifted to the Vangorda deposit in 1992. Production ceased in 1993 due to the bankruptcy of the parent company (Curragh Resources Ltd).

The host rocks include the Lower Cambrian Mount Mye Formation overlain by the Cambrian to Ordovician Vangorda Formation. The Mount

Mye Formation consists of non-calcarous phyllite and schist. The Vangorda Formation consists of calcareous phyllite and impure carbonate. The five known deposits are associated with a 150 m thick interval that straddles these two formations. The sulphide lenses have been traced laterally into a carbonaceous pelite unit which has been identified as a submarine exhalite layer produced through hydrothermal venting at the sea floor. The Faro deposit is close to the mid-Cretaceous Anvil batholiths, leading to metamorphism of the host Mount Mye Formation to biotite- andalusite-muscovite schist. The occurrence of pyrrhotite in the Faro deposit has also been attributed to metamorphism.

Sulphide minerals, in decreasing order of abundance, include pyrite, sphalerite, galena, pyrrhotite, chalcopyrite and marcasite. Less significant minerals include barite with traces of tetrahedrite, bournonite and arsenopyrite. Zoning is present in the Faro deposit and has been recognized as cyclical. The idealized cycle begins with ribbon-banded carbonaceaous pyritic quartzites that give way to pyritic quartzites, siliceous pyritic sulphides, massive pyritic sulphides and baritic massive pyritic sulphides. In general, the upper part is baritic and higher grade; the lower and outer parts are lower grade, carbonaceous and quartzose. Alteration identified in the hanging wall and footwall includes "bleaching", silicification and quartz-muscovite-plagioclase alteration (Pigage, 1991). Deformation of the Faro deposit is associated with the upper limb of a Z-shaped fold. There are also extension faults that have down dropped the central part of the deposit.

The Anvil deposits are identified as sedimentary exhalative type. Characteristic features include layering of sulphides, fine-scale interbedding of sulphides with unmineralized sediments, limited stratigraphic range, and pre-metamorphic and pre-tectonic ore deposition (Pigage, 1991).

Clear Lake (Medium)

The property was first staked in 1965 by Conwest Exploration Company Ltd. at the time of discovery of the Faro deposit. Exploration expanded considerably with the Macmillan Joint Venture from 1975 to 1980, and then with Getty Canadian Metals Ltd (including drilling) to 1983. Renewed drilling was carried out from 1991 to 1996.

The Clear Lake deposit is considered to be a sedimentary exhalative deposit consisting mostly of pyrite but including a sizeable component of lead and zinc. The deposit occurs in carbonaceous argillite, siltstone, chert and tuff of the Devonian

Figure 30. Anvil: Faro mine site, Yukon including open pit, tailings piles, mine roads and mine buildings (Yukon Geological Survey).

to Mississippian Earn Group. The property straddles the Tintina Fault with Lower Cambrian phyllite of the Mount Mye Formation to the N along with Cambrian to Ordovician phyllite and limestone of the Vangorda Formation. South of the fault the host rock Earn Group overlies Ordovician to Lower Devonian shale of the Road River Formation. The deposit has a significant gravity and EM anomaly and adjacent to this is a small lake with anomalous bottom sediment zinc values. The deposit is 1000 m long and up to 120 m wide. The sulphides are laminated and include framboidal pyrite, interlayered with tuffaceous rocks in the stratigraphic footwall. This interval also includes concretions of galena, sphalerite, barite, siderite and calcite. Silicification is prominent in both footwall and hanging wall locations, and massive barite forms a hanging wall cap. Metal ratios for the deposit indicate a syngenetic origin related to Devonian rifting. This is also indicated by worm-tube fossils partly replaced by sphalerite (Anonymous, 2014b).

Howard's Pass (Large, potentially Very Large)

The Howard's Pass property is located along the Yukon-Northwest Territories border 350 km NE of Whitehorse: most of the claims are located in the Yukon.

The Howard's Pass deposits were discovered in 1972 during follow-up of a 1971 stream sediment reconnaissance program. This led to a significant staking rush. Anomalies of zinc, lead and cadmium were subsequently found in soil surveys. Geophysical methods proved to be ineffective. 218 drill holes were collectively drilled from 1973 to 1981 and also in 2000. Bulk testing on the XY deposit occurred in 1980 and 1981. The property is currently held by Chihong Canada Mining Ltd.

Figure 31. Howard's Pass: deformed finely laminated, pyrite, galena and sphalerite in host black shale (Yukon Geological Survey).

The Howard's Pass deposit is located in the eastern part of the Selwyn Basin, a deep-water basin of Ordovician to Devonian age in which shale, chert and deep-water carbonate are predominant rocks. In general, the lower part of the basin, of Early Ordovician to Early Devonian age, has mudstone, siltstone and carbonates whereas the upper part has mudstone and siltstone with sandstone and some conglomerate. Compressive deformation of Mesozoic age has produced folds and thrust sheets across the basin.

The oldest unit in the vicinity of Howard's Pass is the Neoproterozoic to Early Cambrian Grit Unit. This is overlain by a massive limestone (lower member) of the Rabbitkettle Formation and is succeeded by a (upper member) wavy banded limestone. Above this is the Howard's Pass Formation, the lowest of four formations of the Road River Group. The Howard's Pass Formation hosts all the ore deposits of the Howard's Pass region. Typical rocks include, from the base: pyritic siliceous mudstone; calcareous mudstone; cherty mudstone; the mid-Llandovery Active Member (containing all the known zinc and lead mineralization), and uppermost, siliceous mudstone. Above the Road River Group is the Earn Group (Late Silurian to Devonian) consisting of siliceous mudstone, mudstone, siltstone and greywacke (O'Donnell, 2009).

The following account focuses on the Active Member, host of the known ore deposits. The Active Member ranges from 0-60 m in thickness and contains nine intercalated facies: grey limestone; graded limestone; calcareous mudstone; thin bedded mudstone; cherty mudstone; rhythmite; thin bedded cherty mudstone; whitish grey lead- zinc mudstone, and; grey chert. The lead-zinc mudstone is a laminated cherty unit containing up to 70% sulphides and consisting of quartz, sphalerite, galena, minor pyrite and only local calcite (Figures 31, 32). Trace constituents include chalcopyrite, tetrahedrite, molybdenite, pyrrhotite, polydymite, millerite and gersdorffite

(Goodfellow & Jonasson, 1986). Depositional features include lamination, carbonate nodules, sulphide replacement of microfossils, framboidal pyrite and bedding truncation surfaces (Jonassen & Goodfellow, 1986). The Active Member has been identified over a strike length of 37.5 km within which there are 15 deposits. The mineralized horizon is generally 20 - 30 m thick and is mineralogically consistent over the entire property. However, higher grades and coarser grain sizes have been encountered in the XY, Don and Anniv zones (O'Donnell, 2009). Syndepositional structure includes slump folds, dilational veins, quartz pressure shadows, sulphide "diapirs", fluid escape structures and local pull-apart basins within which sulphidic sediments are concentrated (Jonassen and Goodfellow, 1986).

The Howard's Pass deposit is classified as vent-distal sedimentary exhalative (SEDEX) type.

Figure 32. Howard's Pass: fractured high-grade ore from the Selwyn property: deformed finely laminated sulphides (galena and sphalerite) in host black shale (Yukon Geological Survey).

Mel (Medium)

The Mel property is located 80 km ENE of Watson Lake in the southeast Yukon. The property is currently held by SilverRange Resources Ltd. The Mel deposit occurs in Cambrian and Ordovician strata consisting of a footwall crypto-grained limestone and a hanging-wall argillite, which grades upwards to wavy banded limestone. To the north on the property there are volcanic flows and volcaniclastic sediments above the crypto-grained limestone. Mineral occurrences are present at four locations. However, only the Mel Main zone has been drilled to any extent and it is on this that known resources are based. This zone is 800 m in length and up to 21.7m thick. It consists of coarse-grained red sphalerite and galena formed in a coarse matrix of barite. Pyrite forms < 2% of total sulphides. Sphalerite also occurs as fracture fillings and irregular masses in sheared and sericitized mudstone. Minor amounts of chalcopyrite and tetrahedrite are associated with a stockwork in the cryptograined limestone (Miller and Wright, 1984; King, 1995).

Geological relationships suggest that the Mel Main zone, the Jeri zone and Mel East zone are all part of a common mineralized horizon repeated and exposed to the surface by thrusting and N-S-trending folding. The deposit type is identified as sedimentary exhalative. The coarse-grained nature of the ore, however, suggests crystallization of metallogenic brines under a thin mudstone blanket. Lead isotope ratios, though, indicate a Devonian age and therefore an epigenetic origin (Godwin et al., 1988).

Tom and Jason (Large)

The property is accessible via the Canol Road from Ross River. The Tom prospect was first staked by Hudson Bay Exploration Development Company Ltd (HudBay) in 1951. Surface evaluation and some drilling were carried out in 1951-1953, and again in 1967 - 1968. Underground evaluation began in 1970 including bulk testing and metallurgy. Claims were staked on the Jason property in 1974 and in 1980 this was taken over by Aber Resources Ltd. who began joint studies with HudBay at this time. A feasibility study was completed in 1986 which indicated a mine life of 15 years for the two combined deposits. There was additional drilling resulting from a Cominco option (from 1988) before this lapsed in 1992. Currently both properties are 100% owned by HudBay.

The Tom and Jason deposits are located along the eastern margin of the largely deep-water facies Selwyn Basin. Major rock packages in the vicinity of the deposits include (from the base) Neoproterozoic clastic rocks and shales; Lower Cambrian to Middle Devonian shelf carbonates; Ordovician to Devonian shales, cherts and minor limestone of the Road River formation and;

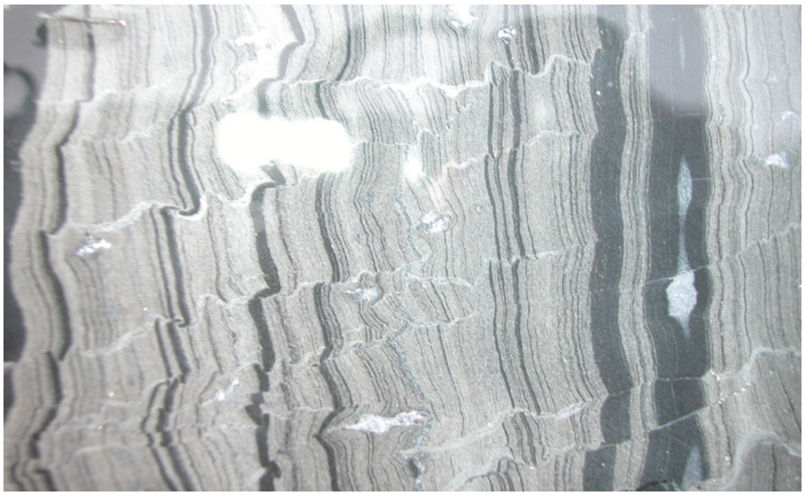


Figure 33. Tom: polished slab of laminated galena and sphalerite ores. GSC 1994-640

Devonian to Mississippian cherty shale and turbidites of the Earn Group (Rennie, 2007). The deposits lie in a structural domain featuring turbidites of the Lower Earn Group. Host rocks include chert pebble conglomerate, breccia, sandstone, siltstone and shale. Barite horizons up to 30 m thick are found in these rocks. Structural features include tight folding and steep reverse faulting. Some faulting has been attributed to syndepositional extensional deformation. Strata on the Tom property include pyritic mudstone with sand layers, siltstone, barite, and Pb-Zn-Ag-bearing sulphides. Local structure is interpreted as a graben bound by horst blocks. Local facies adjacent to these structures are conglomerate and diamictite. Hydrothermal vent facies include ankerite and quartz veins containing pyrite, chalcopyrite and galena.

Sulphide-barite mineralization occurs as laminae within sediment host rocks (Figure 33) and collectively is found in stratiform lenses up to 40 m thick and traceable for up to 1200 m along strike. In total there are three mineralized zones at Tom. Economic minerals include fine to coarse sphalerite, galena and minor chalcopyrite with accessory barite, pyrite, pyrrhotite, quartz, and iron carbonates. The mineralization is separately identified as Grey facies (pink sphalerite, galena, pyrite and grey barite) or as Black facies (black mudstone, cream sphalerite, galena, and pyrite). Collectively these two facies comprise the bulk of the mineralization (Rennie, 2007).

VOLCANOGENIC MASSIVE SULPHIDE DEPOSITS (VMS)

VMS deposits (Figure 23) of Paleozoic age have been discovered most notably in the Devonian and Mississippian strata of the Finlayson Lake area of the central Yukon (medium to large Fyre Lake, Kudz Ze Kayah, Wolverine, Ice and GP4F) but also at Hart River (not described), Hasselberg (large: Devonian- Mississippian) and Marg (Devonian-Mississippian).

Finlayson Lake (Medium to Large)

The Finlayson Lake district covers an area of 300 km x 50 km within the Yukon-Tanana terrane south of Ross River and northwest of Watson Lake, Yukon. Host rocks are early Mississippian to early Permian age consisting of mafic and felsic volcanic rocks, phyllite, chert, volcanic-derived sandstone and some limestone, conglomerate and diamictite in the upper part. There are also plutonic rocks that are coeval with the volcanic units. Metamorphism is mostly upper greenschist to lower amphibolite facies. Franklin et al. (2005) have identified the deposits of the Finlayson Lake district as bimodal-felsic type volcanogenic massive sulphides (VMS). However, the geological contrast between deposits would suggest a more complex genetic history. The district features five significant deposits, briefly described here, and numerous showings.

The Fyre Lake deposit (medium) is 160 km NW of Watson Lake. The host rocks include metavolcanic chlorite phyllite, quartz muscovite phyllite and sedimentary carbonaceous phyllite.

The East zone consists of massive pyrite and lesser pyrrhotite, chalcopyrite, sphalerite and magnetite. The West zone consists of: magnetite, pyrite, and chalcopyrite massive sulphide grading to pyrite and chalcopyrite, and to pyrrhotite farthest west. A chert-pyrite-chalcopyrite-magnetite layer is considered to be an exhalite. The footwall shows chlorite alteration and a stringer zone. Weak hanging wall alteration is also present (Peter et al., 2007). The deposit is classified as Besshi-type mineralization in a forearc setting or as a pelitic-mafic VMS in the classification scheme of Franklin et al. (2005).

The host rocks for the Kudz Ze Kayah deposit (large) are felsic volcanic and volcaniclastic rocks overlain by argillite and mafic volcanics. The main zone is 500 m long, 400 m deep and 18-34 m thick. The mineralization consists of pyrite, sphalerite, pyrrhotite, galena and chalcopyrite, with traces of arsenopyrite, sulphosalts and electrum. Gangue minerals include chlorite, magnetite, quartz, iron carbonate, sericite, albite and barite. Footwall alteration includes silica, albite, sericite and chlorite. There is also a footwall stringer zone (Peter et al., 2007). The deposit is classified as a Kuroko-type VMS in a back-arc basin or rift setting, or as a bimodal-felsic type VMS (Franklin et al., 2005).

