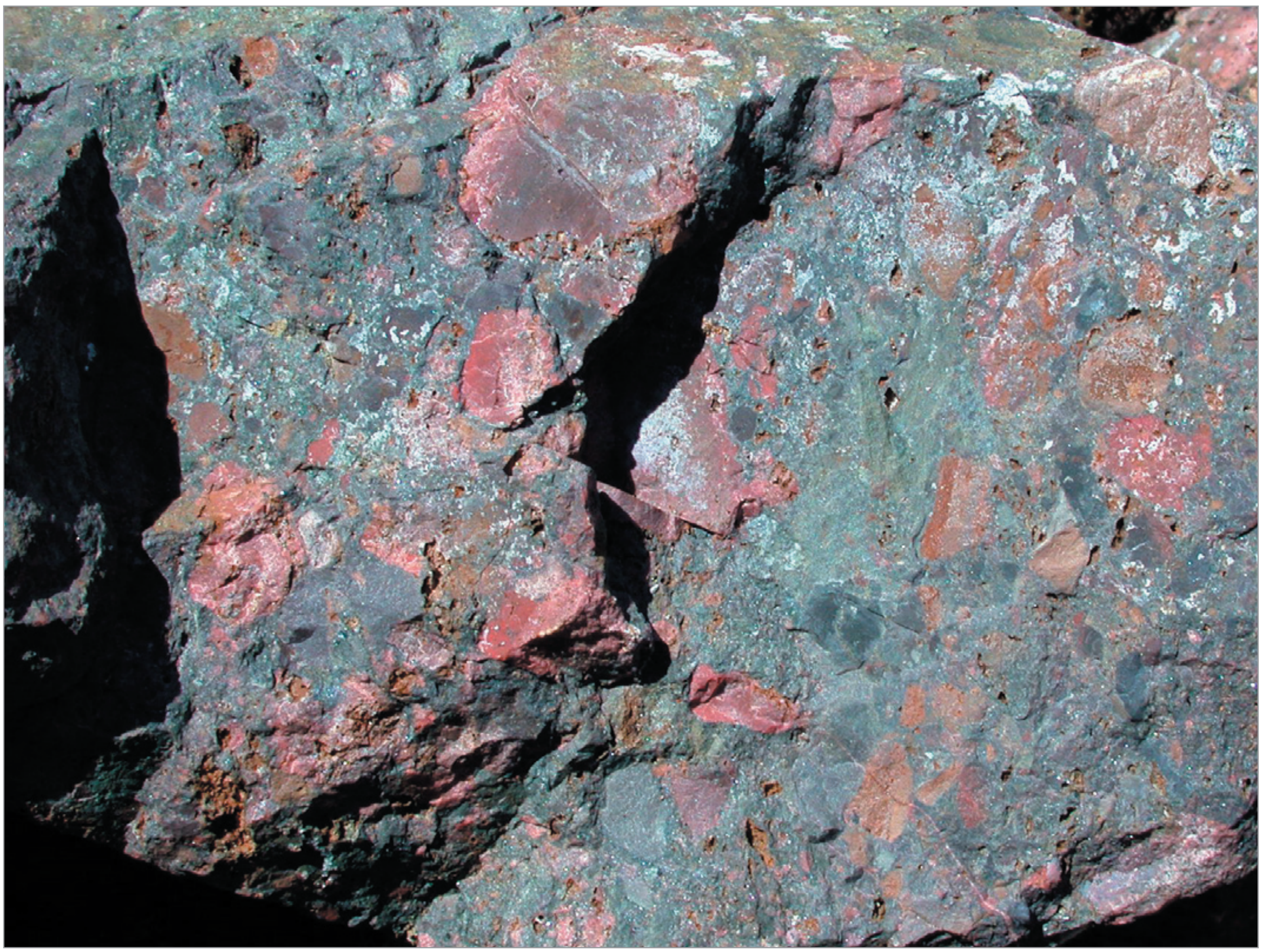
YGS OPEN FILE 2005-5

Yukon Mineral Deposit Profiles

compiled by A. Fonseca and G. Bradshaw



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British Columbia Geological Survey
Mineral Deposit B.C. Profiles
Yukon Energy, Mines and Resources

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Cover Photo: Boulder of matrix-supported Wernecke Breccia in the vicinity of "Iron Hill" at the Pagisteel deposit. Sub-angular to sub-rounded cm-sized clasts of red, hematitic chert and dark grey siltstone in a fine-grained matrix of rock fragments, magnetite, actinolite, feldspar and carbonate minerals. Photo taken by Craig Hart.

Preface

The deposit models project is an attempt to classify the many known metallic mineral deposits and occurrences in Yukon into specific *mineral deposit models*. This work began with the initiation of regional mineral potential assessments by the Yukon government (e.g., Bradshaw and vanRanden, 2004). The quantitative method used for regional mineral assessments in Yukon is based on a method developed by the United States Geological Survey (USGS), which uses the mineral deposit models of Cox and Singer (1986). The reader is encouraged to consult this reference for further discussion on the fundamental purpose for defining mineral deposit models. In general terms, resource assessments require that tracts of land be assessed on the basis of probability for the occurrence of one or more specific deposits of a particular type with previously defined grades and tonnages. In the course of conducting regional mineral potential assessments, grade and tonnage information for deposit types that occur or potentially could occur in Yukon was compiled, grade and tonnage curves were constructed, and deposit models were assigned to known mineral deposits and occurrences (i.e., Yukon MINFILE occurrences; Deklerk, 2003).

Many of the mineral deposit types that occur in Yukon are the same as those that occur in British Columbia, therefore the written descriptions of Yukon deposit types within this Open File contribution are essentially the same as the respective BC deposit profiles (Lefebure and Ray, 1995; Lefebure and Hoy, 1996). The descriptions written by scientists from the British Columbia Geological Survey (BCGS) are presented here in their entirety, with some additional information and references relevant to Yukon deposits and occurrences distinguished by **boldface type**. In addition to the deposit model descriptions, the spectrum of mineral deposits and their grade and tonnage curves used in the regional mineral assessments for each deposit model are presented. Yukon and BC deposits with defined resources were used where available, though paucity of information for some occurrences required best estimates and/or use of data from other jurisdictions. This contribution also includes a list of Yukon examples for the respective deposit profile (from Yukon MINFILE; Deklerk, 2003) organized by status (i.e., past producer, deposit, drilled prospect, showing, etc.). Finally, one or more compilation maps are included with each deposit model. They integrate the MINFILE occurrences with additional public data, including Yukon Digital Geology (Gordey and Makepeace, 2003), regional geochemistry (Héon, 2003) and regional geophysics (Lowe et al., 1999).

This Open File is the result of data compilation done from 1999-2003 as part of the ongoing Yukon regional mineral assessment process. This compilation will be useful to the mineral exploration industry, despite the fact that the information is incomplete in some areas. The deposit profiles included herein represent most of the major deposit types that occur, or could occur, in Yukon but with several notable absences: flood basalt-associated Ni-Cu (e.g., Wellgreen; Yukon MINFILE 115G 024); carbonate-hosted disseminated Au-Ag or Carlin-type Au (e.g., Hyland gold; Yukon MINFILE 095D 006); and Superior-type iron formation (e.g., Crest; Yukon MINFILE 106F 008). Also missing are models for sedimentary and/or intrusive rock hosted uranium deposits, shale-hosted Ni-Zn-Mo-PGE deposits, and some classes of vein and skarn deposits (e.g., Sn veins and greisens; manto and stockwork Sn; W veins; Mo skarns). Coal, hydrocarbon and industrial mineral deposits were not part of the quantitative mineral assessment process.

BCGS profiles and USGS deposit models exist for some of these deposit types. Furthermore, the assignment of deposit model types to individual mineral occurrences is seldom clear-cut, and is more problematic for those occurrences for which specific characteristics are poorly known. We hope to address these shortcomings in future editions of Yukon Deposit Profiles.

Citation and Acknowledgements

This volume is heavily based on the deposit models developed by the BCGS. The authors of these individual models are indicated and should be cited, where possible, rather than referring to this compilation. The scientists and staff who were part of the BCGS Mineral Potential Project, particularly Dave Lefebure, are gratefully acknowledged for contributing their mineral deposit profiles.

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YUKON PROFILE #	DEPOSIT TYPE	APPROXIMATE SYNONYMS	BCGS PROFILE #	USGS MODEL #
	WERNECKE BRECCIA DEPOSITS			
D07	**Wernecke Breccia**	**Iron oxide breccias & veins ±P±Cu±Au±Ag±U, Olympic Dam type**	**D07**	**25i, 29b**
	MISSISSIPPI VALLEY TYPE DEPOSITS			
E12	**Mississippi Valley-type Pb-Zn**	**Southeast Missouri Pb-Zn, Appalachian Zn**	**E12**	**32a, b**
	SEDIMENT ASSOCIATED DEPOSITS			
E14	**Sedimentary exhalative Zn-Pb-Ag**	**Sedex, Sediment-hosted massive sulphide**	**E14**	**31a**
	VOLCANIC ASSOCIATED DEPOSITS			
G04	**Besshi massive sulphide Cu-Zn**	**Kieslager**	**G04**	**24b**
G06	**Noranda / Kuroko massive sulphide Cu-Pb-Zn**		**G06**	**28a**
	VEIN/ BRECCIA ASSOCIATED DEPOSITS			
H04	**Epithermal Au-Ag-Cu; high sulphidation**	**Acid-sulphate, qtz-alunite Au, Nansatsu-type**	**H04**	**25d**
H05	**Epithermal Au-Ag; low sulphidation**	**Adularia-sericite epithermal**	**H05**	**25c**
I01	**Au-quartz veins**	**Mesothermal, Motherlode, saddle reefs**	**I01**	**36a**
I05	**Polymetallic veins Ag-Pb-Zn±Au**	**Felsic intrusion associated Ag-Pb-Zb veins**	**I05**	**22c, 25b**
I06	**Cu±Ag quartz veins**	**Churchill-type vein Cu**	**I06**	**?**
I09	**Stibnite veins and disseminations**	**Simple and disseminated Sb deposits**	**I09**	**27d, 27e**
	SKARN/REPLACEMENT ASSOCIATED DEPOSITS			
J01	**Polymetallic mantos Ag-Pb-Zn**		**J01**	**19a**
K01	**Cu skarns**		**K01**	**18a, b**
K02	**Pb-Zn skarns**		**K02**	**18c**
K05	**W skarns**		**K05**	**14a**
K06	**Sn skarns**		**K06**	**14b**

YUKON PROFILE #	DEPOSIT TYPE	APPROXIMATE SYNONYMS	BCGS PROFILE #	USGS MODEL #
	PORPHYRY/SHEETED VEIN ASSOCIATED DEPOSITS			
L02	**Plutonic-related Au-quartz veins and veinlets**	**Fort Knox-type, intrusion-related Au, Tintina Au**	**I18**	**- -**
L03	**Alkalic porphyry Cu-Au**	**Diorite porphyry copper**	**L03**	**- -**
L04	**Porphyry Cu ± Mo ± Au**	**Calcalkaline porphyry**	**L04**	**17, 20, 21a**
L05	**Porphyry Mo (Low F- type)**	**Calcalkaline Mo stockwork**	**L05**	**21b**
L06	**Porphyry Sn**	**Subvolcanic tin**	**L06**	**20a**
L07	**Porphyry W**	**Stockwork W-Mo**	**L07**	**21c***
	ULTRAMAFIC / MAFIC ASSOCIATED DEPOSITS			
M03	**Podiform chromite**		**M03**	**8a/8b**
	GEMSTONE DEPOSITS			
Q07	**Schist-hosted emeralds**	**Exometamorphic emerald deposit**	**Q07**	**- -**

WERNECKE BRECCIA D07

(**Profile name changed from "iron oxide breccias and veins P-Cu-Au-Ag-U"; no longer includes magnetite-apatite deposits – see Hitzman, 2000**)

by David V. Lefebure[1]

Modified for Yukon by A. Fonseca and then J. A. Hunt (in progress)

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYMS: Proterozoic iron oxide (Cu-U-Au-REE), Olympic Dam type, iron oxide-rich deposits.

COMMODITIES (*BYPRODUCTS*): Fe, Cu, Au, Ag, U (*potential for REE, Co, Ba, F*).

EXAMPLES: **(Yukon): Slab (106D 070)**;
(British Columbia - *Canada/International*): *Ernest Henry (Australia), Olympic Dam (Australia), Candelaria (Chile), Salobo (Brazil), Aitik (Sweden).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Low TiO_2 magnetite- and/or hematite-rich mineralization ± Cu ± Co ± Au ± U ± REE occurs as veins and disseminations. **Wernecke Breccia vein and disseminated mineralization occurs within and peripheral to breccia bodies.**

TECTONIC SETTING: Intracratonic extensional tectonics. Upper crustal sedimentary rocks (presence of evaporites may be important) and/or igneous rocks.

DEPOSITIONAL ENVIRONMENT/ GEOLOGICAL SETTING: Found crosscutting a wide variety of sedimentary and igneous rocks; spatially associated with regional-scale faults. **Wernecke Breccias cut Lower Proterozoic sedimentary rocks ± igneous rocks and are spatially associated with regional- and local-scale faults.**

AGE OF MINERALIZATION: Proterozoic to Tertiary commonly roughly coeval with spatially associated igneous rocks. **Wernecke Breccia is *ca.* 1.6 Ga.**

HOST/ASSOCIATED ROCK TYPES: Veins and breccias crosscut, or are conformable with, a wide variety of continental sedimentary and volcanic rocks and intrusive stocks, including felsic volcanic breccia, tuff, clastic sedimentary rocks and granites. There may be a spatial association with a igneous rocks (check recent work by Pollard). Fe oxides have been reported as common accessories in the associated igneous rocks. In some deposits the Fe oxide forms the matrix to heterolithic breccias which are composed of lithic and oxide clasts (commonly hematite fragments), hematite-quartz microbreccia and fine-grained massive breccia. Some deposits have associated hematite-rich breccias. **Bodies of Wernecke Breccia were emplaced into Early Proterozoic Wernecke Supergroup marine sedimentary rocks that are crosscut by small mafic to intermediate dykes and sills of the Bonnet Plume River Intrusions suite; minor amounts of mafic to intermediate subaerial volcanic rocks (Slab volcanics) are also present locally in the host rock package.**

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[1] British Columbia Geological Survey, Victoria, B.C., Canada

DEPOSIT FORM: Discordant pod-like zones, veins (dyke-like), tabular bodies and stockworks.

TEXTURE/STRUCTURE: Cu-U-Au mineralization is typically hosted in the Fe-oxide matrix as disseminations with associated microveinlets and sometimes rare mineralized clasts. Textures indicating replacement and microcavity filling are common. Intergrowths between minerals are common. Hematite and magnetite may display well developed crystal forms, such as interlocking mosaic, tabular or bladed textures. Some of the deposits (typically hematite-rich) are characterized by breccias at all scales with Fe oxide and host rock fragments which grade from weakly fractured host rock on the outside to matrix-supported breccia (sometimes heterolithic) with zones of 100% Fe oxide in the core. Breccias may be subtle in hand sample as the same Fe oxide phase may comprise both the fragments and matrix. Breccia fragments are generally angular and have been reported to range up to more than 10 m in size, although they are frequently measured in centimetres. Contacts with host rocks are frequently gradational over scale of centimetres to metres. **Wernecke Breccias vary from cm to km size; clasts vary from centimetres to several hundred metres; metallic minerals occur as veins, disseminations, breccia clasts, and/or form the breccia matrix. Copper-uranium-gold-cobalt minerals occurs within and/or spatially separate from iron-oxide minerals. Multiple phases of mineralization and brecciation are evident.**

ORE MINERALOGY (Principal and *subordinate*): Hematite-magnetite deposits with varying amounts of Cu sulphides, Au, Ag, uranium minerals and REE (Olympic Dam type). Hematite (variety of forms), specularite, magnetite, bornite, chalcopyrite, chalcocite, pyrite; *digenite, covellite, native copper, carrolite, cobaltite, Cu-Ni-Co arsenates, pitchblende, coffinite, brannerite, bastnaesite, monazite, xenotime, florencite, native silver and gold and silver tellurides*. At Olympic Dam, Cu is zoned from a predominantly hematite core (minor chalcocite-bornite) to chalcocite-bornite zone then bornite-chalcopyrite to chalcopyrite-pyrite in the outermost breccia. Uraninite and coffinite occur as fine-grained disseminations with sulphide minerals; native gold forms fine grains disseminated in matrix and inclusions in sulphide minerals. Bastnaesite and florencite are very fine grained and occur in matrix as grains, crystals and crystal aggregates. **Wernecke Breccia: chalcopyrite is the dominant copper mineral; uranium occurs mainly as pitchblende and brannerite; cobalt occurs as cobaltian pyrite; gold values are generally associated with copper mineralization.**

GANGUE MINERALOGY (Principal and *subordinate*): Gangue occurs intergrown with ore minerals, as veins or as clasts in breccias. Sericite, carbonate, chlorite, quartz, fluorite, barite, and sometimes minor *rutile and epidote*. Hematite breccias are frequently cut by 1 to 10 cm veins with fluorite, barite, siderite, hematite and sulphides.

ALTERATION MINERALOGY (Principal and *subordinate*): A variety of alteration assemblages with differing levels of intensity are associated with these deposits, commonly with broad lateral extent. <u>Olympic Dam type:</u> Intense sericite and hematite alteration with increasing hematite towards the centre of the breccia bodies at higher levels. Close to the deposit the sericitized feldspars are rimmed by hematite and cut by hematite veinlets. Adjacent to hematite breccias the feldspar, rock flour and sericite are totally replaced by hematite. Chlorite or K-feldspar alteration predominates at depth. **Wernecke Breccia: associated with extensive sodic and/or potassic alteration overprinted by carbonate alteration.**

WEATHERING: Supergene enrichment of Cu and U. **Wernecke Breccia: malacite ± azurite staining; cobalt bloom; pitchblende and minor uranium bloom.**

ORE CONTROLS : Strong structural control with emplacement along faults or contacts, particularly narrow grabens. Mid-Proterozoic rocks particularly favourable hosts. Hydrothermal activity on faults with extensive brecciation. May be associated with felsic volcanic and alkalic igneous rocks. In some deposits calderas and maars have been identified or postulated. Deposits may form linear arrays more than 100 km long and 40 km wide with known deposits spaced 10-30 km along trend. **Wernecke Breccia: formed in weak and/or permeable zones e.g., faults, shear zones, fold axes; strong spatial relationship to regional- and local-scale faults.**

ASSOCIATED DEPOSIT TYPES: Volcanic-hosted U (D06)?; alkaline porphyry Cu-Au deposits (L03); supergene uranium veins.

COMMENTS: Hitzman *et al.* (1992) emphasize that these are low-Ti iron deposits, generally less than 0.5% TiO_2 and rarely above 2% TiO_2 which allows distinction from Fe oxides associated with anorthosites, gabbros and layered mafic intrusions. Fe and Cu sulphide minerals may be more common with hematite Fe oxides.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Anomalously high values for Cu, U, Au, Ag, Ce, La, Co, ± P, ± F, and ± Ba in associated rocks and in stream sediments.

GEOPHYSICAL SIGNATURE: Large positive gravity anomalies because of Fe oxides. Regional aeromagnetic anomalies related to magnetite and/or coeval igneous rocks. Radiometric anomaly (such as airborne gamma-ray spectrometer survey) expected with polymetallic deposits containing uranium.

OTHER EXPLORATION GUIDES: Proterozoic faulting with associated Fe oxides (particularly breccias), possibly related to intracratonic rifting. Widespread hematite, sericite or chlorite alteration related to faults. Possibly form linear arrays 100 or more kilometres long and up to tens of kilometres wide. **In Yukon, many occurrences are proximal to ca. 1.71 Ga Bonnet Plume River Intrusions (e.g., Hunt et al., 2002).**

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE : Deposits may exceed 1000 Mt grading greater than 20 % Fe and frequently are in 100 to 500 Mt range. Olympic Dam deposit has estimated reserves of 2000 Mt grading 1.6% Cu, 0.06% U_3O_8, 3.5 g/t Ag and 0.6 g/t Au with a measured and indicated resource in a large number of different ore zones of 450 Mt grading 2.5% Cu, 0.08 % U_3O_8, 6 g/t Ag and 0.6 g/t Au with ~5000 g/t REE. The Ernest Henry deposit in Australia contains 100 Mt at 1.6% Cu and 0.8 g/t Au. Sue-Dianne deposit in the Northwest Territories contains 8 Mt averaging 0.8% Cu and 1000 g/t U and locally significant gold. The Kiruna district contains more than 3000 Mt of Fe oxide apatite ore grading 50-60% Fe and 0.5 -5 % P. The largest orebody at Bayan Obo deposit in Inner Mongolia, China contains 20 Mt of 35 % Fe and 6.19% REE. **The Pagisteel deposit in Yukon contains 0.9 Mt grading 29.2% Fe.**

ECONOMIC LIMITATIONS: Larger Fe oxide deposits may be mined for Fe only; however, polymetallic deposits are more attractive. **Exploration in the Wernecke Breccia district of northern Yukon is hindered by remoteness and poor infrastructure, as most occurrences are more than 100 km from the nearest major road.**

IMPORTANCE: These deposits continue to be significant producers of Fe and represent an important deposit type for producing Cu, U and possibly REE. **Mineralization in the Wernecke Breccia district in northern Yukon is believed to be temporally and spatially associated with the giant Olympic Dam deposit in Australia.**

ACKNOWLEDGEMENTS: This deposit profile represents the results of a literature review. The only “ground truthing” is thanks to instructive conversations with Sunil Gandhi of the Geological Survey of Canada and Tom Setterfield of Westminer Canada Ltd.

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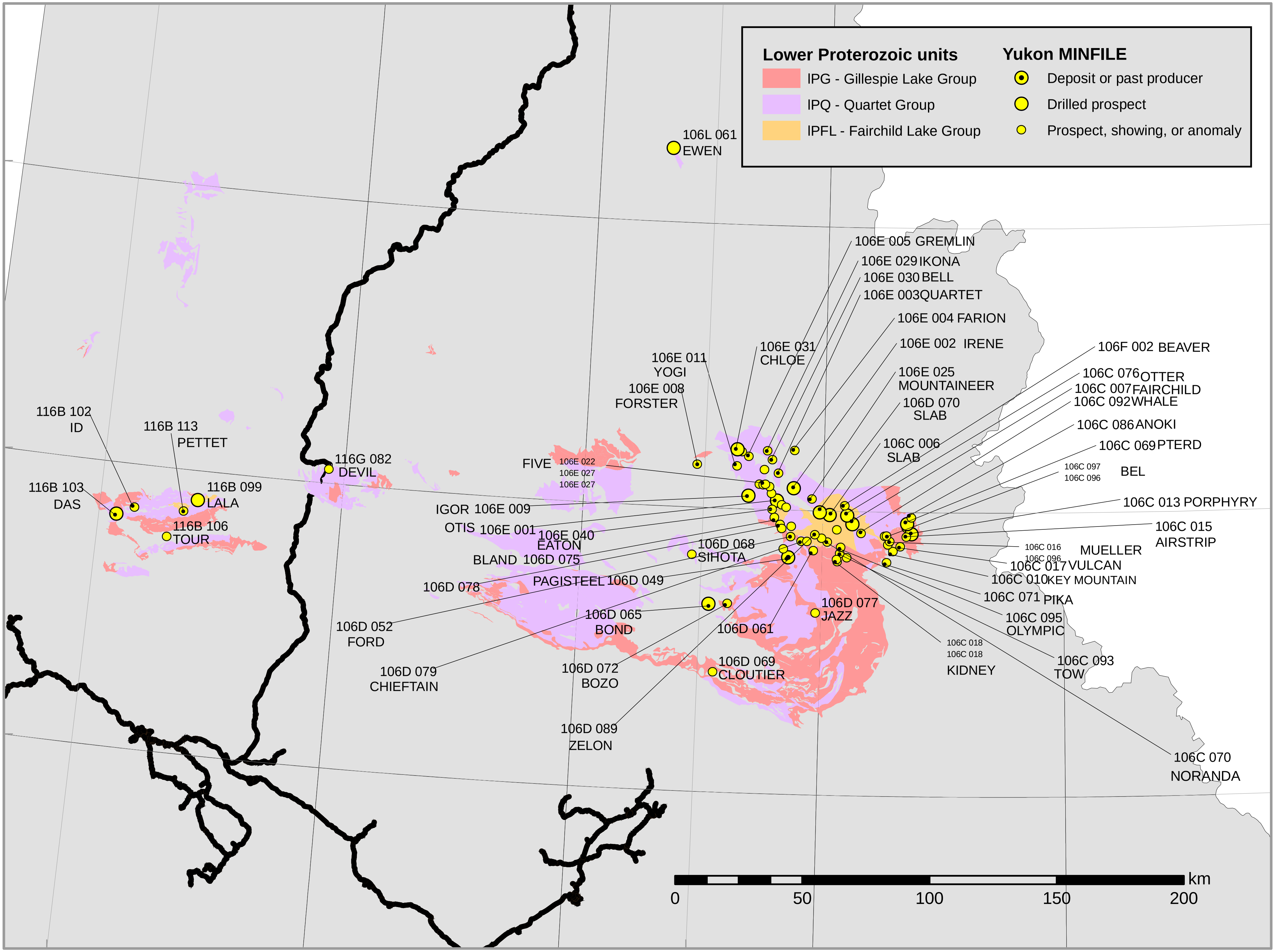
D07 - Wernecke Breccias - World Deposits

Deposit	country	tonnes	Cu%	U_3O_8 %	Au (g/t)	Ag (g/t)	Fe %	REE %
Olympic Dam	AUST	2 000 000 000	1.6	0.06	0.6	3.5		
Pagisteel	CNYT	910 000					29.2	
Eastern Henry	AUST	100 000 000	1.6		0.8			
Sue-Dianne	CNNT	8 000 000	0.8	0.1				
Bayan Obo	CHIN	20 000 000					35	6.19

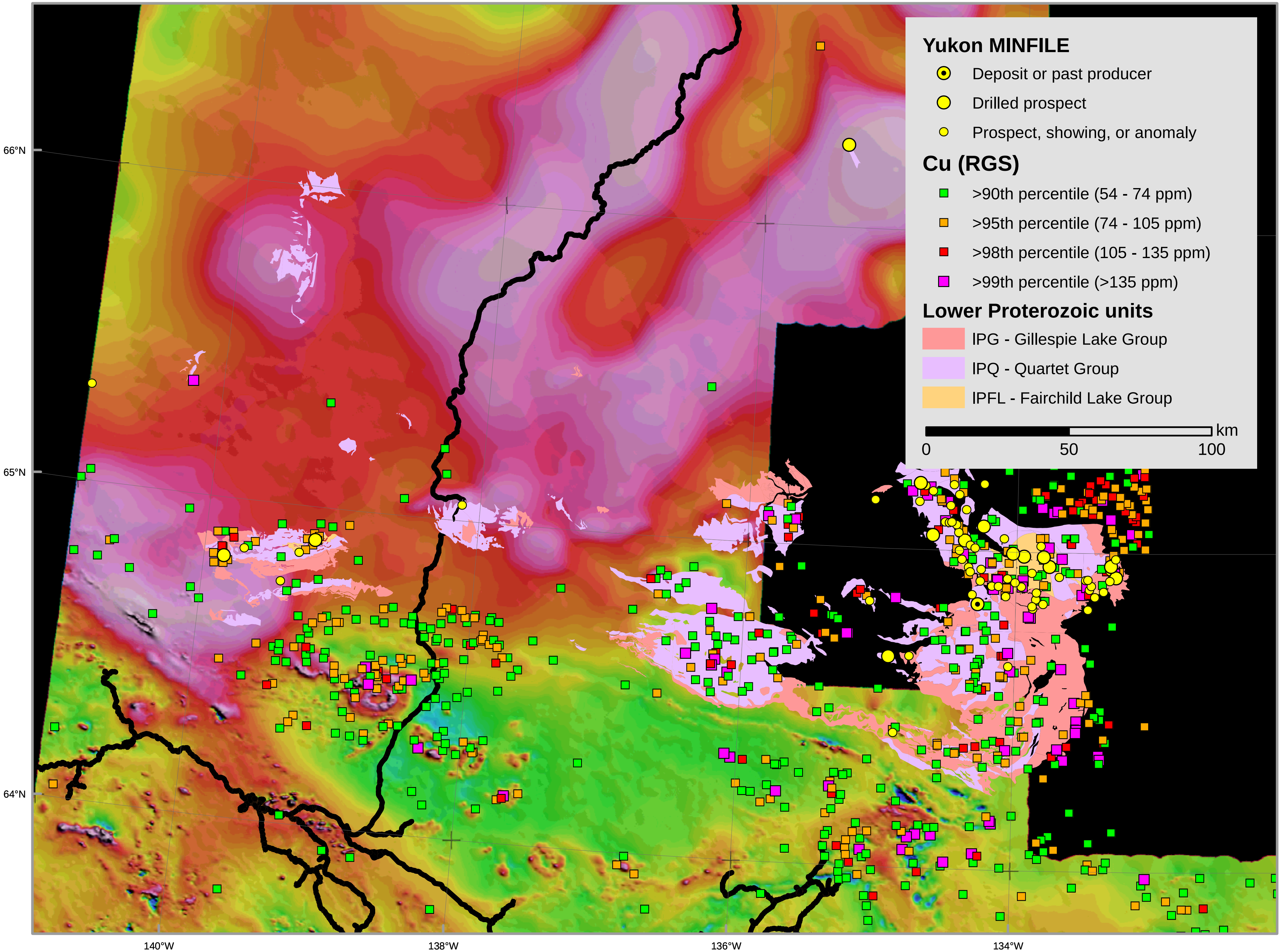
Yukon MINFILE

MINFILE	NAMES	STATUS
106D 049	PAGISTEEL	DEPOSIT
106C 006	PLUME, SLAB	DRILLED PROSPECT
106C 007	FAIRCHILD	DRILLED PROSPECT
106C 013	PORPHYRY	DRILLED PROSPECT
106C 069	PTERD	DRILLED PROSPECT
106C 076	OTTER	DRILLED PROSPECT
106D 065	BOND	DRILLED PROSPECT
106D 070	SLAB	DRILLED PROSPECT
106D 077	JAZZ	DRILLED PROSPECT
106E 001	OTIS	DRILLED PROSPECT
106E 002	IRENE	DRILLED PROSPECT
106E 009	IGOR	DRILLED PROSPECT
106E 031	DARNEY	DRILLED PROSPECT
106L 061	EWEN	DRILLED PROSPECT
116B 099	LALA	DRILLED PROSPECT
116B 103	DASH, DAS, LALA	DRILLED PROSPECT
116G 082	DEVIL, CANADIAN OLYMPIC	DRILLED PROSPECT
106C 012	CIRQUE	PROSPECT
106C 086	ANOKI	PROSPECT
106D 052	FORD	PROSPECT
106D 078	PITCH, ARCTOS	PROSPECT
106E 005	GREMLIN	PROSPECT
106E 023	RADIO	PROSPECT
106E 024	BREAK	PROSPECT
106E 026	HELIKIAN	PROSPECT
106E 027	FIVE	PROSPECT
106C 010	KEY MOUNTAIN	SHOWING
106C 015	AIRSTRIP	SHOWING
106C 016	MUELLER	SHOWING
106C 017	DOBBY, VULCAN	SHOWING
106C 018	KIDNEY	SHOWING