Four km from Kudz Ze Kayah, the host of the GP4F deposit is Late Devonian to Early Mississippian felsic volcanic flows and volcaniclastic rocks cut by mafic dykes. The deposit is a massive sulphide lens 200 m long by 350 m down dip and ≤ 3.2 m thick. The ore consists of banded "buckshot" (pebbly) pyrite in a matrix of sphalerite, pyrrhotite and galena with local magnetite and traces of chalcopyrite. Gangue minerals include quartz, feldspar, chlorite, carbonate, sericite and biotite. In addition there is footwall sericite alteration (Peter et al., 2007). The deposit is classified as a Kuroko-type VMS, or as a bimodal-felsic type VMS (Franklin et al., 2005).

The host rocks of the Wolverine deposit (large) are Tournaisian argillite, volcaniclastic rocks, magnetite iron formation and a carbonate exhalite. The metamorphic grade is middle greenschist. The deposit dimensions are 750 m x 16m max. thickness: the deposit is open down dip. The ore types include: 1) layered massive sulphides; 2) semi-massive replacement ore, and; 3) stringer sulphide veins. The massive sulphide type includes pyrite, sphalerite, minor pyrrhotite, chalcopyrite and galena with rare antimonides, native gold and electrum (Figure 34). The ore is generally recrystallized due to deformation. However, local colloform textures and framboidal pyrite are also present. The deposit is zoned, from copper-rich in the lower part to zinc- and lead-rich on the fringes. Footwall alteration asssemblages include carbonate, silica, chlorite- and sericite alteration. There is a footwall stringer zone and weak hanging wall alteration (Peter et al., 2007). The deposit is classified as a volcanic-sediment- hosted massive sulphide (like the deposits in the Bathurst camp,

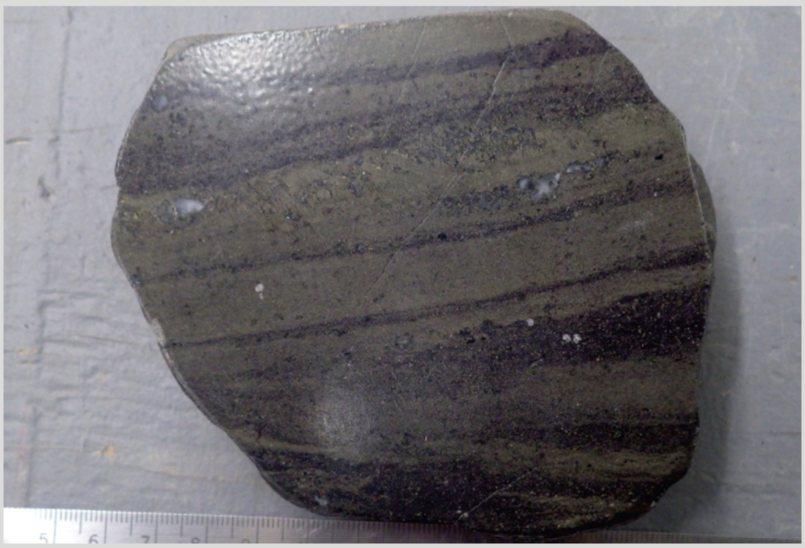


Figure 34. Wolverine: laminated ore from Wolverine polymetallic volcanogenic massive sulphide deposit: predominantly fine-grained pyrite and sphalerite (Yukon Geological Survey)

New Brunswick), or as a siliciclastic-felsic VMS (Franklin et al., 2005).

The host rocks of the Ice deposit (small) are massive, pillowed and brecciated basalts interlayered with chert, minor greywacke and carbonaceous mudstone. The deposit is 28 m thick with a copper-rich basal zone underlain by a sulphide stringer zone featuring pyrite, quartz, chalcopyrite and hematite. The sulphides are overlain by hematitic chert and, above this, by basalt. Footwall chlorite alteration is accompanied by a footwall stringer zone (Peter et al., 2007). The deposit is classified as a Cyprus-type massive sulphide. This deposit is identified as a mafic VMS (Franklin et al., 2005).

Hasselberg (Large)

The Hasselberg property is located SW of the Tintina Fault in the Pelly Mountains SE of Ross River. Newmont Exploration of Canada Ltd discovered the original showing in 1955 and staked claims in 1966. The property changed hands several times before being optioned from YGC Resources Ltd. by Atna Resources in 1995. The deposit lies within the Late Devonian - Early Mississippian Pelly Mountains volcanic belt, part of the Pelly-Cassiar Platform. The volcanic belt overlies cliff-forming carbonates, siltstones and shales of Silurian to Middle Devonian age and is overthrust by sandstone, grit, argillite and massive carbonates of the Ordovican to Devonian Road River Formation and Earn Group-equivalent strata. The Pelly Mountains volcanic belt consists of volcaniclastic strata, lapilli tuff, argillite and lesser trachyte flows, sills and dykes. Bedded barite and massive sulphides are interbedded with these strata (Anonymous, 2014f).

The Hasselberg deposit consists of two massive sulphide lenses collectively up to 1200 m wide and extending to a depth of 500 m: they are underlain by andesitic tuffs, and overlain by rhyolite tuff and porphyry. Potassium feldspar-sericite-clay-carbonate alteration is pervasive. The upper part of the deposit features lenticular barite and disseminated pyrite, sphalerite and galena. Drilling in 1997 and 1998 indicated the possibility that the deposit, with stringer mineralization above and exhalite below, lies on an overturned fold limb. In general the deposit is 3 - 5 m thick and consists of pyrite with banded amber sphalerite and galena, or botryoidal sphalerite and galena in a matrix of Fe-Mg carbonate and lesser barite (Anonymous, 2014f).

Marg (Medium)

The Marg property is located 140 km E of Dawson near the settlement of Keno City in the central Yukon: it was first staked in response to Geological Survey of Canada stream sediment geochemical survey results. The claims were allowed to lapse when no obvious mineralization was found. Renewed interest led to drilling in 1988 which uncovered extensive volcanogenic massive sulphide mineralization. The latest owner is Golden Predator Mining Corp. in a joint venture with Minquest Ltd.

The property lies near the northern margin of the Selwyn Basin within a panel of southeast dipping strata that are intensely sheared, penetratively deformed and metamorphosed to lower- and middle greenschist facies. The property lies between two significant thrusts and features a Paleozoic metamorphic succession with up to three phases of deformation: lineation and isoclinal folding (D1), upright to isoclinal folds with steep cleavage (D2) and open to tight southwest-vergent folds (D3). The Earn Group host rocks (Devono-Mississippian) consist of tuffs and greywacke with interbedded black shale and sulphide mineralization. The dominant rock type in the sulphide zone is quartz chlorite schist with variable carbonate content. This is thought to be a hydrothermally altered ash tuff and or pyroclastic rock.

The Marg deposit is classified as a volcanogenic massive sulphide (VMS) deposit and shares some features with other Yukon VMS prospects including Kudz Ze Kayah, and Wolverine in the Finlayson Lake area. It is hosted by felsic volcanic rocks and in this respect is similar to the Kuroko deposits of Japan and Noranda, Quebec. The mineralization at Marg occurs in multiple sheets traceable over 1400 m along strike and to a depth of 700 m. The sulphide minerals include pyrite, sphalerite, chalcopyrite, galena, tetrahedrite and arsenopyrite. Gangue minerals include quartz, ferroan carbonate, muscovite and rare barite. The sulphides occur as massive to semi-massive bands in a zone which is overlain by a silica-ferroan carbonate-barite assemblage, interpreted as a possible exhalite (Burgoyne and Giroux, 2011).

ULTRAMAFIC-HOSTED NICKEL-COPPER PGE

Wellgreen (Large)

The large Wellgreen deposit is located 317 km NW of Whitehorse in the southwest Yukon (Figure 36). Mineralization was discovered by prospectors in 1952 and was optioned in the same year to the Yukon Mining Company, a subsidiary of Hudson Bay Mining and Smelting. There was a significant drilling program in 1955 and underground development from 1953 to 1956. Mining and milling began in 1972 but was shortly afterwards suspended due to low metal prices and unexpectedly erratic ore. The latest owner is Wellgreen Platinum Ltd.

The property lies within the Insular Superterrane consisting of the Wrangel and Alexander terranes which were amalgamated at ~320 Ma. The Wellgreen host rock is within the Kluane Ultramafic Belt which lies within Wrangellia and consists of Triassic flood basalts and related intrusive rocks. Below the basalts there are Pennsylvanian and Permian arc volcanics and Permian sediments (Skolai Group) overlain by Middle and Late Triassic basalt and limestone (Nikolai Formation). Sills of the Kluane Ultramafic Belt are common within the Skolai Group and are thought to feed the Nikolai volcanics. The Wellgreen deposit lies along the lower contact of an Upper Triassic sill, locally referred to as the Quill Creek Complex (Carter et al., 2012).

The main component of the Quill Creek Complex is 4.2 km long and 700 m wide consisting of a main intrusion with associated overturned sills. These are crudely layered, variably serpentinized and deformed. Compositions within the Quill Creek Complex include gabbro, clinopyroxenite, peridotite and dunite. The mineralizations are described as the East Zone, West Zone and North Zone of which the East Zone, described here first, has received the most attention. The mineralization occurs at the base of a peridotite body within which there are massive sulphide lenses as well as a skarn zone in calcareous footwall strata: its extent is 1500 m by 700 m wide but of unreported thickness. The East Zone was mined in 1972-73, after which mining operations were suspended. The West Zone has mineralization in gabbro, clinopyroxenite and in the interfingering of these. Typical ore forming features include nickel-copper sulphides in disseminated, net-textured, semi-massive and massive mineralization (Carter et al., 2012).

Figure 35. Wellgreen: High-grade ore consisting of pyrrhotite-rich massive sulphide with lesser amounts of chalcopyrite, pentlandite and magnetite (Yukon Geological Survey)

Typical mineral assemblages within the Wellgreen ores are pyrrhotite, pentlandite, chalcopyrite, pyrite, magnetite and ilmenite (Photo 35). Less common phases include violarite, sphalerite, chromite, cobaltite, arsenopyrite and 14 others. Specific to the platinum and palladium minerals are arsenides, antimonides, tellurides and bismuthinides of which more than sixteen have been recognized (Carter et al., 2012).

POLYMETALLIC SILVER-LEAD-ZINC

This group of deposits (see Figure 36) includes the skarn-associated epithermal zinc-lead mineralization at the Andrew deposit (veins with zinc and lead), Keglovic (skarn associated zinc, copper and lead), Keno Hill (silver, lead, zinc), Logan (silver and zinc) and Quartz Lake (not described).

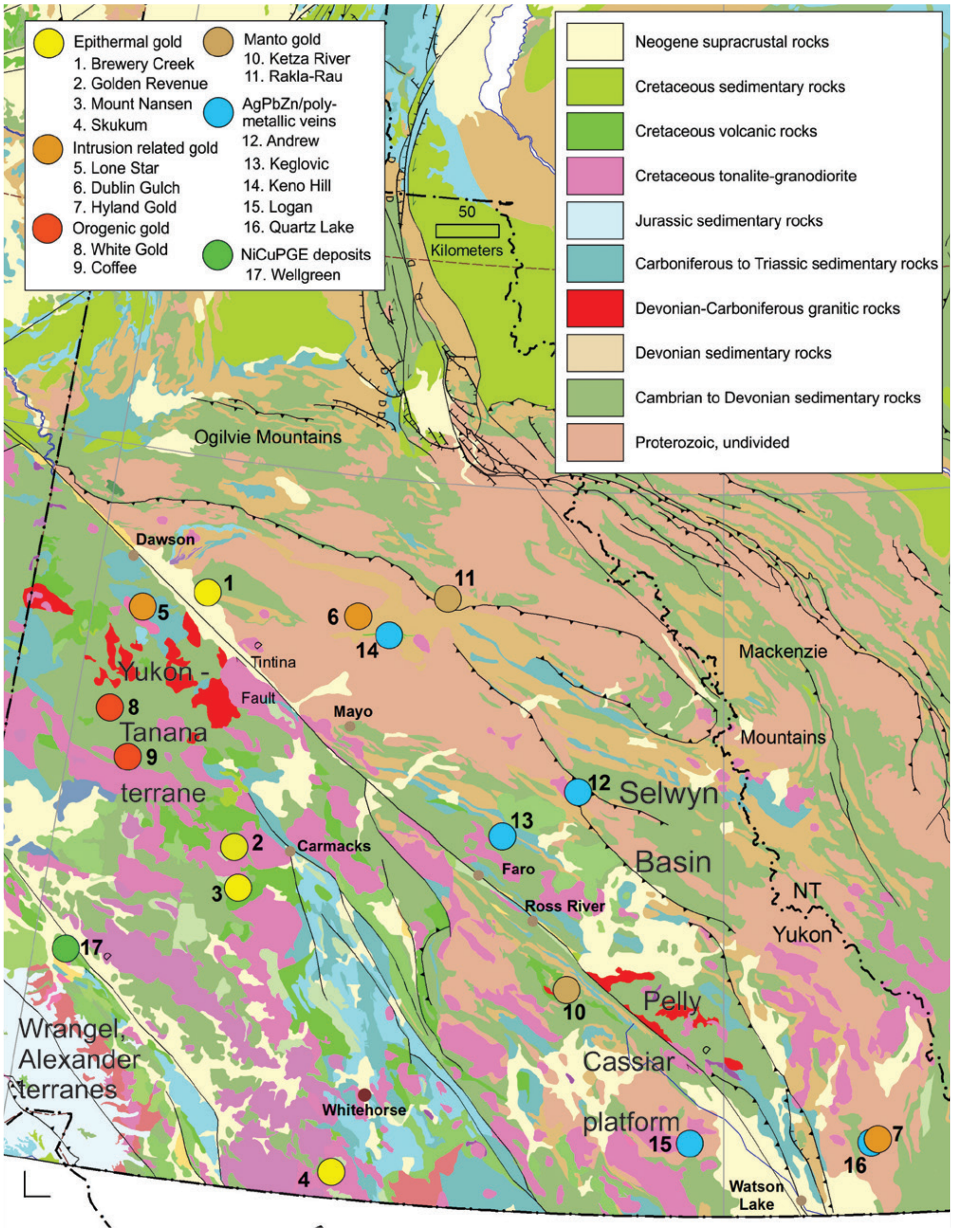


Figure 36. Simplified geology of Yukon and western Northwest Territories also showing deposits of lode gold, silver-lead-zinc polymetallic veins, and nickel-copper-PGE.

Andrew (Medium)

The property is located 100 km NE of Faro in the east-central Yukon. Geochemical results acquired by a mining syndicate led to the first staking in 1967. Fieldwork in 1968 led to the staking of the showings that included the Andrew deposit. The deposit is held by Overland Resources Ltd. Resource estimates based on drilling to date were announced in 2008 and continued property work was accomplished through at least 2012.

The property is located within the western Selwyn basin. Host rocks include the Yusezyu and Narchilla formations of the Hyland Group (Neoproterozoic to Early Cambrian), Ordovician to Silurian Road River Formation, and Devonian to Mississippian Earn group. This sequence is intruded by Cretaceous granite, quartz monzonite and granodiorite. The Andrew deposit is underlain by massive quartz arenite interbedded with Narchilla Formation red-green mudstone and lesser limestone. The deposit is described as a polymetallic vein system consisting of multigeneration breccia and veining, extending over an area of 650 m x 250 m (Anonymous, 2014a). The mineralization consists of coarse-grained sphalerite and galena, also as disseminated blebs, veins and massive aggregates. Chalcopyrite occurs in trace quantities.

Keglovic (Medium)

The Keglovic property is located in the south-central Yukon 40 km N of Faro which is 365 km by road from Whitehorse. Exploration from 1965 to 1985 focussed on SEDEX potential (similar to the nearby deposits of the Anvil district): this proved unsuccessful. Occurrence of disseminated, bleb and banded pyrite and pyrrhotite in drill holes was initially ignored. Exploration continued with varying success to 2012.

The property, held by Silver Range Resources Ltd, is located within the Selwyn Basin. Deformation and metamorphism accompanied granitoid intrusion and terrane accretion from the Jurassic to the mid-Cretaceous. Strike-slip faulting, notably the Tintina Fault, was active in the Paleogene. Paleozoic strata on the property are sandwiched between the Anvil Batholith (monzonite, granodiorite) to the southwest and the Teddy Caldera (tuff) to the northeast. The youngest igneous rocks are Paleogene plugs associated with the Ross volcanics.

Intense alteration is associated with the Mount Christie shale (Mississippian) and Tay (Carboniferous, Permian) formations along with sulphide veinlets and disseminated sulphides. Mineralization is associated with the “Keg Main Zone” which occurs in altered and skarn-associated Tay and Mount Christie formations. Coarse grained sphalerite, chalcopyrite and galena occur together with varying amounts of pyrrhotite, pyrite and arsenopyrite collectively making up 1 - 10% of rock volume or 20 - 50% of skarn intervals. Galena abundance increases to the east and into the upper parts of the deposit whereas pyrrhotite and chalcopyrite is enriched downwards and to the west. This implies a more proximal hydrothermal cell at depth and westward (Giroux and Mehlis, 2013).

Keno Hill (Large)

The Keno Hill district (a large resource) is located in the central Yukon 500 km by all-weather road from Whitehorse. Exploration and mining in the Keno Hill district dates back to the early 1900s, beginning with the hunt for gold associated with the Klondike gold rush of 1898. Silver was first discovered in 1901 but mining was delayed to 1913 then deferred due to World War I. New discoveries and a staking rush marked the immediate post-war period: mining resumed in the early 1920s, but was terminated because of World War II. Mining reached a peak in the 1950s but declined in the 1960s due to a lack of new discoveries. Mining, including open pit operations, marked activity in the late 1970s. There were also a number of small scale operations through the 1980s. Production ended in 1989. Remaining assets were purchased by Alexco Resource Corporation in 2006.

Within the mining camp, the bulk of the mineralization occurs in the Basal Quartzite Member of the Keno Hill Quartzite (Mississippian). This unit consists of thinly- to thickly-bedded quartzite and graphitic phyllite. Silver mineralization is hosted by a series of northeast-striking faulted veins with left-lateral and normal displacement. These veins can be

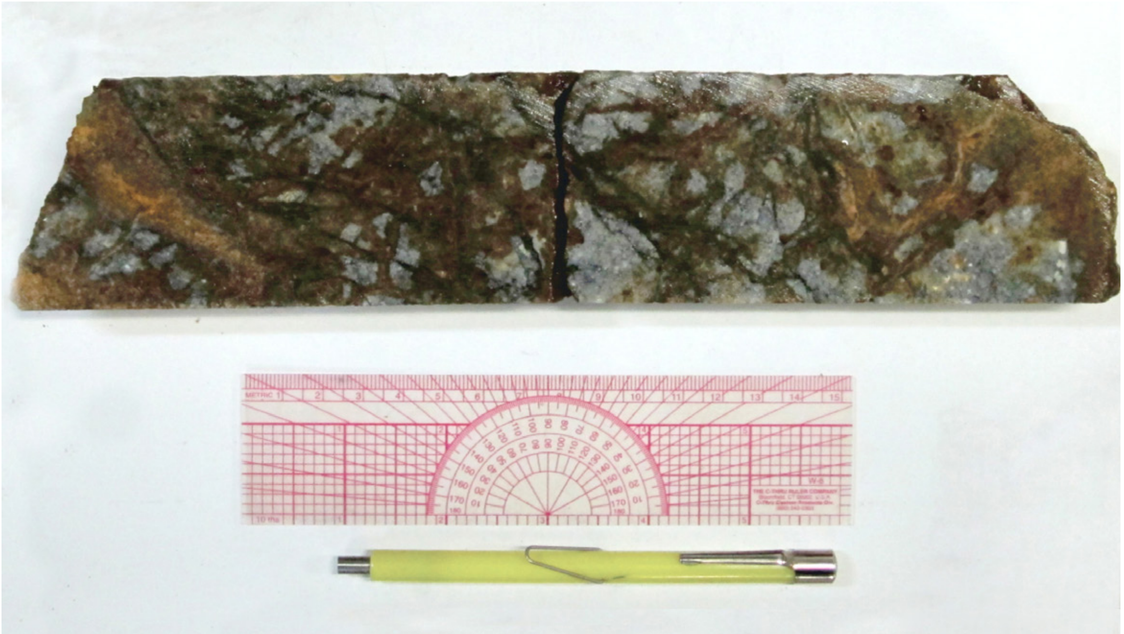


Figure 37. Keno Hill: Brecciated drill core from the North Slope deposit (Yukon Geological Survey).

up to 30 m wide. Other faults strike northwest and are seen to offset mineralized veins. The vein mineralogy is complicated by the fact that there have been multiple pulses of hydrothermal activity acting on the system. This has produced vein reactivation and related brecciation. Silver mostly occurs in argentiferous galena, argentiferous tetrahedrite (freibergite) and locally in native silver, polybasite, stephanite and pyrargyrite. Other typical sulphides include galena, sphalerite, pyrite, pyrrhotite, arsenopyrite and chalcopyrite (Figure 37). Zoning has also been suggested with the original belief that the high silver grades only occur at shallow depths, above 120 m. However there are deposits with good silver grades to depths of at least 370 m. Features diagnostic of better or more continuous veins include quartzite or greenstone on a vein wall, veins adjacent to cross-faults, vein splitting, and changes in the dip of the veins (Taylor and Arsenault, 2014).

The Keno Hill district is a polymetallic silver-lead-zinc camp with similarities to Coeur-d'Alene, Idaho, mineralization in the Harz Mountains in Germany, and Pribram in the Czech Republic (Cathro, 2006).

Logan (Medium)

The Logan silver-zinc deposit is located 108 km NW of Watson Lake, Yukon and 38 km N of the Alaska Highway. The property was first staked in 1979 by Regional Resources Ltd, who carried out geochemical and geophysical investigations on the property until 1982. Ownership was jointly controlled with Getty Canadian Minerals Ltd from 1984 but was transferred to Fairfield Minerals Ltd in 1986 who expanded the claim block, added an airstrip (1987) and completed a campaign of trenching and drilling (to 1988). The latest owners are Almaden Minerals (2015).

The zinc and silver occur in a fault-bounded body 1100 m long and 50 - 140 m wide. The deposit is open to a depth of below 200 m. Ore minerals include sphalerite, pyrite, arsenopyrite, chalcopyrite, minor silver sulphosalts and cassiterite. There are also traces of pyrrhotite, covellite, galena, chalcocite, tetrahedrite, stannite, jamesonite, kobellite and native copper. These are concentrated in multiphase quartz- and quartz-ankerite veins, breccia bodies, stockwork and silicified zones. Alteration phases include sericite, biotite and silica (Anonymous, 2014c).

EPITHERMAL GOLD

This group includes the Brewery Creek, Golden Revenue (large), Mount Nansen (not described) and Skukum deposits, all located near to, or S of the Tintina Fault in the southwestern Yukon (Figure 36).

Brewery Creek (Medium)

The Brewery Creek property lies in the foothills of the Ogilvie Mountains, 55 km E of Dawson City in the northwest Yukon. Claims were first staked by Noranda Exploration in 1987. Northern Tiger then took over the Brewery Creek project in late 2013. The current operator is Golden Predator Corporation.

The Brewery Creek site lies along the northeastern edge of the 15 km wide Tintina fault zone within the western margin of the Selwyn Basin. Strata within the property are composed of deep-water Cambrian to Mississippian strata. These are cut by Cretaceous intrusives of the Tombstone Suite and have suffered deformation in association with transport on the Dawson, Tombstone and Robert Service thrusts. Intrusives on the Brewery Creek property are sill-like bodies of monzonite and quartz monzonite emplaced in graphitic argillite along the contact between the Earn (Devono-Mississippian) and Road River (Ordovician-Silurian) groups. Gold mineralization is contained within, or adjacent to these intrusive rocks. Alteration associated with the gold includes carbonate-clay, quartz and pyrite-arsenopyrite alteration of monzonite, quartz monzonite and intruded siliciclastic rocks. There are fourteen named deposits. The Kokanee and Golden deposits occur primarily in a quartz monzonite sill and to a lesser extent in siltstone and argillite. Millimetre-scale veinlets contain oxidized pyrite and quartz (Figures 38, 39). Feldspar phenocrysts and the matrix in the host quartz monzonite are altered to clay (Hulse et al., 2014). The Brewery Creek deposit is considered to be an alkalic intrusion-related epithermal deposit.

Golden Revenue (Large)

The property is located 200 km NW of Whitehorse. Lode gold was first discovered on Freegold Mountain in 1930, which precipitated a staking

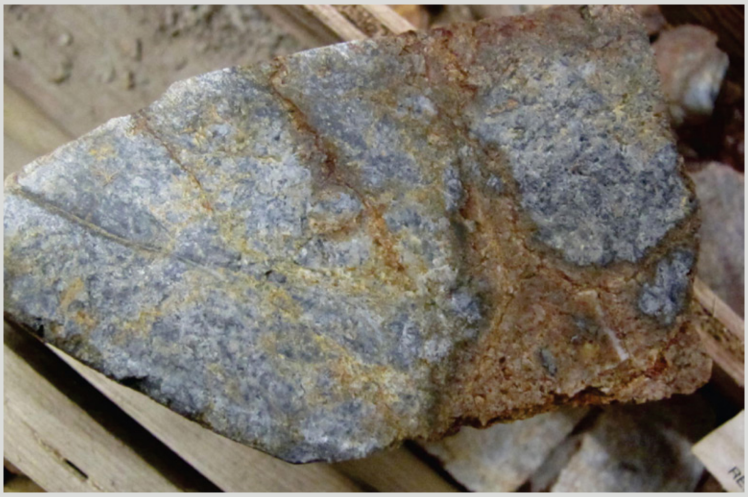


Figure 38. Brewery Creek : hydrothermal alteration associated with fractures in quartz monzonite from the Schooner zone, grade:13.65 g/t (Golden Predator Mining Corp.).

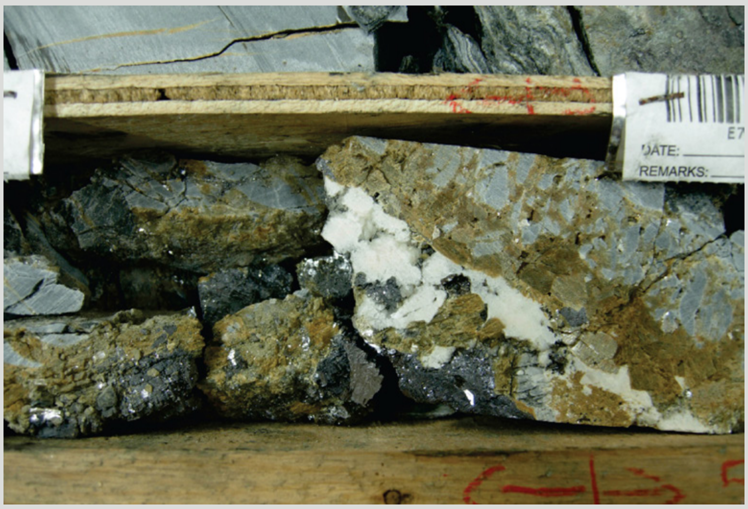


Figure 39. Brewery Creek: hydrothermal alteration associated with fractures in quartz monzonite from the Schooner zone, grade: 17.7 g/t (Golden Predator Mining Corp.).

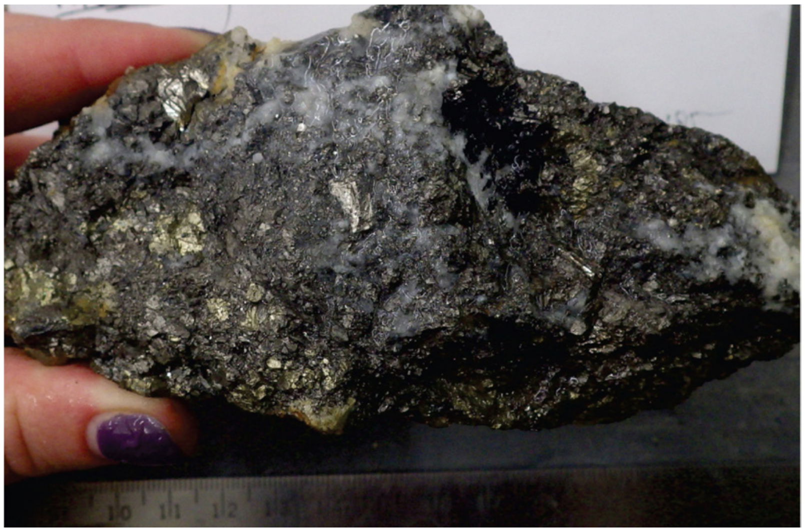


Figure 40. Mt. Skukum: Gold-bearing pyrite and arsenopyrite quartz vein (Yukon Geological Survey).

rush through to 1931. Work continued intermittently through the 1950s when interest shifted to porphyry deposits. A soil survey in the 1960s led to the discovery of the Nucleus deposit. Northern Freegold Resources Ltd acquired the property in 2006 and has since conducted extensive surveys.