MINFILE	NAMES	STATUS
106C 070	NORANDA	SHOWING
106C 071	PIKA	SHOWING
106C 090	TOW	SHOWING
106C 092	WHALE	SHOWING
106C 093	ATHENS	SHOWING
106C 095	OLYMPIC	SHOWING
106C 096	JULIE	SHOWING
106C 097	BEL	SHOWING
106D 061	FOUND	SHOWING
106D 062	GNUCKLE	SHOWING
106D 068	SIHOTA	SHOWING
106D 072	BOZO	SHOWING
106D 075	BLAND	SHOWING
106D 076	FACE	SHOWING
106D 079	CHIEFTAIN	SHOWING
106D 087	SNOWSTAR	SHOWING
106D 096	REID	SHOWING
106D 097	BEAR RIVER	SHOWING
106E 003	QUARTET	SHOWING
106E 004	FARION	SHOWING
106E 006	CHLOE	SHOWING
106E 011	YOGI	SHOWING
106E 022	SPHINX	SHOWING
106E 025	MOUNTAINEER	SHOWING
106E 028	RAPITAN	SHOWING
106E 029	IKONA	SHOWING
106E 030	BELL	SHOWING
106E 040	EATON	SHOWING
106F 002	BEAVER	SHOWING
116B 102	WIZARD, ID	SHOWING
116B 113	PETTET, ROB	SHOWING
116B 106	TOUR	ANOMALY
116F 068	YINGEN	ANOMALY
106C 068	LAW	UNKNOWN



Map of the Wernecke Mountains, northeast Yukon showing the distribution of Lower Proterozoic rocks and Wernecke Breccia occurrences



Map of the Wernecke Mountains showing Lower Proterozoic rocks, Wernecke Breccia occurrences, regional magnetics and copper geochemistry

MISSISSIPPI VALLEY-TYPE (MVT) Pb-Zn E12

by Dani Alldrick[1] and Don Sangster[2]
Modified for Yukon by A. Fonseca and G. Bradshaw
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Alpine-type Pb-Zn, Appalachian Zn, Low-temperature epigenetic Pb-Zn.

RELATED DEPOSIT TYPE: Irish-type Zn-Pb (E13) is classified with MVT deposits in some studies.

COMMODITIES (BY-PRODUCTS): Pb, Zn, ± Ag (Cd, Ge, barite, fluorite)

EXAMPLES: **(Yukon): Goz (106C 020), Blende (106D 064), Craig (106C 073);**
(British Columbia - *Canada/ International*): Robb Lake (94B005), Monarch (82N020), Kicking Horse (82N282); *Nanisivik, Pine Point, Polaris (Northwest Territories), Gays River (Nova Scotia), Newfoundland Zinc (Newfoundland) / Mascot-Jefferson City, Copper Ridge district (Tennessee, United States), Old Lead Belt and Viburnum Trend (Missouri, United States), Tri-State (Oklahoma, Kansas and Missouri, United States), Harberton Bridge (Ireland), Upper Silesia (Poland), Raibl, Bleiberg (Austria)*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Epigenetic, low-temperature, stratabound deposits of galena, sphalerite, pyrite and marcasite, with associated dolomite, calcite and quartz gangue in platformal carbonate sequences having primary and secondary porosity.

TECTONIC SETTINGS: Most commonly stable interior cratonic platform or continental shelf. Some deposits are incorporated in foreland thrust belts.

DEPOSITIONAL ENVIRONMENT / GEOLOGIC SETTING: Host rocks form in shallow water, particularly tidal and subtidal marine environments. Reef complexes may be developed on or near paleotopographic basement highs. The majority of deposits are found around the margins of deep-water shale basins; some are located within or near rifts (Nanisivik, Alpine district).

AGE OF MINERALIZATION: Proterozoic to Tertiary, with two peaks in Devonian to Permian and Cretaceous to Eocene time. Dating mineralization has confirmed the epigenetic character of these deposits; the difference between host rock age and mineralization age varies from district to district. **Known Yukon deposits are hosted in Proterozoic strata, but true mineralization ages of these epigenetic deposits are poorly constrained.**

[1] British Columbia Geological Survey, Victoria, British Columbia, Canada.
[2] Geological Survey of Canada, Ottawa, Ontario, Canada.

HOST / ASSOCIATED ROCK TYPES: Host rocks are most commonly dolostone, limestone, or dolomitized limestone. Locally hosted in sandstone, conglomerate or calcareous shale. **In Yukon, MVT deposits are hosted in Proterozoic to Paleozoic carbonate rocks of the North American margin: Goz is hosted by dolomite of the Proterozoic Backbone Ranges Formation; the Val and Blende deposits are hosted by Middle Proterozoic Gillespie Group dolomite; and Craig is hosted by dolomite within a late Proterozoic shale unit.**

DEPOSIT FORM: Highly irregular. May be peneconcordant as planar, braided or linear replacement bodies. May be discordant in roughly cylindrical collapse breccias. Individual ore bodies range from a few tens to a few hundreds of metres in the two dimensions parallel with bedding. Perpendicular to bedding, dimensions are usually a few tens of metres. Deposits tend to be interconnected thereby blurring deposit boundaries.

TEXTURE / STRUCTURE: Most commonly as sulphide cement to chaotic collapse breccia. Sulphide minerals may be disseminated between breccia fragments, deposited as layers atop fragments ("snow-on-roof"), or completely filling the intra-fragment space. Sphalerite commonly displays banding, either as colloform cement or as detrital layers ("internal sediments") between host-rock fragments. Sulphide stalactites are abundant in some deposits. Both extremely fine-grained and extremely coarse-grained textured sulphides minerals may be found in the same deposit. Precipitation is usually in the order pyrite (marcasite) → sphalerite → galena.

ORE MINERALOGY (Principal and *subordinate*): Galena, sphalerite, *barite, fluorite*. Some ores contain up to 30ppm Ag. Although some MVT districts display metal zoning, this is not a common feature. The Southeast Missouri district and small portions of the Upper Mississippi Valley district are unusual in containing significant amounts of Ni-, Co-, and Cu-sulphides.

GANGUE MINERALOGY (Principal and *subordinate*): Dolomite (can be pinkish), pyrite, marcasite, *quartz, calcite, gypsum.*

ALTERATION MINERALOGY: Extensive finely crystalline dolostone may occur regionally, whereas coarse crystalline dolomite is more common close to ore bodies. Extensive carbonate dissolution results in deposition of insoluble residual components as internal sediments. Silicification (jasperoid) is closely associated with ore bodies in the Tri-State and northern Arkansas districts. Authigenic clays composed of illite, chlorite, muscovite, dickite and/or kaolinite accumulate in vugs; minor authigenic feldspar (adularia).

WEATHERING: Extensive development of smithsonite, hydrozincite, willemite, and hemimorphite, especially in non-glaciated regions (including upstanding hills or monadnocks). Large accumulations of secondary zinc minerals can be mined. Galena is usually much more resistant to weathering than sphalerite. Iron-rich gossans are not normally well-developed, even over pyrite-rich deposits.

ORE CONTROLS: Any porous unit may host ore; porosity may be primary (rare) or secondary. Dissolution collapse breccias are the most common host although fault breccias, permeable reefs, and slump breccias may also be mineralized. Dissolution collapse breccias may form through action of meteoric waters or hydrothermal fluids. Underlying aquifers may be porous sandstone or limestone aquifers; the limestones may show thinning due to solution by ore-bearing fluids.

GENETIC MODELS: Deposits are obviously epigenetic, having been emplaced after host rock lithification. Ore-hosting breccias are considered to have resulted from dissolution of more soluble sedimentary units, followed by collapse of overlying beds. The major mineralizing processes appear to have been open-space filling between breccia fragments, and replacement of fragments or wall rock. The relative importance of these two processes varies widely among, and within, deposits. Fluid inclusion data show that these deposits formed from warm (75°- 200°C), saline, aqueous solutions similar in composition to oil-field brines. Brine movement out of sedimentary basins, through aquifers or faults, to the hosting structures is the most widely accepted mode of formation. Two main processes have been proposed to move ore solutions out of basin clastics and into carbonates:

A. Compaction-driven fluid flow is generated by over-pressuring of subsurface aquifers by rapid sedimentation, followed by rapid release of basinal fluids.
B. Gravity-driven fluid flow flushes subsurface brines by artesian groundwater flow from recharge areas in elevated regions of a foreland basin, to discharge areas in regions of lower elevation.

In addition to fluid transport, three geochemical mechanisms have been proposed to account for chemical transport and deposition of ore constituents:

1. Mixing - Base metals are transported by fluids of low sulphur content. Precipitation is effected by mixing with fluids containing hydrogen sulphide; replacement of diagenetic iron sulphides; and/or reaction with sulphur released by thermal degradation of organic compounds.
2. Sulphate reduction - Base metals are transported together with sulphate in the same solution. Precipitation is the result of reduction of sulphate by reaction with organic matter or methane.
3. Reduced sulphur - Base metals are transported together with reduced sulphur. Precipitation is brought about by change in pH, dilution, and/or cooling.

ASSOCIATED DEPOSIT TYPES: Fracture-controlled, fluorine-dominant deposits (with subordinate Ba, Pb, and Zn) such as those of Illinois-Kentucky, the English Pennines and the Tennessee Sweetwater F-Ba-Pb-Zn district (E10, E11). “Irish-type carbonate-hosted Zn-Pb” (E13) is described as a separate deposit type in the BC Mineral Deposit Profiles, others regard these deposits as a variant of MVT deposits. In the latter case, they are viewed as a sub-group of MVT deposits which are associated with tensional regimes and rifts. Oxide zinc deposits have evolved from weathering and alteration of MVT deposits (Skorpion, Berg Aukas, Namibia: B09).

COMMENTS: British Columbia has prospective strata for MVT deposits in the miogeoclinal carbonate platform rocks along its eastern border. MVT deposits are distinct from syngenetic carbonate-hosted Pb-Zn deposits (Mt. Isa, Australia; E14) and high-temperature epigenetic deposits or mantos (Midway, British Columbia; Santa Eulalia, Mexico; J01).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Readily detectable positive anomalies of Zn in residual soils and stream sediments. Regionally anomalous amounts of Pb, Zn, Cu, Mo, Ag, Co, Ni, Cd, Mg, F in insoluble residues of carbonate rocks. Background lithogeochemical concentrations for unmineralized carbonates: Pb = 9 ppm; Zn = 20; Cu = 4; Ag = 0.01.

GEOPHYSICAL SIGNATURE: Deposits may be detected by IP, resistivity, gravity and EM (CS-AMT/AFMAG) systems. Test seismic lines have yielded ambiguous results. In southeast Missouri magnetic and gravimetric surveys have been used to outline basement topographic highs (knobs) which control the distribution of favourable sites of deposition.

OTHER EXPLORATION GUIDES: Reef complexes in platformal carbonate successions. Proximal to, or updip from, petroleum fields in large (continental-scale) sedimentary basins. Peripheral to basement highs. Aligned along basement lineaments.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Data for individual deposits are difficult to obtain because deposits tend to be interconnected. Most deposits are small and fall in the range 1 to 10 Mt. Grades generally range between 5% to 10% combined lead-zinc, with a majority being decidedly zinc rich (Zn/Zn+Pb = 0.8). Silver content is not commonly reported since it typically occurs only in solid solution in base metal sulphides. MVT deposits tend to occur in clusters, usually referred to as districts. The Pine Point district , for example, contains more than 80 deposits, the Upper Mississippi Valley district more than 400. Deposits in such districts, therefore, can collectively contain extremely large tonnages. Of more than 80 deposits in the Pine Point district, 40 were mined for a total production of 80 Mt grading 6.5% Zn and 3% Pb. The largest deposit (X15) was 17.4 Mt and the richest deposit (N81) produced 2.7 Mt of ore grading 12% Zn and 7% Pb. The Robb Lake deposit in British Columbia contains 5.3 Mt grading 5.0% Zn and 2.3% Pb. **The Craig deposit of Yukon has a geological resource of 964 500 tonnes averaging 13.5% Pb, 8.5% Zn and 123.4 g/t Ag. The Blende deposit contains a geological resource of 19.4 million tonnes grading 55.9 g/t Ag and 5.85% Pb-Zn.**

ECONOMIC LIMITATIONS: Mining districts may extend over many hundreds of square kilometres, increasing mining costs (stripping, haulage to mill, etc.). One of the more favourable attributes of MVT deposits is the normally large grain size, resulting in good mineral separation and high metal recoveries (typical zinc recovery exceeds 90%). Recovery is especially high in deposits with little or no pyrite (Newfoundland Zinc, Gays River and the east and central Tennessee districts).

IMPORTANCE: Metal production from MVT districts can be similar to production from giant stratiform, sediment-hosted (SEDEX) deposits. The Tri-State district was one of the world's major producers of lead during the 20th century, yielding 500 Mt of ore. The Viburnum Trend produced over 123 Mt grading 5.8% Pb,
0.8% Zn, 0.14% Cu and 17 g/t Ag between 1960 and 1984.