The Golden Revenue region lies within the Dawson Range, part of a belt of Jurassic to Late Cretaceous plutons that extends to the Alaska border along the boundary between the Stikine and Yukon-Tanana terranes. Components of the Yukon-Tanana terrane include Early Mississippian plutonic rocks and Mississippian and older undifferentiated metasediments and metavolcanic rocks. The property lies within the Yukon-Tanana terrane comprising Paleozoic (or older) quartz-feldspar-mica schist and gneiss, chlorite schist, amphibolite, grey marble and quartzite. There is a penetrative foliation striking northwest and dipping northeast. Granitoid rocks in the area are Jurassic and Cretaceous in age: syenite is found locally. These intrusives are all intruded by Late Cretaceous plugs, sills, dykes and breccia bodies, of felsic to intermediate composition, closely associated with mineralization.

The mineralization is contained between two regional fault systems with a northwesterly trend: the Big Creek fault and the Southern Big Creek Fault. Between these are secondary structures that strike variably west to northwest and northwest to north and northeast. Mineralization is closely associated with west- to northwest-striking structures.

The Revenue Breccia is closely associated with the Revenue deposit. Its matrix is quartz feldspar porphyry. The breccia is typically altered to clay and carbonate and also contains pyrite and copper oxides. Mineralization is contained within the Revenue breccia and in host granodiorite. It is typically seen as porphyry veins, stockwork and disseminated sulphides. Minerals of economic interest include native gold, chalcopyrite and silver with lesser molybdenite and scheelite. Alteration includes potassic (as biotite), sericitic and clay varieties (Armitage et al., 2012).

Skukum (Medium)

The Skukum property (owner: New Pacific Metals Corp) is located 80 km S of Whitehorse. There are three deposits on the property: Mt. Skukum discovered in 1982, Skukum Creek (1922) and Goddell Gully (1898). The oldest rocks are assigned to the metamorphosed Nisling and Nasina assemblages (Proterozoic and Paleozoic). Mesozoic plutonic rocks, however, underlie much of the Skukum region. These intrude Jurassic andesite and siliciclastic sediments and are overlapped by strata of the Whitehorse Trough (Simpson, 2013).

Productive mineralization consists of electrum in quartz-calcite-sericite veins. At Mt. Skukum this includes the Main Cirque Zone (veins and stockwork 200 m long x 5 m wide) emplaced into porphyritic andesite. The Lake Zone (650 m x average 0.6 m wide), consisting of veins, hydrothermal breccia and stockwork, features pyrite, pyrrhotite, sphalerite, galena, rhodochrosite, rhodonite and electrum in a gangue of quartz, calcite and sericite. At Skukum Creek, mineralization occurs in andesite and rhyolite dykes and in a series of northeast-striking faults. Gold occurs as electrum and silver as freibergite and some native silver. Sulphides include pyrite, arsenopyrite, galena, sphalerite and chalcopyrite (Figure 40). In the Goddell Gully zone, gold mineralization is associated with the easterly-striking Goddell Fault, with disseminated arsenopyrite, arsenian pyrite, and with veins of sphalerite, stibnite and quartz. The deposits in the Skukum area are classified as precious metal epithermal veins, in part intrusion-related (Simpson, 2013).

INTRUSION-RELATED GOLD

This group includes intrusion-related gold deposits of the central Yukon including the Lone Star (not described), Dublin Gulch and Hyland gold deposits (Figure 36).

Dublin Gulch (Medium)

The property is located 85 km by road N of Mayo and 400 km N of Whitehorse. The Dublin Gulch property has a history dating back to 1895 with the onset of placer mining. Exploration of bedrock has been more-or-less continuous since 1970 initially for tungsten, later for gold. Victoria Gold Corp. acquired the property in 2009. The property lies within the north-central part of the Selwyn Basin, which consists of four local units: Neoproterozoic to lower Cambrian Hyland Group, Keno Hill Quartzite and Upper Schist (Devonian-Mississippian), and Lower Schist (Mesozoic). These are associated with three principal thrusts: the Dawson, Tombstone and Robert Service thrusts of which the Robert Service Thrust is closest to the property. It places the Hyland Group over the Keno Hill Quartzite. The thrusting is closely associated with the development of a penetrative cleavage with superimposed east-trending and south-plunging folds.

Phases of intrusion include mid- to late-Cretaceous granitoids: the Selwyn Suite (104 to 98 Ma); the Tombstone Suite (94 to 92 Ma) and the McQueston Suite (64 Ma). These intrusives are closely associated with gold, silver, lead and zinc mineralization. The composition of the Dublin Gulch stock includes granodiorite (oldest and most important), quartz diorite, quartz monzonite and dykes and sills of aplite (Mosher and Tribel, 2011). Mineralization on the Dublin Gulch property is hosted by Hyland Group clastic rocks in close proximity to the Dublin Gulch granodiorite intrusion (93 Ma), part of the Tombstone Suite.

The Eagle zone is located in the Dublin Gulch stock near its western limit with the Hyland

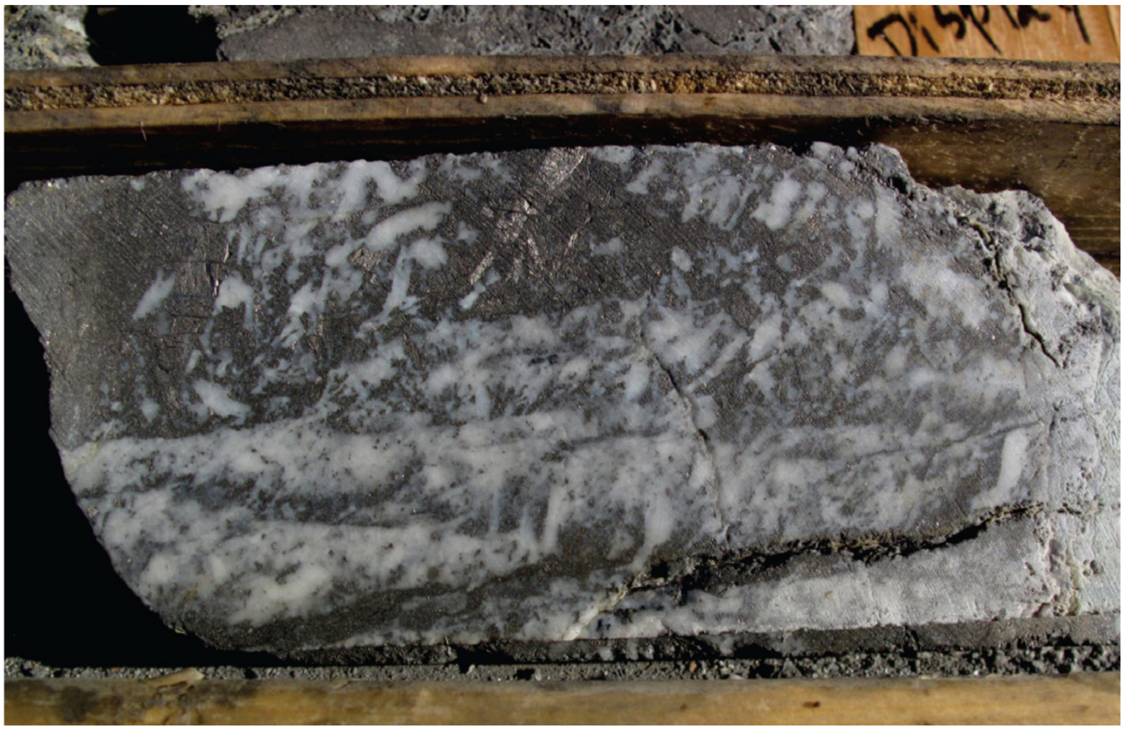


Figure 41. Dublin Gulch: High-grade gold-bearing arsenopyrite quartz vein from Shamrock zone of Dublin Gulch property (Yukon Geological Survey).

Group. The mineralization consists of sub-parallel quartz veins of grey quartz and potassium feldspar. Vein densities average 3-5/m. Sulphide phases include pyrrhotite, pyrite, arsenopyrite, chalcopyrite, sphalerite, bismuthinite, molybdenite and galena (Figure 41). Alteration assemblages typically include potassium feldspar and sericite-carbonate. Potential mineralization may be located in the Hyland Group near the Dublin Gulch stock (Mosher and Tribel, 2011).

The Eagle Zone on the Dublin Gulch property is considered to be a reduced, intrusion-related gold system. This type occurs as a vein array in the carapace of small plutons where they form bulk-tonnage, low-grade deposits with an association of gold, bismuth, tellurium and tungsten.

Hyland Gold (Small)

The Hyland property is located 74 km NE of Watson Lake in the southeast Yukon. It is located within the southeastern Selwyn Basin, consisting of Neoproterozoic to Devonian shale, deep water limestone, chert and grit. Mineralization in the Main zone consists of semi-massive to massive sulphide (pyrite, lesser arsenopyrite) that at the surface is widely oxidized to limonite, goethite, hematite and manganese oxides. In addition there are vein sets consisting of Type I: pyrite and arsenopyrite; Type II: quartz, pyrite, arsenopyrite, chalcopyrite, bismuthinite, tetrahedrite, native gold and, youngest; Type III: quartz, iron carbonate, pyrite, and titanite. Gold grains, up to 35 microns, occur as inclusions in pyrite or along pyrite grain boundaries (Armitage and Gray, 2012).

OROGENIC GOLD

These are orogenic gold deposits distinguished from those of Archean and Paleoproterozoic ages by their association with Cordilleran deformation in the Jurassic and Cretaceous. The group includes the large Coffee deposit and the White Gold property, both located S of Dawson in the northwest Yukon (Figure 36).

Figure 42. Coffee: silicified, oxidized gold-bearing vein breccia. (Yukon Geological Survey).

Coffee (Large)

The Coffee deposit is located 130 km S of Dawson and 160 km NW of Carmacks. The property area has a sporadic history of placer mining up to 1982. Recent hard-rock gold exploration began with the discovery in 1981 of arsenic anomalies in Coffee Creek. Gold anomalies in soils were uncovered in 1999 over an area of 400 m x 900 m. Kaminak Gold Corp. optioned the property in 2009 and expanded a program of exploration and drilling down to the present (2013).

The Coffee property lies within the Yukon-Tanana terrane (YTT). The YTT consists of pre- Devonian schist, local amphibolite, greenstone and ultramafic rocks. An intrusive arc (Klondike arc) developed on the Yukon-Tanana terrane in the Late Permian, leading to collision with the Laurentian margin in the Jurassic. Ongoing shortening produced folding and thrusting of greenstone and ultramafic slivers (Slide Mountain terrane) within the YTT. These events are dated to the Early Jurassic. Extensional emplacement of local granite is of mid-Cretaceous age (~110 - 90 Ma).

Figure 43. White Gold: silicified and brecciated gold -bearing drillcore from the Golden Saddle Zone (Yukon Geological Survey).

The Coffee property is underlain by Paleozoic metasediments, Cretaceous Coffee Creek granite and a portion of the Dawson Range batholith. Deformation fabrics include metamorphic foliation, shearing (Jurassic) and brittle fracturing and faulting. These latter structures host gold mineralization and are identified as splays of the nearby Big Creek fault which displaces the Cretaceous granite and are therefore younger. Fault-associated structures include crackle breccia and stockwork fracture systems. In total nineteen gold zones have been discovered (Sim and Kappes, 2014).

Hydrothermal breccia is the dominant host in the Supremo zone (Figure 42) but lower -grade mineralization is also found in hydrothermally altered gneiss and in altered dykes. Minerals found in association with micron-scale and "invisible" gold include pyrite, micron-sized barite, an iron-barium arsenate, a phosphorus phase, monazite and zircon (Mackenzie et al., 2015). Supergene alteration, expressed as iron oxides, is present to depths exceeding 200 m. It has been suggested that the Coffee deposit is of the epizonal high-sulfidation hydrothermal orogenic gold type.

White Gold (Medium)

The White Gold property is located 95 km S of Dawson City and 350 km NW of Whitehorse at the confluence of the Stewart, White and Yukon rivers. In spite of a long history of placer mining, hard rock exploration did not begin in earnest until 2007 when the property was optioned to Underworld Resources Inc. It is now held by Kinross Gold.

White Gold occurs in greenschist and lower amphibolite facies, metamorphic rocks of the Yukon-Tanana terrane which was accreted to ancestral North America in the Jurassic. Thrusting marked the Jurassic and plutonism the Jurassic and Cretaceous. The deposit is now located between the Tintina and Farewell faults inthe central Yukon.

Three geological zones are exposed on the property: quartzite in the west; overlying strongly foliated and lineated metavolcanic rocks (amphibolite gneiss) in the central region; and an eastern belt of metasediments (quartz-rich unit and schist) intruded by pyroxenite and serpentinite. Two ore zones have been delineated at White Gold: Golden Saddle and Arc. The Golden Saddle mineralization is located within felsic orthogneiss, amphibolite and ultramafic rocks. Fault zones and breccia have important associations with the mineralization. Gold is specifically associated with vein- and disseminated pyrite, lode and stockwork quartz veins, quartz vein breccias, silicification, and limonite (Figure 43). Lode veins and breccias also carry minor molybdenite, galena and chalcopyrite. Gold occurs as blebs up to 15 microns close to or within pyrite (Weiershauser et al., 2010).

Gold in the Arc zone is mostly present in metasedimentary rocks, specifically in quartzite and biotite schist, but it is also found in felsic to intermediate dykes. Alteration is present as silicification and graphite. Mineralization occurs in veinlets as micron-scale gold in arsenopyrite along with pyrite, pyrrhotite, graphite and minor sphalerite (Weiershauser et al., 2010).

MANTO GOLD

The Manto gold deposits are located at Ketza River (not described), close to, but S of the Tintina Fault in the southern Yukon, and at Rakla-Rau in the Mackenzie Mountains (Figure 36).

Rackla - Rau (Medium)

The Rau property is located in the northern Yukon 100 km NE of Mayo. Exploration began in 1922 with the discovery of mineralized float within the property area. More silver-bearing galena float was discovered by Geological Survey of Canada staff in 1924. However, the source was not located. The first “in situ” discoveries were by an independent prospector in 1923. Claims were periodically staked and dropped up to 1974. The history of ATAC Resources Limited in the property and of accelerated exploration dates to 2006.

The Rau property is located within a zone of thrust imbrication that includes rocks of the Mackenzie Platform (shallow water carbonates and clastics) and Selwyn Basin (Neoproterozoic to Paleozoic basinal rocks). These are intruded by Late Cretaceous felsic plutons of the Tombstone Suite and by felsic intrusions of the McQueston Suite (65 Ma). There is, within the property, a region of dykes and sills considered to be the upper portion of a largely unroofed granite body referred to as the “Rackla Pluton”. Ar/Ar ages are in the range of 59.1-62.4 Ma. This area is a locus for skarn development (Strosheim et al., 2011). Gold mineralization in the Tiger zone is developed in a carbonate replacement body 700 m x up to 200 m wide x up to 96 m thick in a high strain zone. The mineralization occurs in folded carbonate beds interleaved with mafic flows and volcaniclastic units. Gold occurs primarily in a sulphide facies, which includes banded pyrite, arsenopyrite and pyrrhotite with minor bismuthinite, sphalerite and scheelite (Strosheim et al., 2011). Carbonate textures indicate extensive karst dissolution and phreatic zone precipitation. Void fill is commonly pyrite, spar calcite and quartz. Alteration consists of talc and sericite, which is limited to volcanic horizons. The Tiger zone mineralization shares features with both the low-temperature Carlin- type gold and others of a higher-temperature genesis.

PORPHYRY COPPER AND MOLYBDENUM

Classic porphyry deposits of the Yukon (Figure 44) variously comprising chalcopyrite, molybdenite, gold and tungsten minerals include Cash (medium: copper, molybdenum and gold), Casino (very large: copper and molybdenum), Logtung (large: tungsten and molybdenum) and Red Mountain (large: molybdenum).

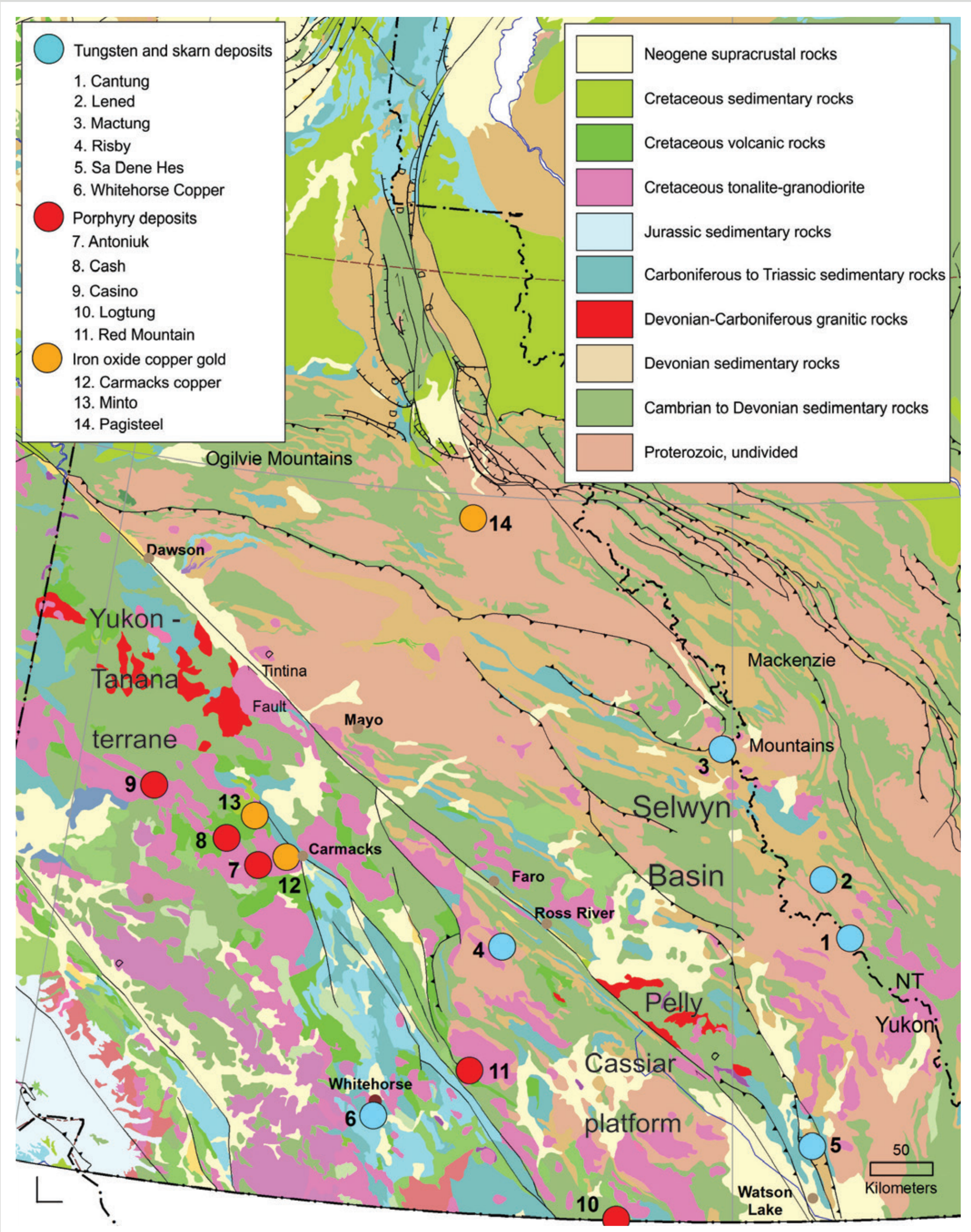


Figure 44. Simplified geology of Yukon and western Northwest Territories also showing deposits of tungsten and copper skarns, porphyrys and iron oxide copper gold.

Figure 45. Casino: molybdenite and minor chalcopyrite in core (Yukon Geological Survey).

Cash (Medium)

The Cash property is located 452 km NE of the seaport of Skagway, Alaska in the vicinity of Carmacks in a belt of porphyry deposits extending 100 km from Casino in the northwest to Antoniuk in the southeast. Copper, molybdenum and gold-porphyry style mineralization underlies an area of 3050 m x 900 m associated with copper-molybdenum soil geochemical anomalies and with mid-Cretaceous Mt. Nansen Group feldspar porphyry dykes and plugs. Older syenite and quartz monzonite stocks, and schist and gneiss of Paleozoic age are also present. The mineralization consists of disseminated and fracture- filling chalcopyrite and pyrite with minor coarse-grained molybdenite in quartz veinlets. Zoning indicates high molybdenum values in the northeast and higher gold in the southwest. Systematic drilling in 1975-1977 defined a northwestern limit to the mineralization. The ore zone remains open on the other three sides and at depth. The deposit is expressed at the surface by a 900 m x 2500 m copper and molybdenum anomaly, which is fringed by anomalies of lead, zinc, silver and gold. Soil sampling within apparent fault zones has produced additional soil geochemical anomalies for gold and arsenic (Anonymous, 2014g).

Casino (Very large)

The very large Casino deposit is located in the Dawson Range Mountains 300 km NW of Whitehorse in the west central Yukon. Placer claims were first staked in 1911. A 1917 report by D.D. Cairns of the Geological Survey of Canada suggested that gold and tungsten might be found in a nearby intrusive complex, on what would become the location of the Casino deposit. Silver-lead-zinc veins were discovered in 1936 and were the focus of exploration up to 1967. Silver-rich veins were mined periodically from 1963 to 1980. Porphyry potential was investigated from 1967 onwards with a variety of owners and joint-venture partners. The current owner is Casino Mining Corporation.

Rocks of the Dawson Range are represented by the Devono-Mississippian Wolverine Creek metamorphic suite consisting of metasedimentary quartz-feldspar-mica schist, gneiss, quartzite and meta-igneous biotite-hornblende-feldspar gneiss, othogneiss and amphibolites.

Cretaceous intrusions in the Dawson Range batholith include potassic quartz diorite, granodiorite, diorite and dykes and plugs of quartz monzonite. The Casino plutonic suite is now considered to be an altered facies of the Dawson Range batholith. The distinctly younger Prospector Mountain plutonic suite consists of hypabyssal rhyodacite and dacite intrusions and dykes up to 1 m wide. These are variously altered and unaltered which indicates that the mineralization may, in part, be the same age as this intrusive suite and in part older (Huss et al., 2013).

The Casino deposit is bound to the south by a northerly-transported thrust, to the north by the northwest-striking, right-lateral Big Creek Fault and to the east by the sinistral, northeast-striking Dip Creek fault. The offset on the Big Creek Fault is thought to be 20 - 45 km. Hydrothermal alteration consists of a potassic core centred on the Patton Porphyry. This is bordered by strong phyllic alteration, a weak propylitic zone and a secondary argillic overprint.

Mineralization types include leached cap mineralization; supergene oxide mineralization; supergene sulphide mineralization; and hypogene mineralization. The leached cap is 70 m thick and consists of a boxwork of iron oxides. Most minerals are replaced by clay. The supergene oxide zone is notably copper-enriched and is typically 10 m thick. Associated minerals include chalcanthite, malachite, brocanthite and others. The supergene sulphide zone is also notably enriched in copper and features digenite, chalcocite, minor covellite, bornite and copper-bearing goethite. Below the weathered zone, mineralization is typically found in stockwork veins and breccias. Hypogene mineralization in the potassic zone consists of finely disseminated pyrite, chalcopyrite, molybdenite and minor sphalerite and bornite. Gold, copper, molybenite and tungsten are present in higher grades in the phyllic zone (Figure 45; Huss et al., 2013).

Logtung (Large)

The large Logtung deposit is located 260 km SE of Whitehorse, Yukon and 165 km W of Watson Lake near the BC-Yukon border (but entirely within the Yukon). The property lies 130 km SW of the Tintina Fault in the Yukon-Tanana terrane. The country rocks consist of Paleozoic and Triassic clastic and carbonate sedimentary rocks. These are intruded by two plutonic suites of Early Jurassic and mid-Cretaceous ages. The Early Jurassic magmatic rocks feature en echelon plutons ranging from ultramafic to granodioritic in composition with a northwesterly trend. The Cretaceous plutonic suite (115 - 97 Ma) also trends northwest and has a compositional range from quartz monzonite to monzogranite. The suite includes batholiths, plutons and hypabyssal dykes and is the host of the Logtung deposit (Molavi et al., 2011).

The Logtung porphyry tungsten-molybdenum deposit is characterized by a quartz- vein stockwork and a sheeted- vein set centred on a quartz-feldspar intrusion complex. This is a branch of a mid-Cretaceous quartz monzonite stock, a satellite of the Seagull batholith, and one of several intrusions that are enriched in tungsten, molybdenum and fluorine. Where skarn is present the ore minerals are associated with veins and with open fractures. For this reason Logtung is considered to be a porphyry deposit rather than skarn mineralization (Noble et al, 1984).

The property is, nevertheless, underlain by skarn and hornfelsed metasedimentary rocks. The skarns include green quartz-diopside skarn and reddish-brown garnet skarn interbedded with grey to black hornfels. Intrusive rocks include Jurassic diorite dykes, a mid-Cretaceous quartz monzonite stock and related quartz-feldspar porphyry dykes. The mineralized zone is 2.5 km x 1.0 km and extends along the northern and western margins of the quartz monzonite stock. Mineralization also extends into the stock and is closely associated with porphyry dykes. Minerals of economic significance include scheelite, molybdenite and molybdoscheelite. There is also a sulphide facies associated with northeast-striking sheeted quartz-pyrite veins that includes beryl, fluorite, bismuthinite, chalcopyrite, sphalerite and pyrrhotite (Molavi et al., 2011). The Logtung deposit is classified as a porphyry of tungsten-molybdenum type. These are large-tonnage, low-grade hydrothermal deposits.

Red Mountain (Large)

The Red Mountain property is located 130 km SSW of Ross River in the south central Yukon. The area was first staked in 1967. Ground surveys and drilling commenced in 1969 with operators including Hudson Bay Oil and Gas Co.Ltd. and Amoco Canada Petroleum Co. Ltd. An application to conduct underground exploration was made by Tintina Mines Ltd. in 2005.

Paleozoic argillite of the Yukon-Tanana terrane is intruded by a quartz monzonite porphyry stock in which molybdenite occurs in a quartz stockwork. Mineralization extends also partly into the surrounding argillite. Geochemical anomalies over a pyritic gossan include molybdenum, copper, silver and tungsten. The porphyry stock has concentric alteration haloes and is cut by a post-mineralization quartz diorite stock. The mineralization underlies an area of 1500 m x 425 m and extends to a depth of >1125 m depth (Anonymous, 2014d).

COPPER AND TUNGSTEN SKARNS

Skarn mineralization has developed adjacent to Cretaceous intrusive rocks most notably along the Yukon-Northwest Territories border (Figure 44). Here is found the Cantung tungsten mine and the economically significant deposits that include the large Mactung (inside the Yukon) and the Lened deposit (inside the Northwest Territories; not described). Also described is the Risby tungsten property west of Ross River, the Sa Dene Hes deposit near Watson Lake, and the copper skarn deposits at Whitehorse.

Cantung (Medium)

The Cantung deposit is located in the Nahanni region of the Northwest Territories, 300 km by all-weather road NE of Watson Lake, Yukon and close to the Yukon border. The Cantung mine lies close to the boundary between the Mackenzie Platform (to the east) and the Selwyn basin (to the west). Stratigraphic units in the mine area include early Cambrian limestone ("Swiss Cheese Limestone") overlain by an early Cambrian clean blue grey limestone (the Ore Limestone) succeeded by argillite, quartzite, dolostone (all Early Cambrian) and above this wavy-banded limestone of the Middle and late Cambrian Rabbitkettle Formation (Fitzpatrick and Bakker, 2011).

The dominant structure is the Flat River Syncline which is ca. 5 km wide and trends northwest. Intrusives of Cretaceous age are post-tectonic and consist of medium-grained biotite quartz monzonite. There are two of these at surface in the immediate vicinity of the mine and a third at depth associated with dykes that cut overlying strata. These are aplite, leucocratic- or tourmaline-bearing granite and porphyry dykes (Fitzpatrick and Bakker, 2011, Rasmussen et al., 2011).

Parts of the deposit, Open Pit and E Zone, lie on the flat-lying upper limb of a local recumbent anticline and on the lower limb, respectively. The mineralization is associated with a calcsilicate skarn in the Ore Limestone within which scheelite is the sole ore mineral (Figure 46). However, chalcopyrite was formerly also acquired during mining. Gangue phases in the Open Pit deposit include pyrrhotite, diopside, garnet and actinolite. The E Zone deposit consists of massive to semi-massive pyrrhotite, pyroxene, garnet,

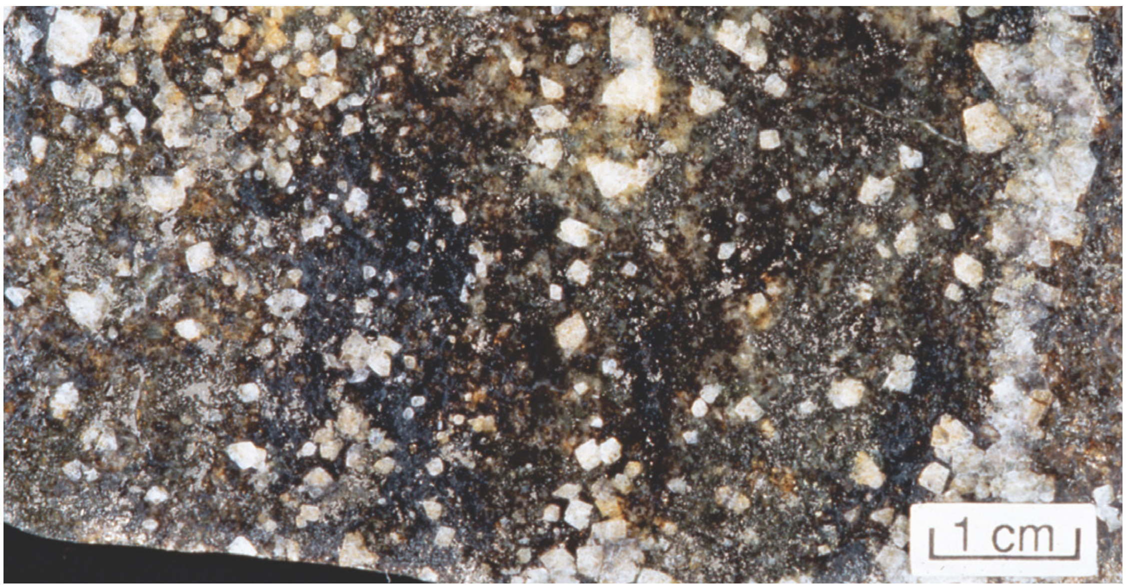


Figure 46. Cantung skarn: high grade tungsten ore; scheelite crystals (white) in biotite diopside pyrrhotite skarn; E zone ore body. GSC 1995-220B.