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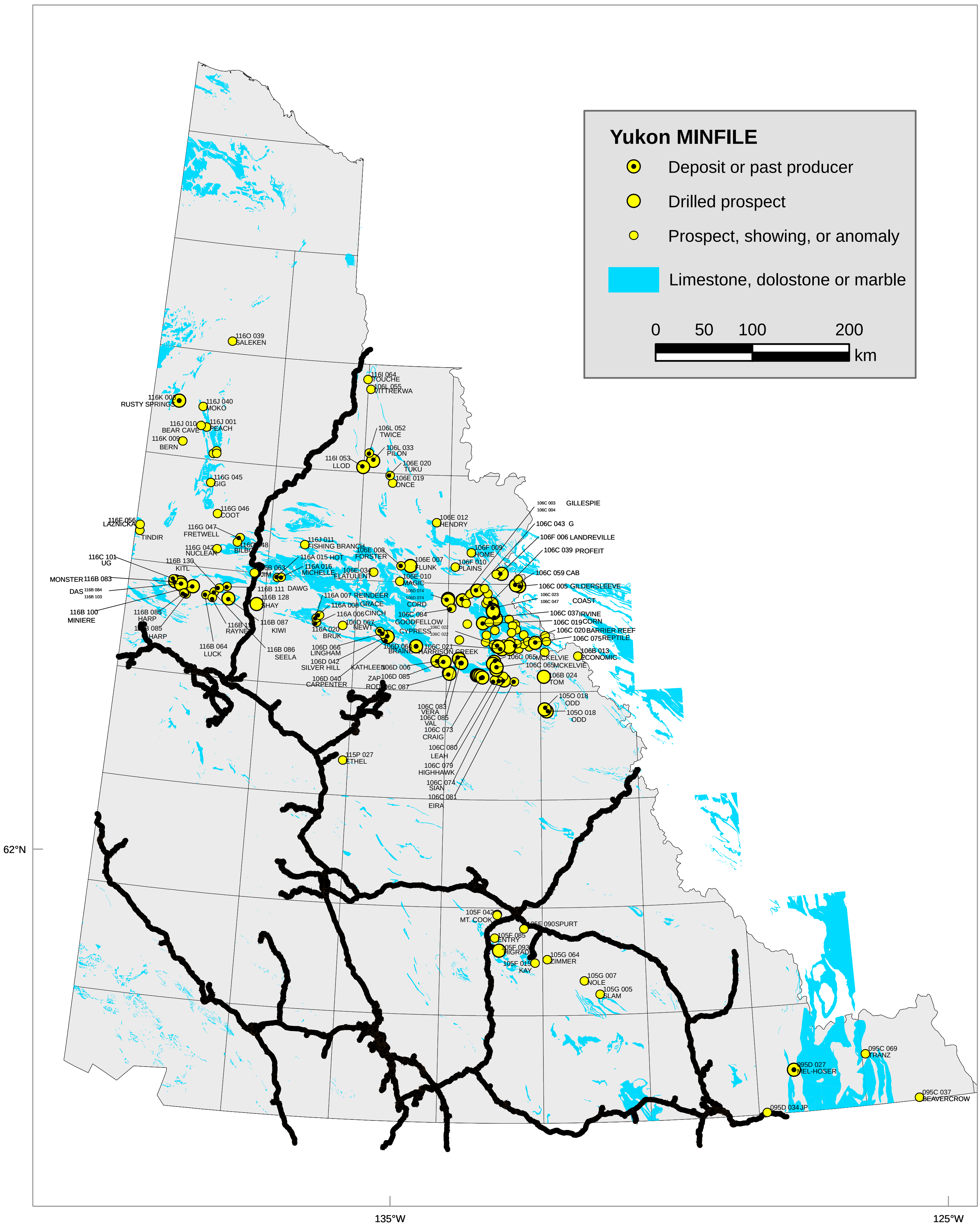
E12 - Mississippi Valley Type Zn-Pb-Ag - World Deposits

Deposit	Country	tonnes	Zn (%)	Pb (%)	Ag (g/t)
CENTRAL MISSOURI	USMO	1 000 000	0.60	2.00	0
N ARKANSAS-OZARK	USAR	1 090 000	2.00	0.12	0
MONARCH	CNBC	1 490 000	5.10	4.67	27.4
NEWFOUNDLAND ZINC	CNNF	4 900 000	7.70	0.00	0
ROBB LAKE	CNBC	5 500 000	5.00	2.30	0
NANISIVIK	CNNT	6 400 000	11.50	1.20	0
FRIEDENSVILLE	USPA	17 900 000	6.10	0.00	0
KENTUCKY-ILLINOIS	USKY	22 000 000	4.00	0.70	1
POLARIS-ECLIPSE	CNNT	23 600 000	14.00	4.30	34
METALLINE	USWA	36 000 000	2.50	1.10	1.4
AUSTINVILLE	USVA	36 400 000	3.90	0.80	0
GAYNA RIVERL	CNNT	58 200 000	4.79	0.60	2.25
ALPINE	AAIY	85 400 000	6.10	1.50	0
PINE POINT	CNNT	95 500 000	6.20	2.50	0

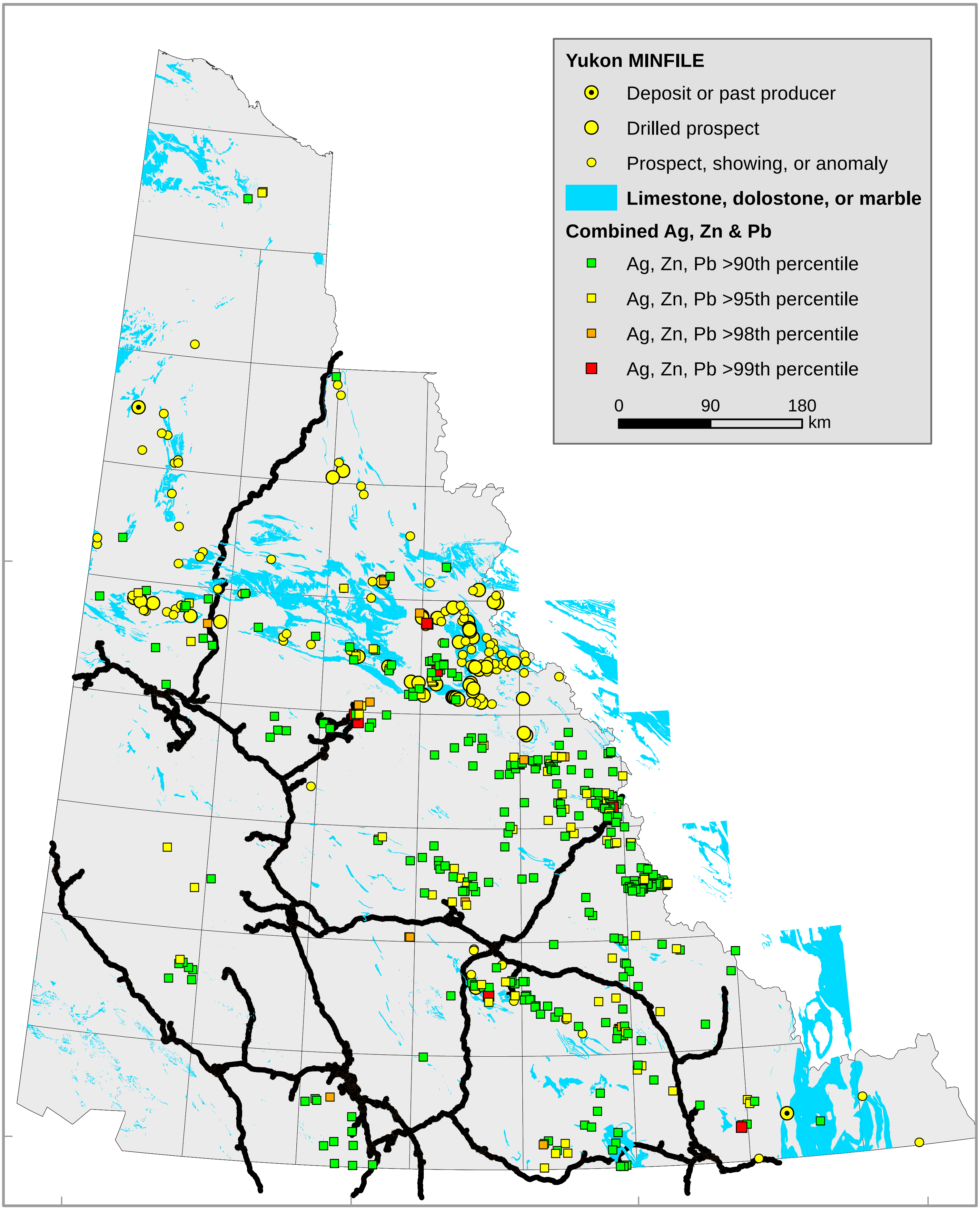
Yukon MINFILE

MINFILE	NAMES	STATUS
106C 020	GOZ, BARRIER REEF	DEPOSIT
106C 073	CRAIG	DEPOSIT
106C 085	VAL	DEPOSIT
106D 064	BLENDE, BRAINE	DEPOSIT
105O 018	ODD	DRILLED PROSPECT
106B 024	BIRKELAND, TOM, MOM	DRILLED PROSPECT
106C 005	GILDERSLEEVE	DRILLED PROSPECT
106C 019	CORN	DRILLED PROSPECT
106C 021	HARRISON, HARRISON CREEK	DRILLED PROSPECT
106C 022	CYPRESS	DRILLED PROSPECT
106C 023	COB, CORN CREEK PROPERTY	DRILLED PROSPECT
106C 037	FRIGSTAD, IRVINE	DRILLED PROSPECT
106C 038	SPECTROAIR	DRILLED PROSPECT
106C 039	PROFEIT	DRILLED PROSPECT
106C 043	DOWSER, G	DRILLED PROSPECT
106C 044	LEARY	DRILLED PROSPECT
106C 054	GAL	DRILLED PROSPECT
106C 059	CAB	DRILLED PROSPECT
106C 065	MCKELVIE	DRILLED PROSPECT
106C 074	SIAN	DRILLED PROSPECT
106C 075	REPTILE	DRILLED PROSPECT
106D 006	KATHLEEN	DRILLED PROSPECT
106D 042	SILVER HILL	DRILLED PROSPECT
106D 074	CORD	DRILLED PROSPECT
106D 085	ZAP	DRILLED PROSPECT
106E 007	FLUNK	DRILLED PROSPECT
106F 006	LANDREVILLE	DRILLED PROSPECT
106L 033	PILON	DRILLED PROSPECT
116B 083	MONSTER	DRILLED PROSPECT
116B 084	TART	DRILLED PROSPECT
116B 087	KIWI	DRILLED PROSPECT
116B 100	MINIERE	DRILLED PROSPECT
116B 128	REIN	DRILLED PROSPECT
116I 053	LLOD	DRILLED PROSPECT
116K 003	RUSTY SPRINGS, TERMUENDE	DRILLED PROSPECT
106C 026	NEST, BAR	PROSPECT
106C 027	TOPOROWSKI	PROSPECT
106C 031	GENTRY	PROSPECT
106C 046	CANWEX	PROSPECT
106C 050	BOB	PROSPECT
106D 040	CARPENTER	PROSPECT
106E 008	FORSTER	PROSPECT
106E 020	TUKU	PROSPECT
106E 034	FLATULENT	PROSPECT
106F 007	COLLEY	PROSPECT
106F 010	PLAINS	PROSPECT
116A 015	HOT	PROSPECT
116J 041	WART	PROSPECT
116O 039	SALEKEN	PROSPECT
095D 027	JONI, MEL EAST, MEL-HOSER	SHOWING
105F 015	KAY	SHOWING
105F 085	ENTRY	SHOWING
105G 007	PLUMB, NOLE	SHOWING
105G 064	ZIMMER, NEW	SHOWING
106B 014	ANDY	SHOWING
106B 015	NECO	SHOWING
106B 030	MARTHA	SHOWING
106C 003	GILLESPIE	SHOWING

MINFILE	NAMES	STATUS
106C 024	ZOG	SHOWING
106C 025	GOODMAN	SHOWING
106C 030	GUS	SHOWING
106C 032	CADET	SHOWING
106C 034	LOG	SHOWING
106C 036	MOUSE	SHOWING
106C 040	POO	SHOWING
106C 041	CARNE	SHOWING
106C 042	DAN	SHOWING
106C 047	COAST	SHOWING
106C 056	ENVOY	SHOWING
106C 062	DUNE	SHOWING
106C 063	SNAKE	SHOWING
106C 077	JAM	SHOWING
106C 078	BLUSSON	SHOWING
106C 079	HIGHHAWK	SHOWING
106C 080	LEAH	SHOWING
106C 088	SUPERDAVE	SHOWING
106D 066	LINGHAM	SHOWING
106D 067	NEWT	SHOWING
106E 010	MAGIC	SHOWING
106E 012	HENDRY	SHOWING
106E 019	ONCE	SHOWING
106F 003	VYE	SHOWING
106F 009	HOME	SHOWING
106L 052	TWICE	SHOWING
106L 055	VITTREKWA	SHOWING
115P 027	ETHEL	SHOWING
116A 016	MICHELLE	SHOWING
116A 020	BRUK	SHOWING
116B 085	OZ, HARP	SHOWING
116B 086	SEELA, KIM	SHOWING
116B 130	TOLBERT, KITL	SHOWING
116C 101	UGLY, UG	SHOWING
116F 015	TINDIR	SHOWING
116F 056	LAZNICKA	SHOWING
116G 042	NUCLEAR	SHOWING
116G 046	COOT	SHOWING
116G 047	FRETWELL	SHOWING
116G 048	BILBO	SHOWING
116J 001	PEACH	SHOWING
116J 011	FISHING BRANCH	SHOWING
116J 040	MOKO	SHOWING
116J 043	YUM	SHOWING
116J 044	BULLIS	SHOWING
116K 009	BERN	SHOWING
095C 069	TRANZ	ANOMALY
095D 034	JP	ANOMALY
106C 028	ANGLO	ANOMALY
106C 029	MONITOR, PLU	ANOMALY
106C 033	CARDIGAN	ANOMALY
106C 035	KENDAL	ANOMALY
106C 051	BRANDON	ANOMALY
106C 058	TAPIN	ANOMALY
106C 081	EIRA	ANOMALY
116B 110	RAYNER, BRX	ANOMALY
116B 111	DAWG	ANOMALY
116G 045	GIG	ANOMALY
116J 010	BEAR CAVE	ANOMALY



Map of Yukon illustrating the distribution of carbonate rocks and possible MVT type occurrences



Map of Yukon illustrating the distribution of carbonate rocks, possible MVT style occurrences and combined Ag, Zn and Pb regional geochemistry

SEDIMENTARY EXHALATIVE (SEDEX) Zn-Pb-Ag E14

by Don MacIntyre[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Shale-hosted Zn-Pb-Ag; sediment-hosted massive sulphide Zn-Pb-Ag; SEDEX Zn-Pb.