Figure 47. Mactung: scheelite-bearing massive pyrrhotite (Yukon Geological Survey).

actinolite and biotite. Accessory phases include apatite, epidote and tourmaline (Fitzpatrick and Bakker, 2011).

Mactung (Large)

The Mactung property (Narcisco et al., 2009; Selby et al., 2003), held by North American Tungsten Corporation Ltd, straddles the Yukon - Northwest Territories border NW of Cantung. It is located in the eastern Selwyn Basin, a region of off-shelf, deep-water sediments that persisted from the Neoproterozoic to the Middle Devonian. Typical deep-water strata include shale, chert and basin-facies limestone. These grade northeastwards into shelf facies carbonates. Deformation was largely of Jurassic and Early Cretaceous age, featuring thrust faulting and open to tight folds. Granite magmatism was prominent in Early to Late Cretaceous time. Five intrusive suites are recognized and range form 97.5 - 92 Ma (Selby et al., 2003).

The Mactung deposit is the most northerly of a 200 km long northwesterly trending belt of tungsten-copper skarns that also includes the Cantung deposit, 160 km to the southeast. A typical feature of these deposits is the location of skarns above the altered apex of Late Cretaceous quartz monzonite plutons. This feature is found in the Mactung deposit, which is closely associated with the Cirque Lake stock.

The mineralization is developed in scheelite skarns within an interbedded succession of Cambrian to Silurian limestones, shales and siltstones near the south contact of the Cirque Lake stock. There are two skarn zones, separated by 100 m of hornfelsed shale and siltstone variously altered to muscovite, biotite and graphite. Cutting these there are numerous veinlets containing pyrite, pyrrhotite, scheelite and molybdenite (Narcisco et al., 2009). The entire section of nine mappable units, four of which contain tungsten ores, forms a recumbent fold with a gently plunging axis. The ore body is also cut by numerous steeply dipping faults with displacements of up to 45 m and consisting of gouge, breccia and quartz and calcite pore-filling.

The mineralization consists of a pyroxene-pyrrhotite-scheelite skarn (Figure 47) and, less commonly, a garnet-pyroxene-scheelite skarn. Disseminated pyrite occurs in some phyllite units, and galena and sphalerite in quartz veinlets. Wolframite and chalcopyrite are rare.

Pyrrhotite and scheelite occur in veins, fracture fillings and disseminations in the upper skarn zone. The Mactung deposit is classified as a contact-metasomatic skarn (with hydrothermal fluids originating in a nearby stock).

Risby (Medium)

The Risby property is located 55 km W of Ross River. Lower Paleozoic rocks are intruded by Cretaceous biotite-quartz monzonite which has produced scheelite skarns containing tungsten with lesser copper and molybdenum. The skarn zones are parallel to the intrusive contact and are identified as lower and upper zones. The known length of the deposit is at least 750 m (as of 2009) (Desautels, 2009). The property was worked from 1968 to 1982 by the Caltor Syndicate and Hudson Bay Exploration and Development Co. Ltd. This included mapping, trenching, stream sediment sampling, ground geophysics and drilling. The drilling was subsequently continued by Playfair Mining Ltd who also obtained a compliant resource estimate.

Sa Dene Hes (Medium)

The Sa Dene Hes property, 50 km N of Watson Lake, consists of four significant occurrences. Mineralization was first discovered in the area in 1962. The Main zone was delineated by surface drilling and other activities by Cima Resources from 1979 to 1981. Underground development by the Mt. Hundere Joint Venture occurred in 1990. The mine opened in 1991 but was soon closed as a result of low metal prices.

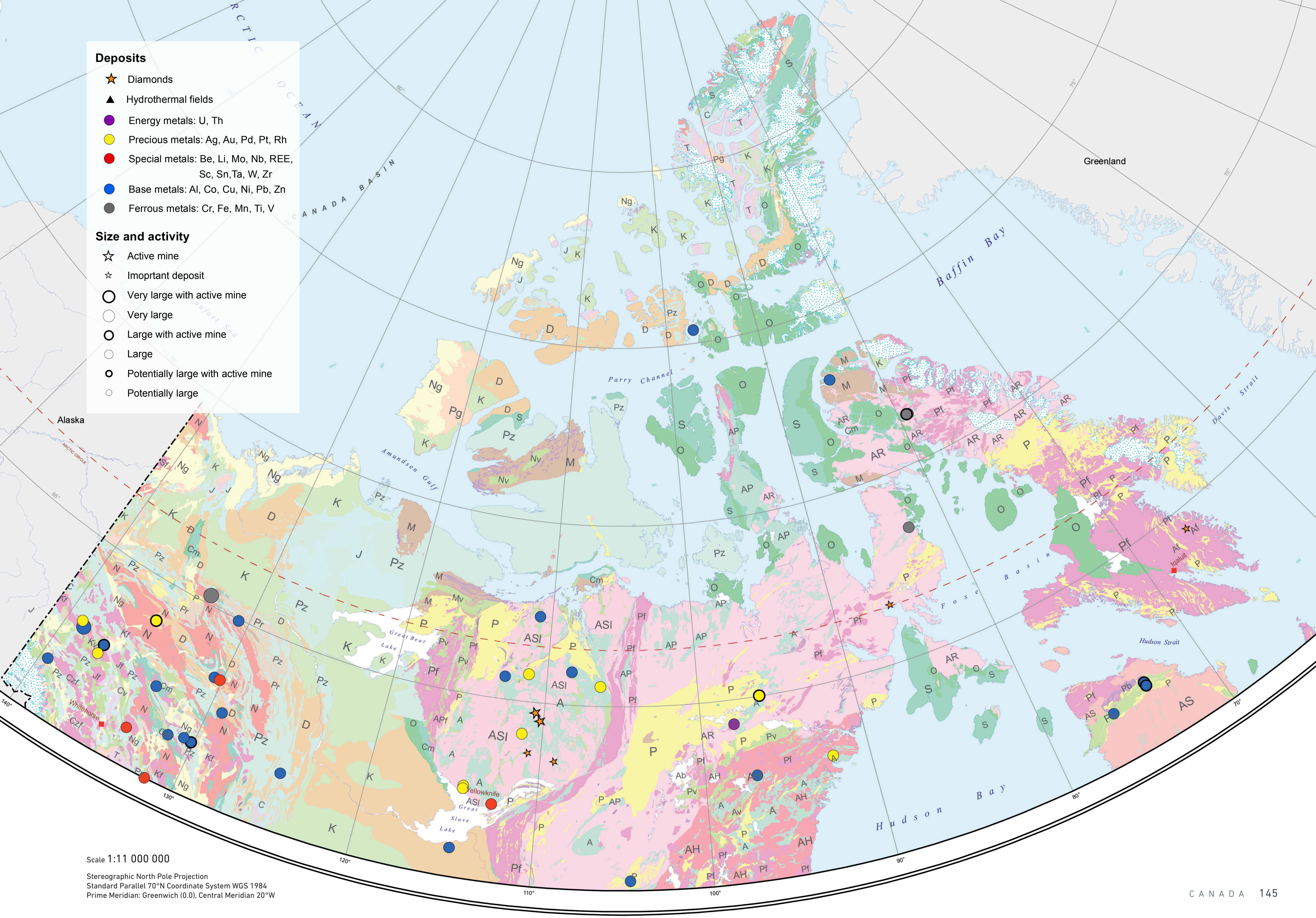
The host rocks include pelitic phyllite and limestone. The limestone occurs as discontinuous units up to 100 m thick, each traceable for hundreds of metres and gradational laterally with phyllite. Archeocyathids indicate an early Cambrian age. The phyllites vary from brown non-calcareous phyllite to grey calcareous phyllite and carbonaceous phyllite. There are three suites of igneous rocks including mafic to intermediate chloritic intrusive, a fine-grained unfoliated intermediate intrusive including skarn, and quartz porphyry occurring as dykes (Anonymous, 2014e).

Skarn mineralization, also associated with hornfelsing, occurs along contacts between limestone and phyllite. The skarn assemblage includes actinolite, hedenbergite, diopside, grossular, andradite, chlorite, calcite and quartz. Wollastonite, fluorite and amethyst have also been reported. The sulphide mineralization features medium to coarse sphalerite and galena occurring as disseminations in skarn. Peripheral to this there are local magnetite skarns (Anonymous, 2014e).

Whitehorse copper (Medium)

The Whitehorse copper belt is located SW and NW of downtown Whitehorse and, at the closest, 5.6 km from the town. The copper belt extends in a northwesterly direction for 32 km along the western margin of the Whitehorse Batholith.

The Whitehorse copper belt consists primarily of skarn deposits found within Late Triassic Lewes River Group but also within mid-Cretaceous granodiorite. Mineralization tends to occur within embayments of the adjacent batholith but also extends up to 150 m from the intrusive contact. Ore deposits range from lenticular or tabular to irregular but are normally conformable with bedding. The best ore occurs on contacts between limestone and quartzite. Two types of skarn are distinguished: magnetite skarn, and; silicate skarn. Magnetite skarn features bornite, chalcopyrite, magnetite, serpentine, specularite, talc, chlorite and minor pyrrhotite and pyrite. The mineral assemblage in silicate skarn includes bornite, chalcopyrite, garnet, diopside, wollastonite, tremolite, epidote, chlorite, calcite and quartz (Anonymous, 2014h). There is also a relationship between skarn mineralogy and protolith composition. Limestone protoliths form skarns with andraditic garnet, iron-rich pyroxene, wollastonite and vesuvianite. Dolomite protoliths form skarns with diopside, forsteritic olivine and andradite with retrograde phlogopite, brucite, serpentine and talc (Dawson and Kirkham, 1995). Sulphides tend to be associated with the retrograde phases: chalcopyrite and pyrite with retrograde actinolite and chlorite; bornite and chalcocite with epidote. Other metal-bearing phases include chrysocolla, native copper, chalcocite and minor molybdenite, scheelite, tetrahedrite and valeriite (a micaceous iron copper hydroxy-sulphide). There are, in addition, indications of elevated contents of gallium and silver in association with copper.



Deposits
Diamonds
Hydrothermal fields
Energy metals: U, Th
Precious metals: Ag, Au, Pd, Pt, Rh
Special metals: Be, Li, Mo, Nb, REE, Sc, Sn,Ta, W, Zr
Base metals: Al, Co, Cu, Ni, Pb, Zn
Ferrous metals: Cr, Fe, Mn, Ti, V
Size and activity
Active mine
Imoprtant deposit
Very large with active mine
Very large
Large with active mine
Large
Potentially large with active mine
Potentially large
Greenland
Alaska
CANADA BASIN
Baffin Bay
Davis Strait
Parry Channel
Amundsen Gulf
Foxe Basin
Hudson Strait
Hudson Bay
Great Bear Lake
Great Slave Lake
Yellowknife
Whitehorse
Iqaluit
Scale 1:11 000 000
Stereographic North Pole Projection
Standard Parallel 70°N Coordinate System WGS 1984
Prime Meridian: Greenwich (0.0), Central Meridian 20°W

DIAMONDIFEROUS KIMBERLITES

Although hundreds of kimberlite pipes have been discovered in the Archean Slave craton and in Archean portions of the Rae and Hearne cratons, most of these are isolated and small or unproductive. One of the key aspects to economic significance is sufficient tonnage to justify a

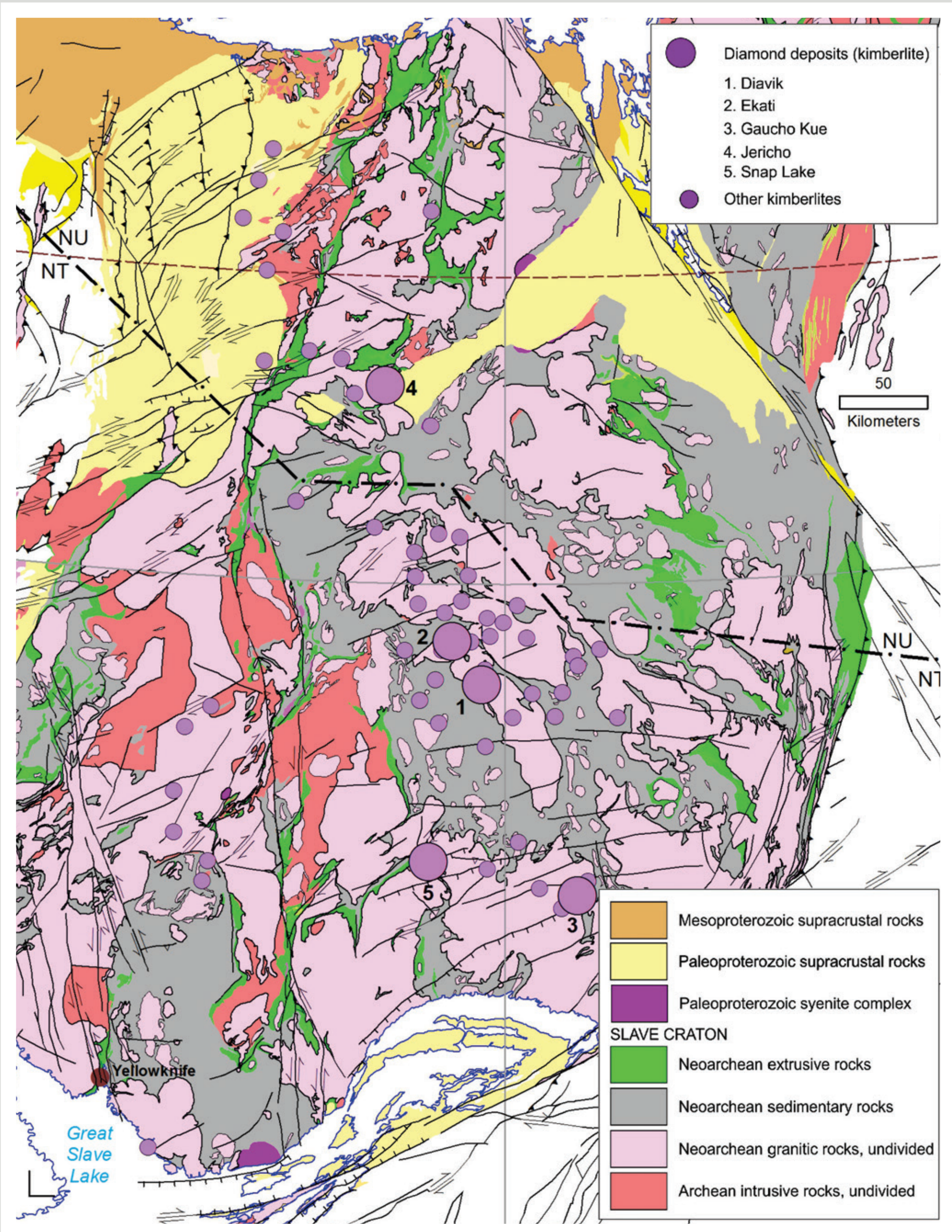


Figure 49. Simplified geology of the Slave craton of Nunavut and Northwest Territories with deposits of diamond and kimberlite.