COMMODITIES (*BYPRODUCTS*): Zn, Pb, Ag (*minor Cu, barite*).

EXAMPLES: **(Yukon): Grum, Dy, Swim, Faro, Vangorda (Anvil District), XY, Anniv (Howard's Pass), Tom, Jason (Macmillan Pass), Clear Lake (Tintina Trench), Mel, Matt Berry (southeast Yukon);**
(British Columbia - *Canada/International*): Cirque, Sullivan, Driftpile; *Red Dog (Alaska, USA), McArthur River and Mt. Isa (Australia); Megen and Rammelsberg (Germany).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Beds and laminations of sphalerite, galena, pyrite, pyrrhotite and rare chalcopyrite, with or without barite, in euxinic clastic marine sedimentary strata. Deposits are typically tabular to lensoidal in shape and range from centimetres to tens of metres thick. Multiple horizons may occur over stratigraphic intervals of 1000 m or more.

TECTONIC SETTING: Intracratonic or continental margin environments in fault-controlled basins and troughs. Troughs are typically half grabens developed by extension along continental margins or within back-arc basins. **The Yukon deposits are located along the margins of Selwyn Basin near the transition to Cassiar Platform to the southwest (Anvil District, Clear Lake and Matt Berry), and to Mackenzie Platform to the northeast (Macmillan Pass, Howard's Pass, Mel).**

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Restricted second and third order basins within linear, fault-controlled marine, epicratonic troughs and basins. There is commonly evidence of penecontemporaneous movement on faults bounding sites of sulphide deposition. The depositional environment varies from deep, starved marine to ?shallow-water restricted shelf.

AGE OF MINERALIZATION: The major metallogenic events are Middle Proterozoic, Early Cambrian, Early Silurian and Middle to Late Devonian to Mississippian. The Middle Proterozoic and Devonian-Mississippian events are recognized worldwide. In the Canadian Cordillera, minor metallogenic events occur in the Middle Ordovician and Early Devonian. **In Yukon, major metallogenic events are Cambro-Ordovician (Faro District), Early Silurian (Howard's Pass), and Devonian-Mississippian (Macmillan Pass, Clear Lake). Minor**

[1] British Columbia Geological Survey, Victoria, B.C., Canada

metallogenic events are Early Cambrian (Mel deposit; Miller and Wright, 1983) and Ordovician (Matt Berry, J. Mortensen, pers. comm., 2000).

HOST/ASSOCIATED ROCK TYPES: The most common host rocks are those found in euxinic, starved basin environments, namely, carbonaceous black shale, siltstone, cherty argillite and chert. Thin interbeds of turbiditic sandstone, granule to pebble conglomerate, pelagic limestone and dolostone, although volumetrically minor, are common. Evaporites, calcareous siltstone and mudstone are common in shelf settings. Small volumes of volcanic rocks, typically tuff and submarine mafic flows, may be present within the host succession. Slump breccia, fan conglomerates and similar deposits occur near synsedimentary growth faults. Rapid facies and thickness changes are found near the margins of second and third order basins. In some basins high-level mafic sills with minor dikes are important. **In Yukon, the most prospective host rocks are: Cambrian and Ordovician Vangorda and Menzie Creek Formations (Anvil District), which are age-correlative to the regional Upper Cambrian and Ordovician Rabbitkettle Formation; Ordovician to Silurian Road River Group (Howard's Pass); and Devonian and Mississippian Earn Group (Macmillan Pass).**

DEPOSIT FORM: These deposits are stratabound, tabular to lens shaped and are typically comprised of many beds of laminae of sulphide minerals and/or barite. Frequently the lenses are stacked and more than one horizon is economic. Ore lenses and mineralized beds commonly are part of a sedimentary succession up to hundreds of metres thick. Horizontal extent is usually much greater than vertical extent. Individual laminae or beds may persist over tens of kilometres within the depositional basin.

TEXTURE/STRUCTURE: Sulphide and barite laminae are commonly very finely crystalline where deformation is minor. In intensely folded deposits, coarser grained, recrystallized zones are common. Sulphide laminae are typically monomineralic.

ORE MINERALOGY [Principal and *subordinate*]: The principal sulphide minerals are pyrite, pyrrhotite, sphalerite and galena. Some deposits contain significant amounts of *chalcopyrite*, but most do not. Barite may or may not be a major component of the ore zone. Trace amounts of *marcasite, arsenopyrite, bismuthinite, molybdenite, enargite, millerite, freibergite, cobaltite, cassiterite, valleriite and melnikovite* have been reported from these deposits. These minerals are commonly present in very minor amounts.

ALTERATION MINERALOGY: Alteration varies from well developed to nonexistent. In some deposits a stockwork and disseminated feeder zone lies beneath, or adjacent to, the stratiform mineralization. Alteration minerals, if present, include silica, tourmaline, carbonate, albite, chlorite and dolomite. They formed in a relatively low temperature environment. Celsian, Ba-muscovite and ammonium clay minerals have also been reported but are probably not common.

ORE CONTROLS: Favourable sedimentary sequences, major structural breaks, basins.

GENETIC MODEL: The deposits accumulate in restricted second and third order basins or half grabens bounded by synsedimentary growth faults. Exhalative centres occur along these faults and the exhaled brines accumulate in adjacent seafloor depressions. Biogenic reduction of seawater sulphate within an anoxic brine pool is believed to control sulphide precipitation.

ASSOCIATED DEPOSIT TYPES: Associated deposit types include carbonate-hosted sedimentary exhalative, such as the Kootenay Arc and Irish deposits (E13), bedded barite (E17) and iron formation (F10).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: The deposits are typically zoned with Pb found closest to the vent grading outward and upward into more Zn-rich facies. Cu is commonly found either within the feeder zone or close to the exhalative vent. Barite, exhalative chert and hematite-chert iron formation, if present, are usually found as a distal facies. Sediments such as pelagic limestone interbedded with the ore zone may be enriched in Mn. NH_3 anomalies have been documented at some deposits, as have Zn, Pb and Mn haloes. The host stratigraphic succession may also be enriched in Ba on a basin-wide scale.

GEOPHYSICAL SIGNATURE: Airborne and ground geophysical surveys, such as electromagnetics or magnetics should detect deposits that have massive sulphide zones, especially if these are steeply dipping. However, the presence of graphite-rich zones in the host sediments can complicate the interpretation of EM conductors. Also, if the deposits are flat lying and comprise fine laminae distributed over a significant stratigraphic interval, the geophysical response is commonly too weak to be definitive. Induced polarization can detect flat-lying deposits, especially if disseminated feeder zones are present.

OTHER EXPLORATION GUIDES: The principal exploration guidelines are appropriate sedimentary environment and stratigraphic age. Restricted marine sedimentary sequences deposited in an epicratonic extensional tectonic setting during the Middle Proterozoic, Early Cambrian, Early Silurian or Devono-Mississippian ages are the most favourable.

ECONOMIC FACTORS

GRADE AND TONNAGE: The median tonnage for this type of deposit worldwide is 15 Mt, with 10 % of deposits in excess of 130 Mt (Briskey, 1986). The median grades worldwide are Zn - 5.6%, Pb -2.8% and Ag - 30 g/t. The Sullivan deposit, one of the largest deposits of this type ever discovered, has a total size of more than 155 Mt grading 5.7% Zn, 6.6% Pb and 7 g/t Ag. Reserves at the Cirque are 32.2 Mt grading 7.9% Zn, 2.1% Pb and 48 g/t Ag. **The median size for Selwyn Basin and Kechika Trough deposits (the southerly extension of Selwyn Basin into British Columbia) is 14.5 million tonnes. The giant Howard's Pass deposits have geological resources estimated in excess of 550 million tonnes, and inferred reserves in excess of 362 million tonnes (Deklerk, 2003). Silver grade is low in comparison to other SEDEX deposits worldwide. At Clear Lake, over 75% of the outlined sulphide reserves consist of barren pyrite.**

ECONOMIC LIMITATIONS: The large, near-surface deposits are amenable to high volume, open pit mining operations. Underground mining is used for some deposits. **Remoteness and lack of infrastructure are the principal reasons for the limited exploration in the Macmillan Pass and Howard's Pass areas. For example, the Howard's Pass deposits are more than 80 km from the nearest road. The Anvil District is covered by glacial overburden, which has rendered conventional geochemical exploration methods inefficient.**

IMPORTANCE: Sedimentary exhalative deposits currently produce a significant proportion of the world's Zn and Pb. Their large tonnage potential and associated Ag values make them an attractive exploration target. **During mine operations, the Anvil District was an important source of wealth and employment, and was a driving force behind major infrastructure initiatives. Large tonnages and the clustered character of SEDEX deposits make the Howard's Pass and Macmillan Pass areas attractive for mineral exploration.**

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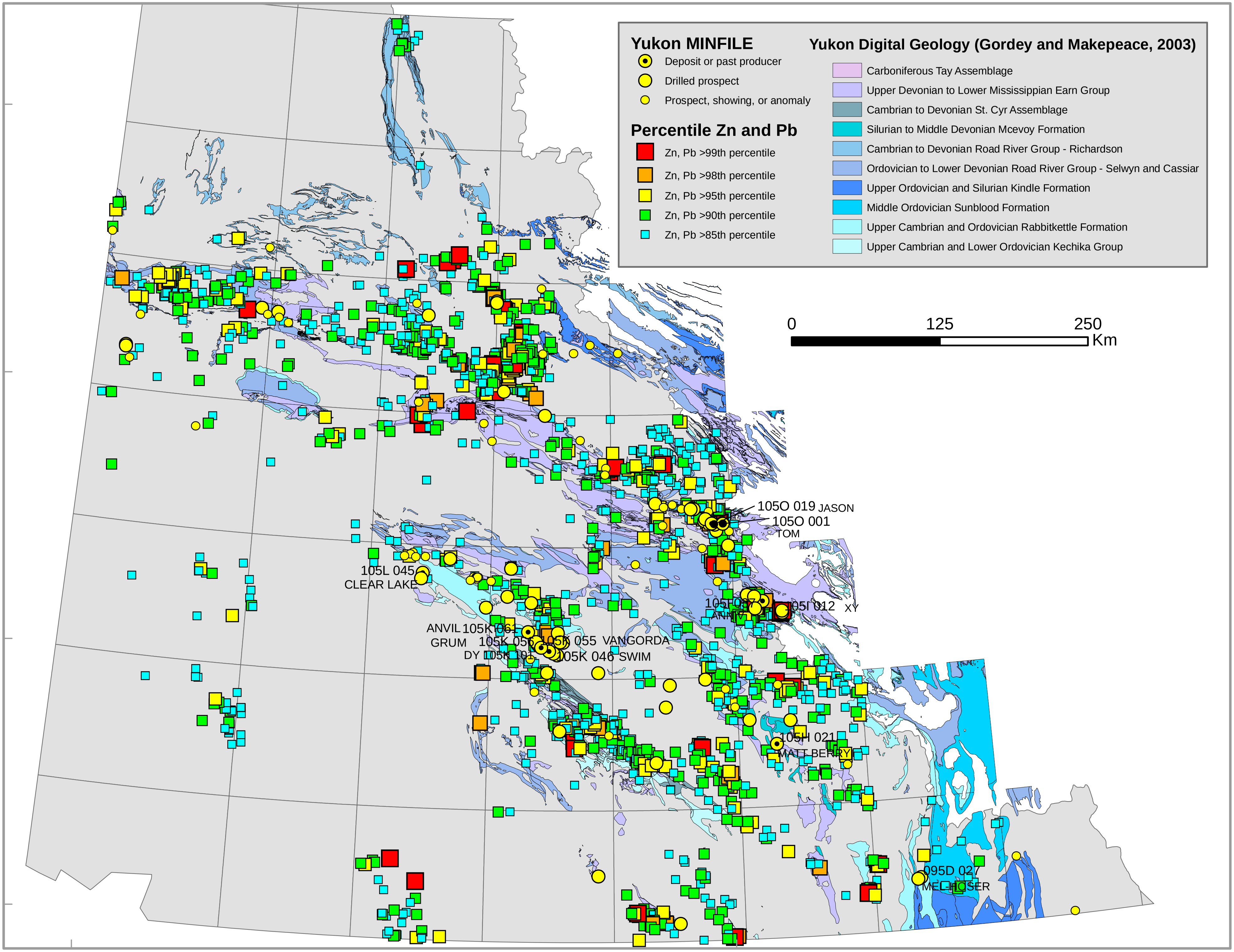
E14 - Sedimentary exhalative Zn-Pb-Ag - BC and Yukon Deposits

Deposit	Country	Tonnes	Ag (g/t)	Pb (%)	Zn (%)
MATT BERRY	CNYK	533 434	102.9	6.10	4.80
OGO (SWIM)	CNYK	4 300 000	42.0	3.80	4.70
BEND CANYON	CNBC	5 000 000	7.0	0.60	2.30
CLEAR LAKE	CNYK	6 100 000	40.8	2.15	11.34
MEL	CNYK	6 800 000	0.0	2.00	7.10
VANGORDA	CNYK	71 000 000	48.0	3.40	4.30
JASON	CNYK	14 100 000	79.9	7.09	6.57
TOM	CNYK	14 528 247	42.3	40.60	7.48
DRIFTPILE	CNBC	18 000 000	0.0	0.00	2.38
BOB (DY)	CNYK	20 300 000	82.0	5.70	7.00
CHAMP (GRUM)	CNYK	30 800 000	49.0	3.10	4.90
CIRQUE	CNBC	32 200 000	48.0	2.20	7.90
FARO	CNYK	57 600 000	0.0	3.40	4.70
SULLIVAN	CNBC	151 000 000	63.3	5.82	5.54
HOWARD'S PASS (XY + ANNIV)	CNYK	550 000 000	9.0	2.00	5.00