Figure 49. A bird's-eye view of Dominion Diamond Corporation's Ekati mine in the Northwest Territories (Dominion Diamond Corporation).

mine life of 10 - 20 years. The majority of the kimberlite pipes in northern Canada are small and of low tonnage, hence there has been focus on multiple diamondiferous pipes in close proximity (Kjarsgaard, 2007). Producing mines include Ekati (1998), Diavik (2001), Snap Lake (2008) and Gahcho Kué (2016) in the Northwest Territories part of the Slave craton (Figure 48), as well as Jericho (past producer). Kimberlite fields that have some possibility of becoming mineable include Chidliak on southern Baffin Island (Figure 11) and Qilalugaq on southern Melville Peninsula near Repulse Bay (Figure 2).

Ekati

Ekati is located 300 km NE of Yellowknife in the central Slave craton. It includes the Ekati diamond mine (Figures 49, 50), currently held by Dominion Diamond Corporation, >150 kimberlites and four producing pipes. Most of the kimberlites are small, steep-sided diatreme-like bodies, relatively xenolith-poor and commonly consisting of bedded volcaniclastic materials.

The Slave craton in the Ekati area consists of Archean supracrustal rocks (Yellowknife Supergroup), syn- and post-tectonic granitoid plutons (2.63-2.58 Ga) and five dyke swarms (2.23-1.27 Ga). Xenoliths in the kimberlites indicate the former existence of Late Cretaceous and Paleogene strata (ca. 105 - 45 Ma) buried to a maximum depth of ~1100 m (Nowicki et al., 2004).

The kimberlites have been preferentially emplaced into Archean plutonic rocks, at lineament intersections, along dykes, and at dyke intersections. Thirty kimberlites have ages of 75-45 Ma. Most are steep-sided and inward-tapering cones but there is a spectrum of shapes (e.g. outward-dipping, elongate, irregular). Normal sizes range from 0.1 ha - 5.0 ha and up to a maximum of 17 ha. Panda, for example, has an area of 3 ha at the surface; Koala North: 0.4 ha; Koala: 4.5 ha and; Fox: 17 ha. Although most are single pipes, the Misery complex consists of eight distinct bodies (Nowicki et al., 2004).

Volcaniclastic kimberlite (VK) is a common diatreme fill, with compositional variability based on olivine abundance, grain size, proportion of matrix, scale of bedding, quantity and nature of xenoliths and the character of cognate clasts and lapilli. Types of volcaniclastic kimberlite include resedimented (RVK), tuffisitic (TK), mud-rich (m-) and olivine rich (o-). Magmatic kimberlite (MK) is less common. The proportion of wall rock xenoliths does not generally exceed 5% (Nowicki et al., 2004).

Mud-rich resedimented volcaniclastic kimberite (mRVK) is ubiquitously common in the Ekati pipes. These are interpreted to have formed by mass flow (debris or mud-flow) processes. The olivine-rich kimberlites (oVK) have >40% olivine. The matrix consists of disaggregated mud, kimberilitic ash and serpentine. Unaltered wood is also common. Olivine-rich kimberlite deposits are interpreted to have formed as crater-rim deposits by cool emplacement processes.

Olivine-poor sedimentary rocks, generally a minor component in the upper part of many pipes, consist of siltstone, mudstone and sandstone in addition to kimberlitic components such as phlogopite, olivine or mantle xenoliths. These have been collectively identified as crater-fill epiclastic sediments.

Primary (juvenile) VK contains 20 to 50% olivine and lacks bedding but includes abundant lapilli. Lapilli consist of olivine set in a carbonate-rich matrix along with serpentine, opaque phases and perovskite. The magma matrix is mostly serpentine with minor mud or ash, and carbonate: it is a dominant component in the deeper part of various pipes, and specifically in Panda, Koala and Lynx. An unreworked, non-resedimented, volcaniclastic origin is indicated.

Tuffisitic kimberlite (TK) occurs in the Fox and Misery pipes. It is a fragmented and clay-altered material with a high concentration (>40%) of comminuted and xenolithic granodiorite, serpentinized olivine (15-30%) and juvenile lapilli set in a matrix of serpentine and clinopyroxene.

Magmatic kimberlite (MK) occurs in both large bodies and in dykes. Minerals present include macrocrystic olivine, macrocrystic phlogopite, xenocrystic garnet, chrome diopside and rare ilmenite. The groundmass includes fine opaque magnesian ulvöspinel, perovskite and monticellite. The matrix of the MK in dykes includes monticellite, phlogopite, carbonate and serpentine. Pipes dominated by MK include Leslie, Grizzly, Pigeon, Arnie and Mark

Syn-depositional winnowing and mass-flow-related sorting may contribute to improvement of grade. Diamond contents are inversely proportional to diluting materials such as mud and ash. Diamond abundances are closely correlated with the contents of macrocrystic olivine and other mantle-derived materials including eclogitic garnet, chromite and chrome diopside. These minerals have also proved to be useful as diamond indicators during till-sampling campaigns.

Figure 50. Diamonds being sorted at Dominion Diamond Corporation's sorting facility (Dominion Diamond Corporation).

Diavik

The Diavik mine property, currently held by Dominion Diamond Corporation, is located 295 km NE of Yellowknife in the central Slave craton. Major features of this craton include a 4.05 - 3.6 Ga orogenic nucleus, felsic granites and gneisses (3.2 - 2.8 Ga), volcanics and supracrustal rocks (ca. 2.7 Ga), and pre- to post-orogenic felsic plutons (2.69 - 2.60 Ga). There are also dyke swarms of various ages (i.e. 2.3 - 2.0 Ga; 1.27 Ga). The Diavik property includes four diamondiferous kimberlite pipes located on the bed of eastern Lac de Gras. Initial staking of the property in 1991 preceded the exploration and discovery phase. Exploration has involved a combination of heavy mineral sampling, airborne magnetics and EM followed by drilling of favourable targets. These methods have resulted in the identification of 52 kimberlite pipes. Four, identified to be commercially significant, were discovered in 1994 and 1995: A21, A154 North, A154 South and A418. Kimberlite Rb-Sr ages on mica yield an age range of 56.0 to 54.8 Ma (Graham et al., 1998). Local host rocks include 2.61 to 2.58 Ga-old granite, granodiorite, tonalite and Yellowknife Supergroup greywacke-mudstone. In addition, there are three diabase dyke swarms dated at 2.23, 2.02 and 1.27 Ga (Buchan et al., 2009). Cover rocks at the time of emplacement included poorly lithified Cretaceous (Albian and younger) to Paleocene sand, silt and muds

The four commercial kimberlites are steeply- to vertically-sided pipes that typically narrow downwards to varying degrees, but also flare outwards with depth. Their surface areas are mostly < 2 ha. The facies found include pyroclastic kimberlite, resedimented volcaniclastic kimberlite, lesser hypabyssal kimberlite, and xenolithic sediments (containing clasts of country-rock granite and Cretaceous-Paleogene mudrock). The volcaniclastic kimberlite contains a large proportion of resedimented tephra, and mud or clasts of xenolithic material. Common components of the pyroclastic and resedimented volcaniclastic kimberlite include fragmented mineral crystals, lithic fragments, plant and vertebrate fossils set in a matrix of serpentine, silt, clay and carbonate (Bryan and Bonner, 2003; Graham et al., 1998).

Features of the pyroclastic kimberlite include: 1) massive to graded beds; 2) lack of evidence of clast reworking; 3) bombs and blocks of host rock material (granite, mudstone, etc.); and 4) particulate mud that is not waterlain. Resedimented volcaniclastic kimberlite has commonly incorporated sediments of Cretaceous and Paleogene ages. In general there is often a lateral gradation in these rocks from kimberlite to kimberlitic sediment to (non-kimberlitic) sediment. At Diavik the volcaniclastic kimberlite contains a large proportion of tephra, xenolith clasts and beds that originate as debris flows. Clasts up to more than 1 m across include kimberlite, granite and mud, along with sand-grade olivine and other minerals. Beds showing alternating mud and sandy olivine are a common feature.

Mantle-derived xenoliths include lherzolite, wehrlite, harzburgite, websterite and eclogite. The A154 South pipe consists of tuff, tuff breccia and alternating pyroclastic and resedimented volcaniclastic kimberlite. This gives way to mudstone xenoliths in the upper part. The A154 North pipe has volcaniclastic kimberlite with an olivine-rich bed in the upper 40 m that increases in grain size with depth. At greater depths (150 m) the pipe is dominated by crystal rich volcaniclastic kimberlite. A418 is dominated by mudrock fragments which significantly affect diamond grade. Also significant are ash lapilli intervals. A21 has a more pronounced flaring pipe. The dominant components include ash lapilli (as for A418) (Graham et al., 1998).

Jericho

The Jericho kimberlite is located 400 km northeast of Yellowknife in the Nunavut portion of the Slave craton, and 150 km NW of the Lac de Gras (Ekati) kimberlite field. Tehera Diamond Corp operated the property as a diamond mine from 2006 to 2008. Shear Minerals Ltd purchased the property in 2010 and briefly reopened the mine in 2012. A Middle Jurassic age is indicated (173.1±1.3 Ma) (Hayman & Cas, 2011). There are fifteen pipes and dykes in the Jericho cluster. Jericho intrudes granitoids of the Contwoyto batholith (2.59-2.58 Ga). Cover rocks at the time of emplacement included Middle Devonian fossiliferous and unfossiliferous limestone with minor shale and sandstone, now exclusively preserved as xenoliths in the kimberlite (Kopylova and Hayman, 2008).

Extensive drilling and underground development shows the Jericho complex to consist of three distinct lobes bounded on the east by a planar dyke of hypabyssal kimberlite. These lobes are independent cone shaped bodies that taper downward. 80% of the central lobe is high-grade, diamond-bearing kimberlite. Kimberlite compositions include hypabyssal kimberlite in early and late stage dyke sets, light and dark varieties of massive pyroclastic kimberlite (MPK1, MPK2), and weakly bedded pyroclastic kimberlite.

Early-stage hypabyssal kimberlite consists of 20 to 30% olivine macrocrysts in a matrix of olivine, serpentinized monticellite, spinel, perovskite, ilmenite, phlogopite and apatite. Late-stage hypabyssal kimberlite has 10-22% olivine phenocrysts in a matrix of carbonate, serpentine, apatite, phlogopite, spinel, ilmenite and perovskite. MPK1 grades to kimberlite breccia with clasts of limestone, granite, diabase and minor sandstone and mudstone. In general, this material is a carbonate-serpentine kimberlite with olivine macrocrysts, xenocrysts, xenoliths, and lapilli in a matrix of serpentine and carbonate. A regional variant is serpentine kimberlite which is distinguished by the absence of carbonate and spinel. In MPK2, 20 - 70% of the olivine is serpentinized and is commonly accompanied by hematite. The matrix is secondary chlorite, carbonate, spinel and phlogopite plates. Juvenile kimberlite clasts contain carbonate, olivine euhedra, monticellite, spinel, and melilite. Weakly bedded pyroclastic kimberlite consists of three components: 1) grains of olivine, garnet and ilmenite; 2) juvenile lapill; and 3) a serpentinitic matrix. The lapilli consist of serpentinized olivine, carbonate and ilmenite in a groundmass of spinel, perovskite, calcite and serpentine.

Snap Lake

The Snap Lake property lies 220 km NE of Yellowknife in the northeastern Slave Craton of Northwest Territories. It is underlain by the 2.7 Ga Camsell Lake greenstone belt (Yellowknife Supergroup) volcanic rocks and metasediments that are intruded by gabbro and leucogabbro sills, granite- granodioritic stocks and dykes, and diabase dykes (2.21 - 1.27 Ga).

A joint venture group that included Winspear Resources Ltd and Aber Resources Ltd was assembled in 1993 and undertook airborne surveys and mineral train studies. This led to drilling and the discovery of the CL25 pipe and of the CL174 pipe in 1995. Kimberlitic boulders with diamonds were discovered along the shore of Snap Lake in 1996. Drilling in 1997 determined that the Snap Lake kimberlite was a north-striking sheet with a thickness of 2.5 m and dipping 150 E. Drilling in 1998 showed that the sheet extends down dip for at least 1800 m. Since then there has been surface and underground testing including bulk sampling. De Beers purchased Winspear Resources Ltd in 2000. The following year De Beers Canada purchased the Aber Resources Ltd interest in Snap Lake. The mine was opened in 2008.

The Snap Lake kimberlite (523 Ma) is a gently dipping sheet that is 2.8 m thick on average (although highly variable in thickness) which is traceable along strike and across strike for 4 km. Within the sheet complex there is a kimberlite pipe (or "blow"), 75 - 100 m in diameter and consisting of granite clast breccia near the surface, grading downwards to lapilli-bearing volcaniclastic kimberlite (Kopylova et al., 2010). Locally the kimberlite sheet bifurcates to form numerous stringers or "horsetails". Faults are also known in the vicinity of the dyke, but these are Proterozoic features and no dyke offset is indicated. Locally it appears that the dyke thickens into the fault zone and has thus exploited this line of weakness.

Groundmass components include phlogopite (20%), monticellite, spinel, apatite, dolomite and serpentine. Opaque phases include chrome spinel and magnetite. Macrocrysts include mostly serpentinized olivine (up to 10 cm), and rare garnet and chromite (Kirkley et al., 2003; Kopylova et al., 2010). Ten percent of the Snap Lake dyke consists of kimberlite breccia with granite and metavolcanic clasts in a phlogopite-rich matrix. A separate, rare component is aphanitic kimberlite which is devoid of macrocrysts and composed largely of serpentine, calcite and opaque phases. A volatile-rich origin, similar to that of carbonatite, has been proposed (Kirkley et al., 2003).

Gahcho Kué

The Gahcho Kué property, held by De Beers Canada Exploration and Mountain Provinces Diamonds Inc., is located 300 km E of Yellowknife and 60 km N of the East Arm of Great Slave Lake. Four significant, named kimberlite bodies (Hearne, 5034, Tuzo and Tesla) are located on the property.