Yukon MINFILE

MINFILE	NAMES	STATUS
105K 055	VANGORDA	OPEN PIT PAST PRODUCER
105K 056	GRUM	OPEN PIT PAST PRODUCER
105K 061	FARO	OPEN PIT PAST PRODUCER
095D 005	MEL, JEAN	DEPOSIT
105H 021	MATT BERRY	DEPOSIT
105I 012	HOWARDS PASS, SUMMIT LAKE, XY	DEPOSIT
105I 037	ANNIV	DEPOSIT
105K 046	SWIM	DEPOSIT
105K 101	DY, GRIZZLY	DEPOSIT
105L 045	CLEAR LAKE	DEPOSIT
105O 001	TOM	DEPOSIT
105O 019	JASON	DEPOSIT
095D 032	JERI	DRILLED PROSPECT
105B 054	OULETTE, OMO	DRILLED PROSPECT
105F 091	ANGIE	DRILLED PROSPECT
105G 056	PAY	DRILLED PROSPECT
105G 093	NEBOCAT, CYR, TAR, ANO, HOOLE	DRILLED PROSPECT
105G 094	DWONK	DRILLED PROSPECT
105H 047	FIN	DRILLED PROSPECT
105H 075	MAXI	DRILLED PROSPECT
105I 032	SHIELD	DRILLED PROSPECT
105I 038	ABBEY	DRILLED PROSPECT
105I 053	BRODELL, OP	DRILLED PROSPECT
105I 058	RITZ	DRILLED PROSPECT
105J 012	ROG	DRILLED PROSPECT
105K 010	FARGO, SUNSET, AL, KIRK, RIM	DRILLED PROSPECT
105K 034	ADAMSON, ACE	DRILLED PROSPECT
105K 036	BETA	DRILLED PROSPECT
105K 042	SEA	DRILLED PROSPECT
105K 043	SB	DRILLED PROSPECT
105K 049	ST. LUCIE	DRILLED PROSPECT
105K 054	SHRIMP	DRILLED PROSPECT
105K 057	KULAN, FIRTH	DRILLED PROSPECT
105K 067	LORNA	DRILLED PROSPECT
105K 074	COLT, BLUE, TWO	DRILLED PROSPECT
105K 104	DEV	DRILLED PROSPECT
105K 105	SIR JOHN A., MONI, TELE	DRILLED PROSPECT
105L 017	LOBO	DRILLED PROSPECT
105L 030	HACHEY	DRILLED PROSPECT
105L 039	ALPHABET	DRILLED PROSPECT
105L 041	KELLY	DRILLED PROSPECT
105L 056	TUM	DRILLED PROSPECT

MINFILE	NAMES	STATUS
105N 015	KIDD	DRILLED PROSPECT
105O 006	SCOT	DRILLED PROSPECT
105O 024	NIDD	DRILLED PROSPECT
105O 025	BREMNER	DRILLED PROSPECT
116A 024	SANGUINETTI	DRILLED PROSPECT
116B 170	TAIGA	DRILLED PROSPECT
116C 116	MICKEY, BRILL	DRILLED PROSPECT
095C 068	BEAV	PROSPECT
105F 106	HOWRU	PROSPECT
105F 115	MT. ROSS	PROSPECT
105G 070	RENO, ELECTRIC MINE	PROSPECT
105J 011	IVOR, BEETHOVEN	PROSPECT
105J 013	CLYDE, ITSI	PROSPECT
105K 103	TENAS	PROSPECT
105L 037	CAVE, MCARTHUR	PROSPECT
116A 013	RIMROCK	PROSPECT
116C 115	CLIP	PROSPECT
095C 037	BEAVERCROW	SHOWING
105F 064	ASKIN	SHOWING
105F 116	HOLLAND	SHOWING
105G 096	WAD, SAS	SHOWING
105H 095	COME	SHOWING
105I 043	DIANNE	SHOWING
105J 025	ST GODARD	SHOWING
105O 011	BEN	SHOWING
105O 036	FAN	SHOWING
116B 142	GRAPS	SHOWING
116F 007	BURGOYNE	SHOWING
095C 024	TROPICAL, SWAN, PYRO	ANOMALY
105G 042	MCEVOY	ANOMALY
105I 029	SUMMIT	ANOMALY
105I 034	BLACK GIANT	ANOMALY
105J 034	DYAK	ANOMALY
105K 012	CASCA, LYN, RIDGE	ANOMALY
105L 032	HORSFALL	ANOMALY
105N 023	KEG	ANOMALY
105O 029	GOW, TH	ANOMALY
106C 072	LINDBERG	ANOMALY
106C 091	TELL	ANOMALY
116A 023	SKETCH	ANOMALY
095C 066	MARS, DEEK	UNKNOWN
105O 026	DICKIE	UNKNOWN
116A 022	SHINE	UNKNOWN



Map of Yukon showing Selwyn Basin rocks that host SEDEX mineralization, SEDEX type mineral occurrences and combined Pb- Zn geochemistry

BESSHI MASSIVE SULPHIDE G04

by Trygve Höy[1]

Modified for Yukon by A. Fonseca and G. Bradshaw
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Besshi type, Kieslager.

COMMODITIES (*BYPRODUCTS*): Cu, Zn, Pb, Ag (*Au, Co, Sn, Mo, Cd*).

EXAMPLES **(Yukon): Hart River (116A 009), Fyre Lake (105G 034);** (British Columbia - *Canada/International*): Goldstream (082M141), Standard (082M090), Montgomery (082M085), True Blue (082F002), Granduc (?) (104B021), Windy Craggy (114P020); *Greens Creek (Alaska, USA), Besshi (Japan).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Deposits typically comprise thin sheets of massive to well layered pyrrhotite, chalcopyrite, sphalerite, pyrite and minor galena within interlayered, terrigenous clastic rocks and calcalkaline basaltic to andesitic tuffs and flows.

TECTONIC SETTINGS: Oceanic extensional environments, such as back-arc basins, oceanic ridges close to continental margins, or rift basins in the early stages of continental separation.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Terrigenous clastic rocks associated with marine volcanic rocks and sometimes carbonate rocks; these may overlie platformal carbonate or clastic rocks.

AGE OF MINERALIZATION: Any age. In British Columbia, most deposits are Cambrian, Late Triassic and less commonly Mississippian-Permian in age. **The Fyre Lake deposit of the Finlayson Lake District is late Devonian. The Hart River deposit is Proterozoic.**

HOST/ASSOCIATED ROCK TYPES: Clastic sedimentary and marine volcanic rocks; basaltic tuffs and flows, shale and siltstone, commonly calcareous; less commonly chert and Fe formations. Possibly ultramafic rocks and metagabbro in sequence.

DEPOSIT FORM: Typically a concordant sheet of massive sulphides up to a few metres thick and up to kilometres in strike length and down dip; can be stacked lenses.

TEXTURE/STRUCTURE: Massive to well-layered, fine to medium-grained sulphide minerals; gneissic sulphide textures common in metamorphosed and deformed deposits; durchbewegung textures; associated stringer ore is uncommon. Crosscutting pyrite, chalcopyrite and/or sphalerite veins with chlorite, quartz and carbonate are common.

ORE MINERALOGY [Principal and *subordinate*]: Pyrite, pyrrhotite, chalcopyrite, sphalerite, *cobaltite, magnetite, galena, bornite, tetrahedrite, cubanite, stannite, molybdenite, arsenopyrite, marcasite*.

[1] British Columbia Geological Survey, Victoria, B.C., Canada

GANGUE MINERALOGY (Principal and *subordinate*): Quartz, calcite, ankerite, siderite, albite, tourmaline, *graphite, biotite.*

ALTERATION MINERALOGY: Similar to gangue mineralogy - quartz, chlorite, calcite, siderite, ankerite, pyrite, sericite, graphite.

ORE CONTROLS: Difficult to recognize; early (syndepositional) faults and mafic volcanic centres.

GENETIC MODEL: Seafloor deposition of sulphide mounds in back-arc basins, or several other tectonic settings, contemporaneous with volcanism.

ASSOCIATED DEPOSIT TYPES: Cu, Zn veins.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Cu, Zn, Ag, Co/Ni>1; Mn halos, Mg enrichment.

GEOPHYSICAL SIGNATURE: Sulphide lenses commonly show either an electromagnetic or induced polarization signature depending on the style of mineralization and presence of conductive sulphides.

OTHER EXPLORATION GUIDES: Mafic volcanic rocks (tholeiitic, less commonly alkalic) associated with clastic rocks; Mn-rich garnets in metamorphosed exhalative horizons, possible structures, such as faults; possible association with ultramafic rocks.

ECONOMIC FACTORS

GRADE AND TONNAGE: Highly variable in size. B.C. deposits range in size from less than 1 Mt to more than 113 Mt. For example, Goldstream has a total resource (reserves and production) of 1.8Mt containing 4.81 % Cu, 3.08 % Zn and 20.6 g/t Ag and Windy Craggy has reserves in excess of 113.0 Mt containing 1.9 % Cu, 3.9 g/t Ag and 0.08% Co. The type-locality Besshi deposits average 0.22 Mt, containing 1.5% Cu, 2-9 g/t Ag, and 0.4-2% Zn (Cox and Singer, 1986).

IMPORTANCE: Significant sources of Cu, Zn and Ag that can be found in sedimentary sequences that have not been thoroughly explored for this type of target.

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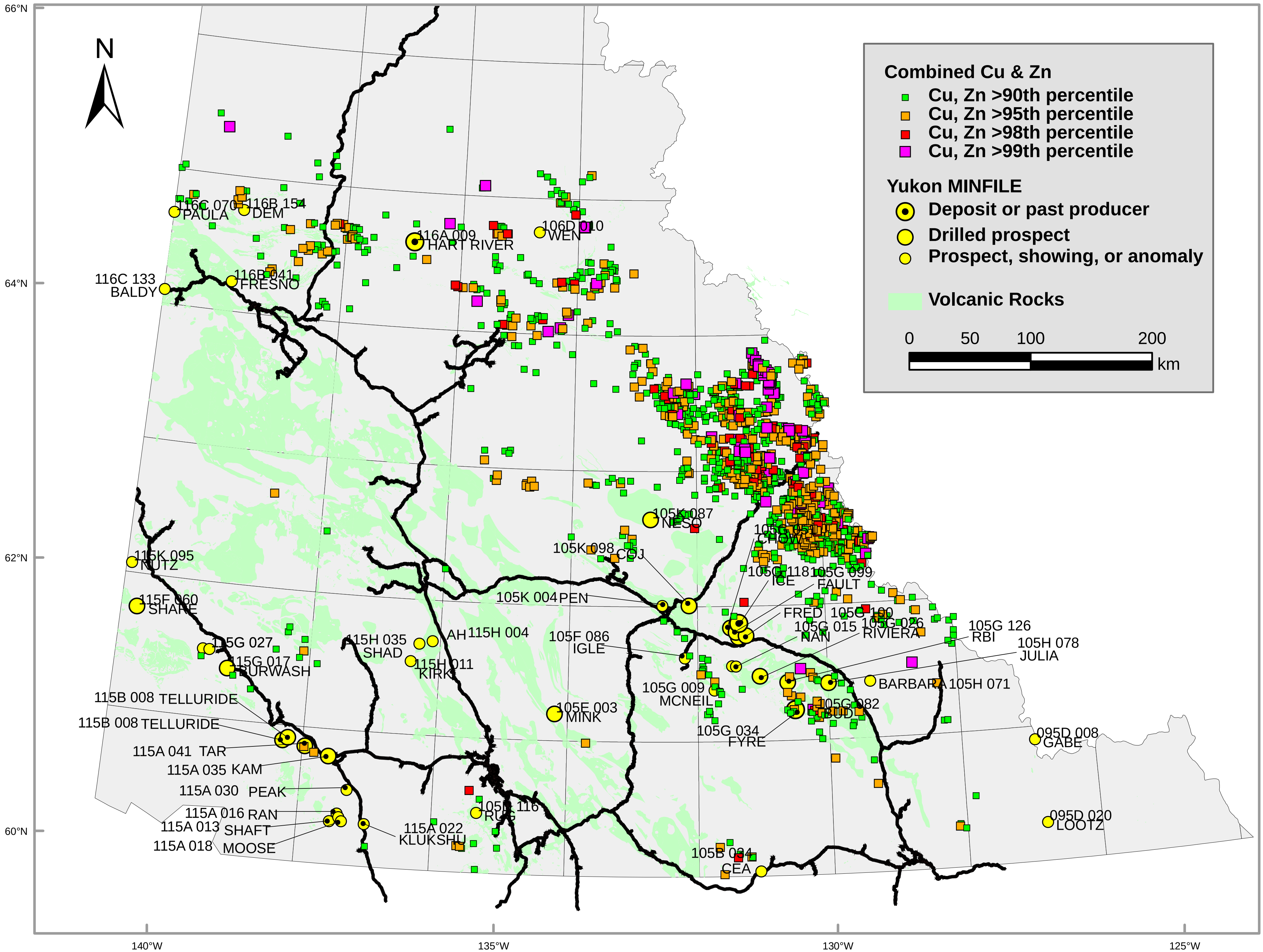
G04 - Besshi massive sulphide - world deposits

deposit	country	tonnes	Au	Ag	Cu	Zn
GOLDSTREAM	CNBC	22 000			3.5	2.15
GRANDUC	CNBC	26 000 000	0	8	1.44	0
WINDY CRAGGY	CNBC	297 000 000	0.2	4	1.38	0
GREENS CREEK	CNBC	2 997 960	4.8	555.42	0	11.9
BESSHI	JAPN	30 000 000	0.2	6.6	2.45	0.3
ICE	CNYK	4 561 863			1.48	
FYRE	CNYK	15 400 000	0.73		2.1	
HART RIVER	CNYK	523 454	1.37	50	1.45	3.65

Yukon MINFILE

MINFILE	NAMES	STATUS
105G 034	KONA, FYRE	DEPOSIT
116A 009	HART RIVER, MARK	DEPOSIT
105G 026	RIVIERA	DRILLED PROSPECT
105G 126	RBI	DRILLED PROSPECT
105H 078	JULIA	DRILLED PROSPECT
115G 017	BURWASH	DRILLED PROSPECT
105G 100	HARRIS, EAGLE	PROSPECT
105G 009	MCNEIL	SHOWING
106D 010	WEN	SHOWING
115G 026	MUSKETEER	SHOWING
115H 004	AH	SHOWING
115H 011	KIRK	SHOWING
115H 035	SHAD	SHOWING
116B 041	FRESNO	SHOWING
116C 133	BALDY	SHOWING
105G 015	NAN	ANOMALY



Map of Yukon showing volcanic rocks, Cu-Zn geochemistry and mineral occurrences that are similar to the Besshi deposit model

NORANDA/KUROKO MASSIVE SULPHIDE Cu-Pb-Zn G06

by Trygve Höy[1]

Modified for Yukon by A. Fonseca and G. Bradshaw

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYM: Polymetallic volcanogenic massive sulphide.

COMMODITIES (*BYPRODUCTS*): Cu, Pb, Zn, Ag, Au (*Cd, S, Se, Sn, barite, gypsum)*.

EXAMPLES: **(Yukon): Wolverine (105G 072), Kudz Ze Kayah (105G 117), Wolf (105G 008), Marg (106D 009), GP4F (105G 143)**; (British Columbia - *Canada/International*): Homestake (082M025), Lara (092B001), Lynx (092B129), Myra (092F072), Price (092F073), H-W (092F330), Ecstall (103h011), Tulsequah Chief (104K011), Big Bull (104K008), Kutcho Creek (104J060), Britannia (092G003); *Kidd Creek (Ontario, Canada), Buchans (Newfoundland, Canada), Bathurst-Newcastle district (New Brunswick, Canada), Horne-Quemont (Québec, Canada), Kuroko district (Japan), Mount Lyell (Australia), Rio Tinto (Spain), Shasta King (California, USA), Lockwood (Washington, USA).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: One or more lenses of massive pyrite, sphalerite, galena and chalcopyrite commonly within felsic volcanic rocks in a calcalkaline bimodal arc succession. The lenses may be zoned, with a Cu-rich base and a Pb-Zn-rich top; low-grade stockwork zones commonly underlie lenses and barite or chert layers may overlie them.

TECTONIC SETTING: Island arc; typically in a local extensional setting or rift environment within, or perhaps behind, an oceanic or continental margin arc.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Marine volcanism; commonly during a period of more felsic volcanism in an andesite (or basalt) dominated succession; locally associated with fine-grained marine sedimentary rocks; also associated with faults or prominent fractures.

AGE OF MINERALIZATION: Any age. In British Columbia typically Devonian; less commonly Permian-Mississippian, Late Triassic, Early (and Middle) Jurassic, and Cretaceous. **In Yukon, deposits and prospects of the Finlayson Lake district, Cassiar Terrane and Selwyn Basin are early Mississippian.**

HOST/ASSOCIATED ROCK TYPES: Submarine volcanic arc rocks: rhyolite, dacite associated with andesite or basalt; less commonly, in mafic alkaline arc successions; associated epiclastic deposits and minor shale or sandstone; commonly in close proximity to felsic intrusive rocks. Ore horizon grades laterally and vertically into thin chert or sediment layers called informally “exhalites”. **Magnetite-predominant iron formation and pyrite-carbonate exhalite occur in the hanging wall of the Wolverine deposit, Finlayson district, Yukon.**

[1] British Columbia Geological Survey, Victoria, B.C., Canada

DEPOSIT FORM: Concordant massive to banded sulphide lens which is typically metres to tens of metres thick and tens to hundreds of metres in horizontal dimension; sometimes there is a peripheral apron of "clastic" massive sulphides; underlying crosscutting “stringer” zone of intense alteration and stockwork veining.

TEXTURE/STRUCTURE: Massive to well layered sulphide minerals, typically zoned vertically and laterally; sulphide minerals with a quartz, chert or barite gangue (more common near top of deposit); disseminated, stockwork and vein sulphides (footwall).

ORE MINERALOGY (Principal and *subordinate*): Upper massive zone: pyrite, sphalerite, galena, chalcopyrite, *pyrrhotite, tetrahedrite-tennantite, bornite, arsenopyrite*. Lower massive zone: pyrite, chalcopyrite, *sphalerite, pyrrhotite, magnetite*.

GANGUE MINERALOGY: Barite, chert, *gypsum, anhydrite and carbonate* near top of lens, carbonate quartz, chlorite and sericite near the base.

ALTERATION MINERALOGY: Footwall alteration pipes are commonly zoned from the core with quartz, sericite or chlorite to an outer zone of clay minerals, albite and carbonate (siderite or ankerite).

ORE CONTROLS: More felsic component of mafic to intermediate volcanic arc succession; near centre of felsic volcanism (marked by coarse pyroclastic breccias or felsic dome); extensional faults.

ASSOCIATED DEPOSIT TYPES: Stockwork Cu deposits; vein Cu, Pb, Zn, Ag, Au.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Zn, Hg and Mg halos, K addition and Na and Ca depletion of footwall rocks; closer proximity to deposit - Cu, Ag, As, Pb; within deposit - Cu, Zn, Pb, Ba, As, Ag, Au, Se, Sn, Bi, As.

GEOPHYSICAL SIGNATURE: Sulphide lenses usually show either an electromagnetic or induced polarization signature depending on the style of mineralization and presence of conductive sulphides. In recent years borehole electromagnetic methods have proven successful.

OTHER EXPLORATION GUIDES: Explosive felsic volcanics, volcanic centres, extensional faults, exhalite (chert) horizons, pyritic horizons.

ECONOMIC FACTORS

GRADE AND TONNAGE: Average deposit size is 1.5 Mt containing 1.3% Cu, 1.9 % Pb, 2.0 % Zn, 0.16 g/t Au and 13 g/T Ag (Cox and Singer, 1986). British Columbia deposits range from less than 1 to 2 Mt to more than 10 Mt. The largest are the H-W (10.1 Mt with 2.0 % Cu, 3.5 % Zn, 0.3 % Pb, 30.4 g/t Ag and 2.1 g/t Au) and Kutcho (combined tonnage of 17 Mt, 1.6 % Cu, 2.3 % Zn, 0.06 % Pb, 29 g/t Ag and 0.3 g/t Au). **In the Finlayson district, Yukon, deposits range from 1.5 Mt (GP4F) to more than 10 Mt (Kudz Ze Kayah).**

ECONOMIC LIMITATIONS: The Wolverine deposit contains unusually high concentrations of selenium, which can increase metallurgical costs, but can also increase the value of ore, depending on the price of selenium.

IMPORTANCE: Noranda/Kuroko massive sulphide deposits are major producers of Cu, Zn, Ag, Au and Pb in Canada. Their high grade and commonly high precious metal content continue to make them attractive exploration targets.

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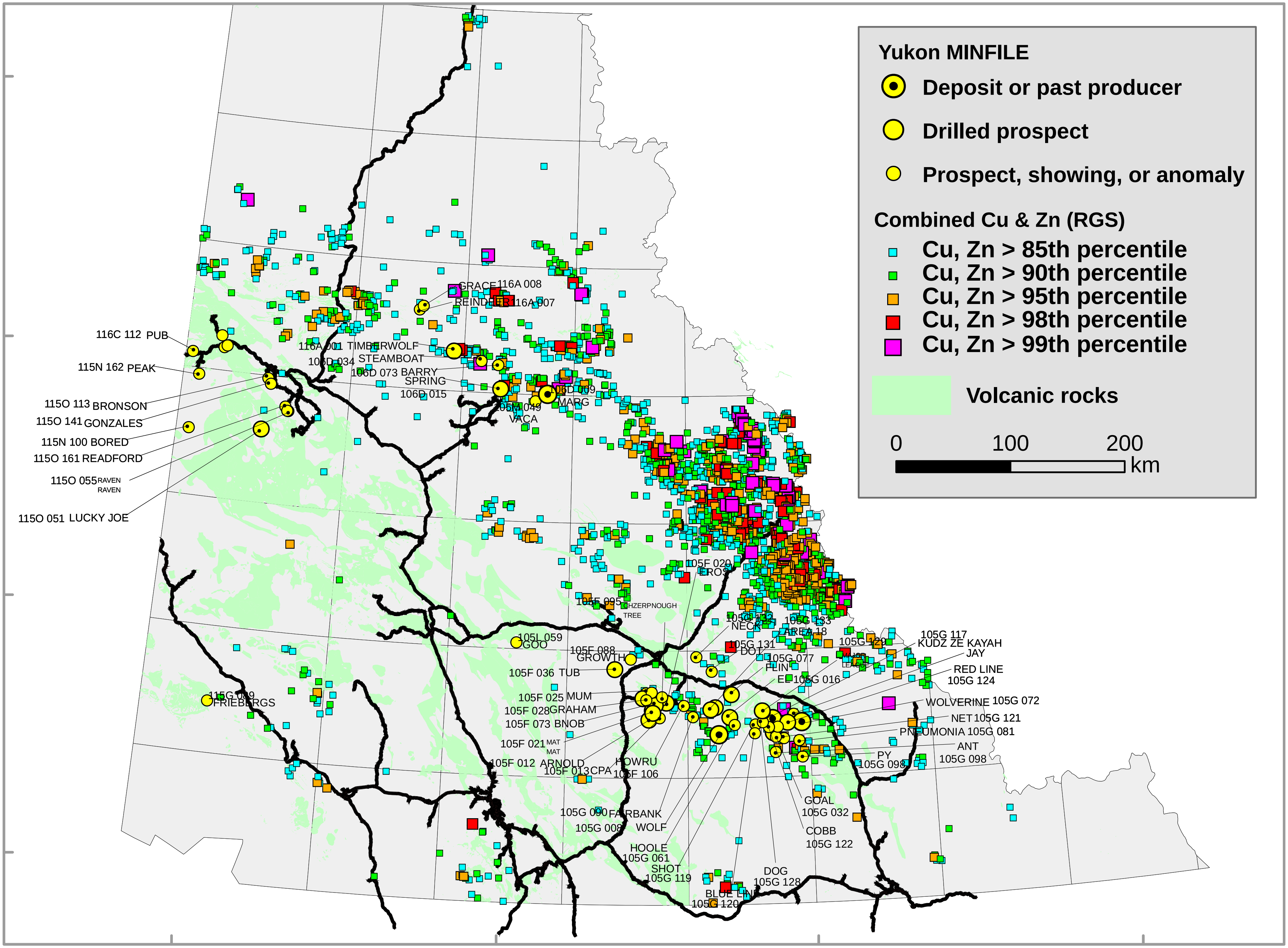
G04 - Noranda- or Kuroko-type massive sulphide - BC and Yukon deposits

Deposit	country	tonnes	Au (g/t)	Ag (g/t)	Cu %	Pb %	Zn %
GEORGE COPPER	CNBC	100 000	0.00	17	2.00	0.00	0.00
BOWLER CREEK	CNBC	312 000	0.00	52	0.20	3.37	2.58
REAGOLD	CNBC	376 000	6.10	69	0.33	2.20	2.30
LARA	CNBC	528 839	4.73	100	1.01	1.22	5.87
LENO	CNBC	594 967	4.16	117	2.46	0.37	3.85
HOMESTAKE	CNBC	1 470 962	0.01	245	0.55	2.50	3.99
SENECA	CNBC	1 506 499	0.82	41	0.63	0.00	3.57
ESKAY CREEK	CNBC	1 987 107	36.69	1709	0.00	0.00	0.00
ECSTALL	CNBC	6 900 000	0.50	17	0.60	2.50	0.00
TULSEQUAH CHIEF	CNBC	8 733 570	2.78	110	1.57	1.21	6.45
KUTCHO CREEK	CNBC	17 000 000	0.30	29	1.62	0.06	2.30
MYRA FALLS	CNBC	28 750 300	2.16	54	1.96	0.57	6.38
BRITANNIA	CNBC	49 308 700	0.31	4	1.10	0.03	0.25
GP4F	CNYT	1 500 000	0.00	0	0.00	3.00	6.00
MARG	CNYT	3 480 000	1.20	65	1.80	2.70	5.00
WOLF	CNYT	4 100 000	0.00	84	0.00	1.80	6.20
WOLVERINE	CNYT	6 200 000	1.76	371	1.30	1.50	12.70
KUDZ ZE KAYAH	CNYT	11 000 000	1.30	130	0.90	1.50	5.90

Yukon MINFILE

MINFILE	NAMES	STATUS
105G 008	HASSELBERG, WOLF	DEPOSIT
105G 072	FETISH, WOLVERINE	DEPOSIT
105G 117	TAG, KUDZ ZE KAYAH, ABM	DEPOSIT
105G 143	GP4F	DEPOSIT
106D 009	MARG	DEPOSIT
105B 143	CONVERT	DRILLED PROSPECT
105F 012	MM, ARNOLD	DRILLED PROSPECT
105F 021	BOX, MAT	DRILLED PROSPECT
105F 028	GULL MINERAL, HAYDN, ANISE	DRILLED PROSPECT
105F 036	TUB, FOX	DRILLED PROSPECT
105F 071	CHZERPNOUGH, FIRE	DRILLED PROSPECT
105F 073	BNOB, ICE	DRILLED PROSPECT
105G 032	PACK	DRILLED PROSPECT
105G 040	JAY, FISHER	DRILLED PROSPECT
105G 077	FLIN	DRILLED PROSPECT
105G 083	PY	DRILLED PROSPECT
105G 098	ANT	DRILLED PROSPECT
105G 124	RED LINE	DRILLED PROSPECT
105G 130	LEAGUE	DRILLED PROSPECT
105G 133	AREA 18	DRILLED PROSPECT
105G 134	PUCK	DRILLED PROSPECT
105G 135	ELLEN CREEK	DRILLED PROSPECT
105G 136	WHITE CREEK	DRILLED PROSPECT
105G 139	ON	DRILLED PROSPECT
105G 141	VERMILLION	DRILLED PROSPECT
106D 015	SPRING	DRILLED PROSPECT
116A 001	TIMBERWOLF	DRILLED PROSPECT
105A 047	SAMBO, SIMPSON	PROSPECT
105F 020	EROS	PROSPECT
105F 112	GRAHAM, BID	PROSPECT
105G 016	EL	PROSPECT
105G 123	GOAL	PROSPECT
105G 138	POP	PROSPECT
105G 140	NAD	PROSPECT

MINFILE	NAMES	STATUS
116C 124	TOP OF THE WORLD	PROSPECT
105F 013	CPA	SHOWING
105F 025	MUM	SHOWING
105F 042	MT. COOK	SHOWING
105F 087	RAMPANT	SHOWING
105F 088	GROWTH	SHOWING
105F 095	TREE	SHOWING
105G 081	MONEY	SHOWING
105G 090	FAIRBANK	SHOWING
105G 120	BLUE LINE	SHOWING
105G 121	NET	SHOWING
105G 122	OVERTIME	SHOWING
105G 127	COBB	SHOWING
105L 062	GOVERNMENT	SHOWING
105L 063	HIGHWAY	SHOWING
115G 089	FRIEBERGS	SHOWING
115N 162	PEAK	SHOWING
115O 055	RAVEN	SHOWING
115O 141	GONZALES	SHOWING
115O 161	READFORD	SHOWING
116C 112	PUB	SHOWING
116C 168	MORT	SHOWING
105G 128	DOG	ANOMALY
105G 129	MAJOR	ANOMALY
105G 131	DOT	ANOMALY
105G 132	NECK	ANOMALY
105G 137	MASK	ANOMALY
105G 142	BLAKE	ANOMALY
105L 059	GOO	ANOMALY
105M 049	VACA	ANOMALY
106D 034	STEAMBOAT	ANOMALY
115N 100	BORED	ANOMALY
115O 113	BRONSON	ANOMALY
106D 073	BARRY	UNKNOWN



Map of Yukon showing the distribution of volcanic rocks, Cu-Zn geochemistry and MINFILE occurrences that fit the Kuroko deposit model

EPITHERMAL Au-Ag-Cu: HIGH SULPHIDATION H04

by Andre Panteleyev[1]

modified for Yukon by A. Fonseca

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYMS: (Epithermal) acid-sulphate, quartz-alunite Au, alunite-kaolinite ± pyrophyllite, advanced argillic, Nansatsu-type, enargite gold. The deposits are commonly referred to as *acid-sulphate* type after the chemistry of the hydrothermal fluids, *quartz-alunite* or *kaolinite-alunite* type after their alteration mineralogy, or *high-sulphidation* type in reference to the oxidation state of the acid fluids responsible for alteration and mineralization.

COMMODITIES (*BYPRODUCTS*): Au, Ag, Cu (*As*, *Sb*).