The Gaucho Kue kimberlite cluster is located in the southeastern part of the Archean Slave Craton. The kimberlites are early Cambrian age (542-534 Ma) (Heaman et al., 2003 or 2004). Host rocks on the Gaucho Kué property include 2.63 – 2.58 Ga granite, granitic gneiss, minor granodiorite and diorite that have been metamorphosed and retrograded to greenschist facies and intruded by dykes inferred to be part of the Malley swarm.

Kimberlite facies include tuffisitic kimberlite, transitional tuffisitic kimberlite, transitional hypabyssal kimberlite and hypabyssal kimberlite. The tuffisitic kimberlite is matrix-supported breccias containing 30 - 95% often unaltered granitoid clasts and, less commonly, clasts of diabase, gneiss and volcanic rocks. Other features include serpentinized olivines, pelletal lapilli, matrix serpentine and clay. Transitional tuffisitic kimberlite is darker and country rock xenoliths are less common. Transitional hypabyssal kimberlite is dark and competent. Groundmass minerals include phlogopite, spinel, carbonate, serpentine and perovskite. Hypabyssal kimberlite is fresh, competent and black to dark green. There are two phases of fresh (unaltered) olivine: medium grained anhedra and smaller subhedra and euhedra. The matrix is well crystallized and includes monticellite, phlogopite, spinel, carbonate, serpentine and perovskite. Mantle xenocrysts include garnet and clinopyroxene. There are also mantle xenoliths of garnet lherzolite and eclogite (Johnson et al., 2014).

The Hearne pipe consists of two bodies underlying a total area of 1.5 ha. Fill consists primarily of tuffisitic kimberlite. The 5034 pipe has five discrete lobes three of which coalesce at depth. There are also two small satellite intrusions. The total area of 5034 is 2.1 ha. Compositions in 5034 include hypabyssal kimberlite at depth, transitional kimberlites above this and tuffisitic kimberlite at the highest levels.

The surface area of the Tuzo pipe is 1.2 ha. Five kimberlite facies have been logged at Tuzo, ranging from tuffisitic in the immediate subsurface to hypabyssal at considerable depth. Other facies include country rock breccia with kimberlite, country rock breccia and an epiclastic unit.

Chidliak

The Chidliak property, held by Peregrine Diamonds Ltd, consists of 60 prospecting permits located on Hall Peninsula (southern Baffin Island) approximately 150 km NE of Iqaluit (the capital of Nunavut). Bedrock on the Hall Peninsula includes Archean basement of the Meta Incognita microcontinent (2920 to 2797 Ma), Paleoproterozoic Lake Harbour Group, and the eastern margin of the Paleoproterozoic Cumberland batholith. Phases of deformation of the microcontinent occurred at 277 Ma and again at 1844 - 1736 Ma. The bulk of the Chidliak property consists of Ramsay River orthogneiss (3019 to 2784 Ma). Northerly-trending belts of Lake Harbour Group are also present. These consist of psammites, quartzite, semi-pelite, pelite, minor marble, calcsilicate and leucogranite. Intermediate, mafic and ultramafic igneous rocks include leucodiorite, tonalite, peridotite, pyroxenite and dunite; all metamorphosed to varying degrees (Pell, 2008).

Kimberlites on the Chidliak property include sheets and small pipe-like bodies. The sheet-like bodies consist of hypabyssal (coherent) kimberlite with basement xenoliths. The kimberlite pipes contain basement xenoliths and fragments of carbonate and clastic rock of Late Ordovician to Early Silurian age. These rocks are not encountered at the surface so it is presumed that the Ordovician-Silurian was a former cover on Hall Peninsula. The kimberlites provide a U-Pb age-range on perovskite of 156.7 - 138.9 Ma (Kimmeridgian to Valanginian; Heaman et al., 2015). Four kimberlite facies have been distinguished - volcanic kimberlite (VK), hypabyssal kimberlite (HK), coherent kimberlite (CK) and pyroclastic kimberlite (PK). All of these contain mantle xenoliths. Some, however, contain clasts of gneissic basement but none of lower Paleozoic age.

The CH-1 kimberlite has an area of close to 6 ha and consists of coherent (magmatic) kimberlite with pyrope garnet, chrome diopside, olivine phenocrysts up to 100 mm across, eclogite and peridotite xenoliths (Pell et al 2008). It is exposed as cobbles in frost boils.

The CH-6 kimberlite underlies an area of ~1 ha and consists of carbonate-clast bearing kimberlite. Deeper in the pipe there are kimberlite facies that are either carbonate-poor or carbonate-free. Basement xenoliths are also rare. It is unclear whether this is a facies of the carbonate-xenolith kimberlite or whether it is a distinct and separate phase (Farrow et al., 2015). The CH-7 kimberlite, also about 1 ha, consists of two distinct lobes, the smaller of which consists of coherent kimberlite (CK) and the other of apparently coherent kimberlite (ACK) and volcanic kimberlite (VK) with clasts of carbonate and basement (Farrow et al., 2015). The CH-44 kimberlite has a surface area of 0.5 ha with ACK in the upper part and volcanic kimberlite (VK) or pyroclastic kimberlite (PK) at greater depths.

Qilalugaq

Exploration of the property by BHP Billiton from 2000 to 2005 included heavy mineral sampling, aerial and ground geophysics and drilling. This uncovered eight diamondiferous kimberlite pipes. The current owner is Stornoway Diamond Corp, and North Arrow Minerals in a joint venture, which has been continuing to bulk sample these pipes. Results point to a high proportion of coloured stones. The host rocks are mostly Archean granitoid gneiss and schist near the known pipes and, further afield, supracrustal rocks of the Archean Prince Albert Group unconformably overlain by Paleoproterozoic metasediments of the Penrhyn Group.

The kimberlite (emplacement age 546 Ma (late Ediacaran) is associated with an emplacement corridor 26 km long, 3 km wide and trending west-northwest. Within this corridor are 8 known pipes with surface areas ranging from 0.6 - 12.5 ha, and a dyke set. The Qilalugaq pipes are interpreted to be steep sided, pipe-like and irregular or elongate in plan view. The preserved material is diatreme-facies volcaniclastic kimberlite. The higher crater facies is missing and presumably eroded away.

The Q1-4 pipe is the primary focus of advanced exploration. Dominant near surface compositions include massive volcaniclastic kimberlite that grades laterally to tuffisitic kimberlite breccia and to depth grades to hypabyssal kimberlite. Multiple pipe-filling phases are found in some pipes, including Q1-4, in which the presence of five main filling phases has been documented. In addition, there are dykes and intrusions of hypabyssal kimberlite. Infill phases include:

1) A28a (41% of the pipe volume) consisting of volcaniclastic kimberlite grading downwards to hypabyssal kimberlite. Mineralogically this includes serpentinized olivine macrocrysts, matrix of serpentine, clinopyroxene, clay minerals, country rock xenoliths, minor phlogopite and perovskite. Mantle-derived indicators include ilmenite, garnet, chrome diopside and mantle peridotite.

2) The A48a phase, 14% of pipe volume consists of hypabyssal kimberlite.

3) A48b (20%) consists of volcaniclastic and hypabyssal kimberlite.

4) A61a (13%): hypabyssal kimberlite; and

5) A88a (12%): volcaniclastic kimberlite grading downwards to hypabyssal kimberlite.

Klondike

The Klondike placers are located in west-central Yukon in an area that has largely escaped glaciation (Figure 51). Initial discoveries in 1896 included gold placers on Quartz Creek, Gold Bottom Creek and most significantly, by George Carmack, Skookum Jim and Tagish Charlie, on Bonanza Creek which precipitated a massive staking rush.

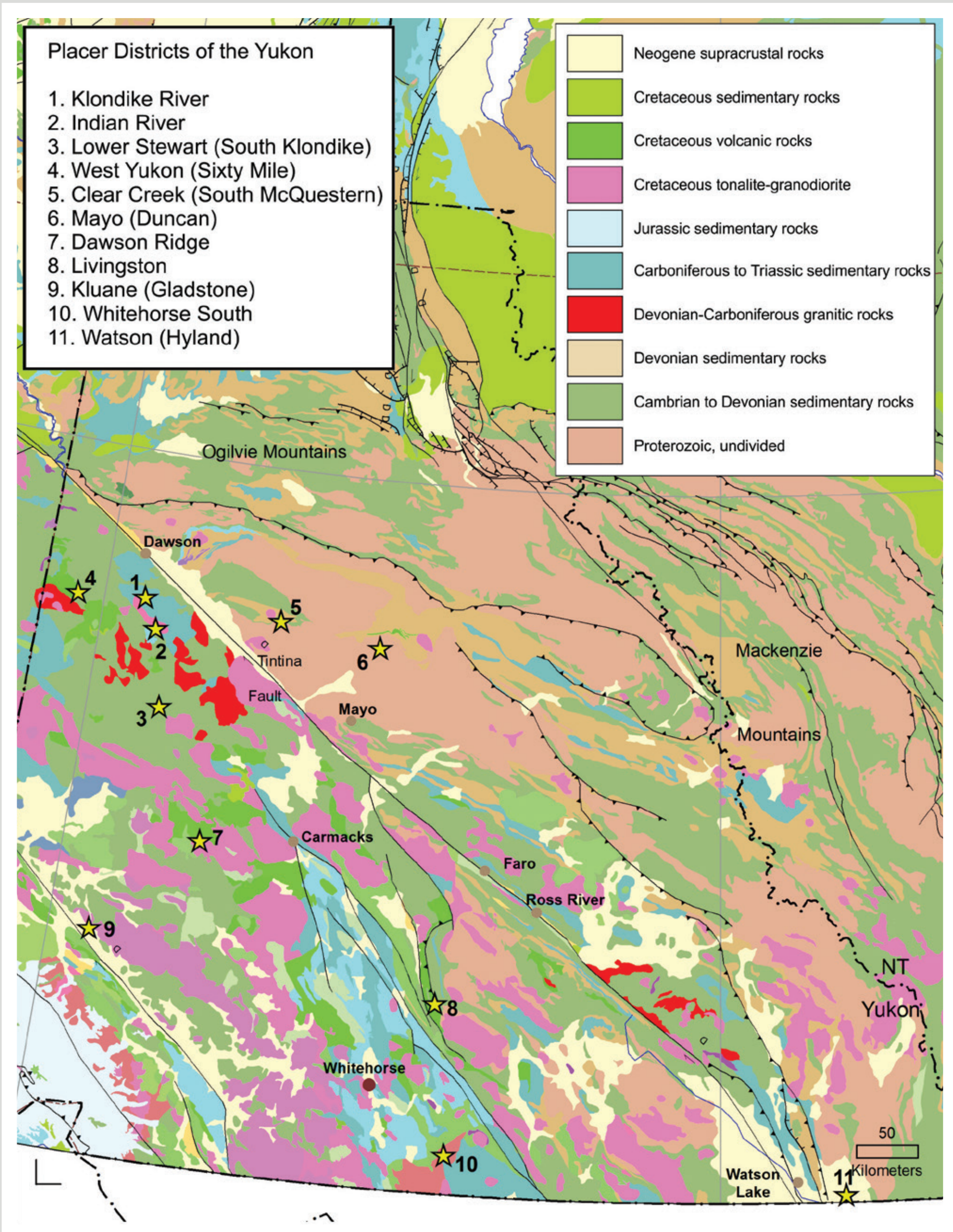


Figure 51. Simplified geology of Yukon and western Northwest Territories showing placer gold mining districts.

Figure 52. Klondike placer mining: excavating pay gravel on Eureka Creek, tributary to the Indian River, Yukon. Articulated haul trucks and excavators are commonly used as an efficient means of earth moving in modern Klondike placer mining. (Yukon Geological Survey).

Collectively the Klondike placers stand as one of the world's most productive gold placers. The region has been more or less continuously productive for 119 years (1896-2015). Key placer streams include Hunker Creek, Bear Creek, Bonanza Creek, Dominion Creek, Eldorado Creek and surrounding drainage areas covering ca. 1200 km^2.

The Klondike area is unglaciated and therefore has not experienced glacial dispersion. This limits the lode gold source to several named ridges: Lone Star Ridge and Violet Ridge of which Lone Star has received the most significant attention. However, the gold content of these lodes does not account for the large volume of mined placer gold (Chapman et al., 2010).

The lode gold hosts are the Devonian to Mississippian and possibly older Nasina assemblage and the middle- to late-Permian (Guadalupian-Lopingian) Klondike Schist assemblage of the Yukon-Tanana terrane. These consist of greenschist-facies mafic and felsic metavolcanic rocks. Also present are thin slices of greenstone and ultramafic rocks of the Slide Mountain terrane. Together these are stacked into a series of thrust slices, subsequently eroded in mid- to Late Cretaceous time to produce locally derived sandstone, shale and conglomerate (Tantalus Formation). Associated volcanics of this age are assigned to the Carmacks Group. The later onset of motion on the Tintina Fault system is dated to early Eocene time. This fault zone remains active (Lowey, 2006; MacKenzie et al., 2008).

Placer gold occurs in four settings: 1) the lower part of the high-level White Channel gravels (5-3 Ma; up to 46 m thick) stratified with, and overlain by; 2) glaciofluvial Klondike gravel (Pliocene; up to 53 m thick), 3) intermediate terrace gravels of limited extent (1.4 Ma; up to 9 m thick), and 4) low-level gravels (late Pleistocene-Holocene; to 20 m thick) that occupy and underlie modern stream and river gravels at 10 - 200 m below the high-level gravels (Figures 52, 53; Lowey, 2006). Gold in the low-level gravels derives from erosion of both the White Channel gravels and primary bedrock sources.

Most of the placer gold is considered to be alluvial in origin. Some, however, may result frrom precipitation from water that carries gold in solution. Concerning the bedrock source, one

Figure 53. A selection of gold nuggets mined from upper Maisy May Creek, tributary to the Stewart River in the south Klondike, Yukon. The rough surface texture of the nuggets suggests limited transport in the fluvial environment, which is typical in first order drainages in the Klondike. (Yukon Geological Survey).

theory is that high-grade lode gold source(s) have been largely eroded away to form the present placer gold deposits leaving only lode gold relicts. An alternative is that one or more high-grade lode gold sources remain to be discovered.

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Anonymous, 2014c: Yukon Mineral occurrence details 105K 089: Andrew; Yukon Geological Survey

Anonymous, 2014d: Yukon Mineral occurrence details 105B 099: Logan; Yukon Geological Survey

Anonymous, 2014e: Yukon Mineral occurrence details 105I 037: Cash deposit; Yukon Geological Survey

Anonymous, 2014f: Yukon Mineral occurrence details 105C 009: Red Mountain; Yukon Geological Survey

Anonymous, 2014g: Yukon Mineral occurrence details 105A 012: Sa Dene Hes; Yukon Geological Survey

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