EXAMPLES: **(Yukon): Yukon Antimony (105D 027), Wheaton Mountain (105D 031), Brown-McDade (115I 064), Webber (115I 065), Tally-Ho (105D 030), Skukum (105D 158), Laforma (115I 054);** British Columbia - *International*): Mt. McIntosh/Hushamu (EXPO, 92L240), Taseko River deposits - Westpine (Empress) (92O033), Taylor-Windfall (92O028) and Battlement Creek (92O005); *Goldfield and Paradise Peak (Nevada, USA), Summitville (Colorado, USA); Nansatsu (Japan), El Indio (Chile); Temora (New South Wales, Australia), Pueblo Viejo (Dominica), Chinkuashih (Taiwan), Rodalquilar (Spain), Lepanto and Nalesbitan (Philippines).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Veins, vuggy breccias and sulphide replacements ranging from pods to massive lenses occur in volcanic sequences associated with high level hydrothermal systems marked by acid-leached, advanced argillic, siliceous alteration.

TECTONIC SETTING: Extensional and transtensional settings, commonly in volcano-plutonic continent-margin and oceanic arcs and back-arcs. In zones with high-level magmatic emplacements, where stratovolcanoes and other volcanic edifices are constructed above plutons.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Subvolcanic to volcanic in calderas, flow-dome complexes, rarely maars and other volcanic structures; often associated with subvolcanic stocks and dikes, breccias. Postulated to overlie, and be genetically related to, porphyry copper systems in deeper mineralized intrusions that underlie the stratovolcanoes.

AGE OF MINERALIZATION: Tertiary to Quaternary; less commonly Mesozoic and rarely Paleozoic volcanic belts. The rare preservation of older deposits reflects rapid rates of erosion before burial of subaerial volcanoes in tectonically active arcs. **In Yukon, high sulphidation epithermal deposits and occurrences of the Wheaton District are associated with Eocene volcanic rocks. Deposits of the Mt. Nansen-Laforma area are associated with Cretaceous volcanic rocks.**

[1] British Columbia Geological Survey, Victoria, B.C., Canada

HOST/ASSOCIATED ROCK TYPES: Volcanic pyroclastic and flow rocks, commonly subaerial andesite to dacite and rhyodacite, and their subvolcanic intrusive equivalents. Permeable sedimentary intervolcanic units can be sites of mineralization.

DEPOSIT FORM: Veins and massive sulphide replacement pods and lenses, stockworks and breccias. Commonly irregular deposit shapes are determined by host rock permeability and the geometry of ore-controlling structures. Multiple, crosscutting composite veins are common.

TEXTURE/STRUCTURE: Vuggy 'slaggy' silica derived as a residual product of acid leaching is characteristic. Drusy cavities, banded veins, hydrothermal breccias, massive wallrock replacements with fine-grained quartz.

ORE MINERALOGY (Principal and *subordinate*): pyrite, enargite/luzonite, chalcocite, covellite, bornite, gold, electrum; *chalcopyrite, sphalerite, tetrahedrite/tennantite, galena, marcasite, arsenopyrite, silver sulphosalts, tellurides including goldfieldite.* Two types of ore are commonly present: massive enargite-pyrite and/or quartz-alunite-gold.

GANGUE MINERALOGY (Principal and *subordinate*): Pyrite and quartz predominate. Barite may also occur; carbonate minerals are absent.

ALTERATION MINERALOGY (Principal and *subordinate)*: Quartz, kaolinite/dickite, alunite, barite, hematite; sericite/illite, amorphous clays and silica, pyrophyllite, andalusite, diaspore, corundum, tourmaline*, dumortierite, topaz, zunyite, jarosite, Al-P sulphates (hinsdalite, woodhouseite, crandalite, etc*.) and native sulphur. Advanced argillic alteration is characteristic and can be areally extensive and visually prominent. Quartz occurs as fine-grained replacements and, characteristically, as vuggy, residual silica in acid-leached rocks.

WEATHERING: Weathered rocks may contain abundant limonite (jarosite-goethite-hematite), generally in a groundmass of kaolinite and quartz. Fine-grained supergene alunite veins and nodules are common.

ORE CONTROLS: In volcanic edifices - caldera ring and radial fractures; fracture sets in resurgent domes and flow-dome complexes, hydrothermal breccia pipes and diatremes. Faults and breccias in and around intrusive centres. Permeable lithologies, in some cases with less permeable cappings of hydrothermally altered or other cap rocks. The deposits occur over considerable depths, ranging from high-temperature solfataras at paleosurface down into cupolas of intrusive bodies at depth.

GENETIC MODEL: Recent research, mainly in the southwest Pacific and Andes, has shown that these deposits form in subaerial volcanic complexes or composite island arc volcanoes above degassing magma chambers. The deposits can commonly be genetically related to high-level intrusions. Multiple stages of mineralization are common, presumably related to periodic tectonism with associated intrusive activity and magmatic hydrothermal fluid generation.

ASSOCIATED DEPOSIT TYPES: Porphyry Cu±Mo±Au deposits (L04), subvolcanic Cu-Ag-Au (As-Sb) (L01), epithermal Au-Ag deposits: low sulphidation type (H05), silica-clay-pyrophyllite deposits (Roseki deposits) (H09), hotspring Au-Ag (H03), placer Au deposits (C01,C02).

COMMENTS: High-sulphidation epithermal Au-Ag deposits are much less common in the Canadian Cordillera than low-sulphidation epithermal veins. However, they are the dominant type of epithermal deposit in the Andes. **In Yukon, high sulphidation epithermal deposits are more common than low-sulphidation.**

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Au, Cu, As dominate; also Ag, Zn, Pb, Sb, Mo, Bi, Sn, Te, W, B and Hg.

GEOPHYSICAL SIGNATURE: Magnetic lows in hydrothermally altered (acid-leached) rocks; gravity contrasts may mark boundaries of structural blocks.

OTHER EXPLORATION GUIDES: These deposits are found in second order structures adjacent to crustal-scale fault zones, both normal and strike-slip, as well as local structures associated with subvolcanic intrusions. The deposits tend to overlie and flank porphyry copper-gold deposits and underlie acid-leached siliceous, clay and alunite-bearing ‘lithocaps’.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: There is wide variation in deposit types ranging from bulk-mineable, low-grade to selectively mined, high-grade deposits. Underground mines range in size from 2 to 25 Mt with grades from 178 g/t Au, 109 g/t Ag and 3.87% Cu in direct smelting ores (El Indio) to 2.8 g/t Au and 11.3 g/t Ag and 1.8% Cu (Lepanto). Open pit mines with reserves of <100 Mt to >200 Mt range from Au-Ag mines with 3.8 g/t Au and 20 g/t Ag (Pueblo Viejo, Dominica) to ore bodies such as the Nansatsu deposits, Japan that contain a few million tonnes ore grading between 3 and 6 g/t Au. Porphyry Au (Cu) deposits can be overprinted with late-stage acid sulphate alteration zones which can contain in the order of ~1.5 g/t Au with 0.05 to 0.1% Cu in stockworks (Marte and Lobo) or high-grade Cu-Ag-Au veins (La Grande veins, Collahausi). More typically these late stage alteration zones carry <0.4 to 0.9 g/t Au and >0.4 to 2% Cu (Butte, Montana; Dizon, Philippines). **In Yukon, individual deposits are smaller than 1 Mt, but groups of deposits in epithermal camps such as in the Mt. Nansen and Wheaton River areas may be economically viable.**

ECONOMIC LIMITATIONS: Oxidation of primary ores is commonly necessary for desirable metallurgy; primary ores may be refractory and can render low-grade mineralization noneconomic.

IMPORTANCE: This class of deposits has recently become a focus for exploration throughout the circum-Pacific region because of the very attractive Au and Cu grades in some deposits. Silica-rich gold ores (3-4 g/t Au) from the Nansatsu deposits in Japan are used as flux in copper smelters.

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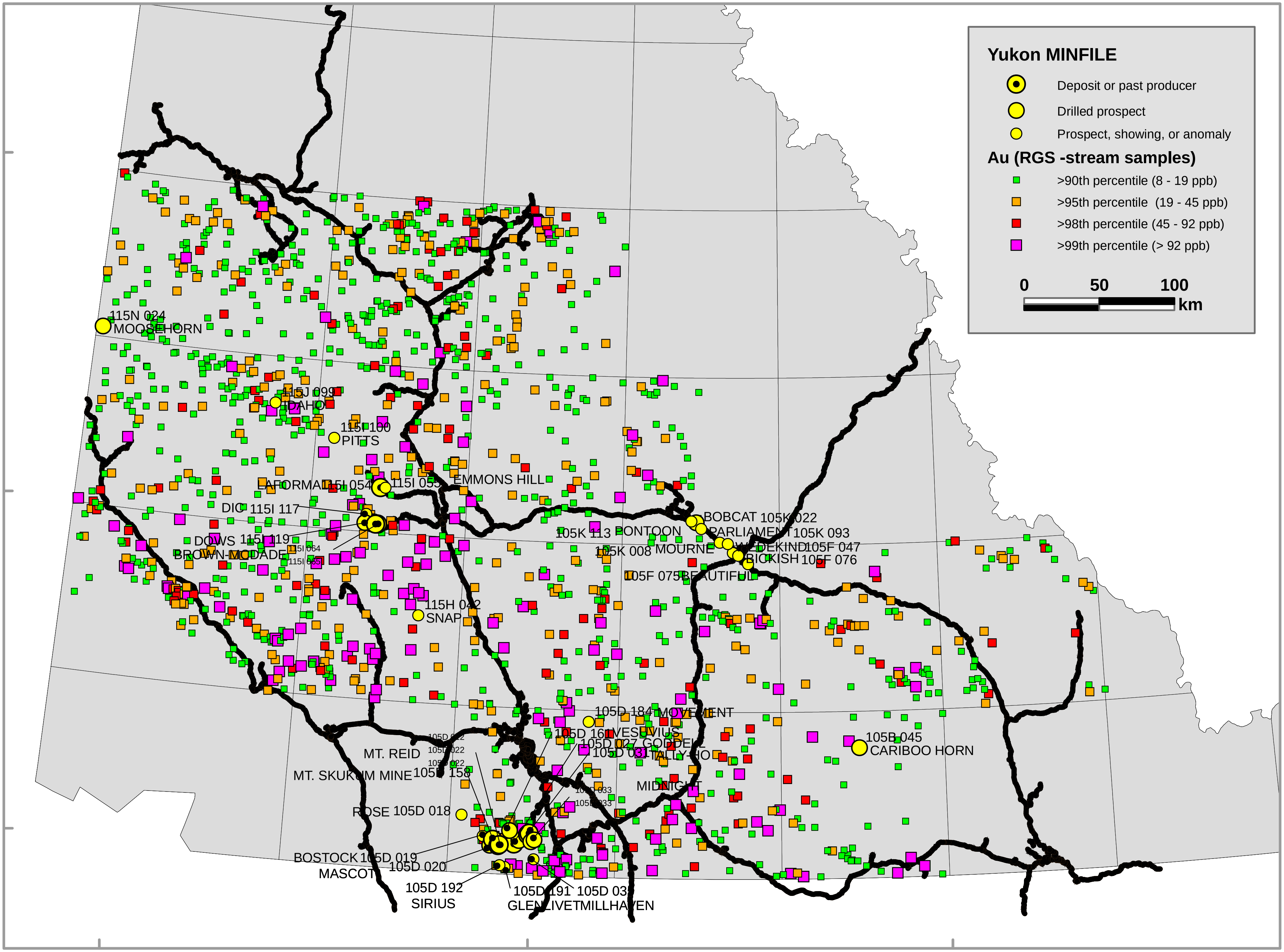
H04 - High sulphidation epithermal Au-Ag-Cu - BC and Yukon deposits

Deposit	Country	tonnes	Au (g/t)	Ag (g/t)	Cu %	Pb %	Zn %
WHEATON MOUNTAIN	CNYK	4 535	17.10	34.30	0.00	0.00	0.00
DUSTY	CNBC	93 392	6.49	112.99	0.00	0.00	0.00
MOUNT NANSEN	CNYK	109 000	5.90	268.00	0.00	0.00	0.00
BAKER	CNBC	120 449	17.87	269.67	0.00	0.00	0.00
METS	CNBC	144 000	11.30	0.00	0.00	0.00	0.00
MT. SKUKUM (CIRQUE)	CNYK	149 000	25.00	20.50	0.00	0.00	0.00
VAULT	CNBC	152 000	14.00	0.00	0.00	0.00	0.00
LAFORMA	CNYK	152 261	5.62	0.00	0.00	0.00	0.00
GOLD WED	CNBC	329 000	24.90	201.20	0.00	0.00	0.00
BLACKDOM	CNBC	368 343	21.48	78.86	0.00	0.00	0.00
GOLDEN	CNBC	500 000	2.70	0.00	0.00	0.00	0.00
LAWYERS	CNBC	528 337	8.42	168.29	0.00	0.00	0.00
NEW MOON	CNBC	609 900	0.99	15.43	0.00	0.00	0.00
BROWN MC-DADE	CNYK	617 000	6.02	53.40	0.00	0.00	0.00
MT SKUKUM (BRANDY & LAKE)	CNYK	915 100	16.50	0.00	0.00	0.00	0.00
SHASTA	CNBC	1 071 033	4.09	217.50	0.00	0.00	0.00
SULPHUR	CNBC	1 437 000	11.50	783.60	0.00	0.00	0.00
SILBAK	CNBC	7 065 528	9.03	188.92	0.03	0.40	0.14
CINOLA	CNBC	23 800 000	2.47	3.10	0.00	0.00	0.00

Yukon MINFILE

MINFILE	NAMES	STATUS
105D 030	TALLY-HO	UNDERGROUND PAST PRODUCER
115I 064	BROWN-MCDADE	OPEN PIT PAST PRODUCER
115N 024	LONGLINE, MOOSEHORN	OPEN PIT PAST PRODUCER
105D 022	MT. REID, SKUKUM CREEK, COMBINATION	DEPOSIT
105D 025	GODDELL	DEPOSIT
105D 031	WHEATON MOUNTAIN	DEPOSIT
105K 009	GREW CREEK, MAIN ZONE	DEPOSIT
115I 054	LAFORMA	DEPOSIT
115I 065	MOUNT NANSEN, WEBBER, HUESTIS	DEPOSIT
105B 045	SHOOTAMOOK	DRILLED PROSPECT
105D 168	DICKSON HILL, ODD	DRILLED PROSPECT
105F 075	BEAUTIFUL	DRILLED PROSPECT
105K 022	BOBCAT	DRILLED PROSPECT
105K 113	PONTOON	DRILLED PROSPECT
115I 055	EMMONS HILL	DRILLED PROSPECT
115I 119	DOWS	DRILLED PROSPECT
105D 192	SIRIUS	PROSPECT
105K 008	MOURNE	PROSPECT
105D 191	GLENLIVET	SHOWING
115H 042	SNAP	SHOWING
115I 100	PITTS	SHOWING
105K 093	PARLIAMENT, 400 ZONE	ANOMALY
105F 076	BICKISH	UNKNOWN
105K 015	EYE, CANYON, RAN	UNKNOWN
105K 107	WEDEKIND, ERN	UNKNOWN



Map of Yukon showing high sulphidation epithermal occurrences and Au regional geochemistry

EPITHERMAL Au-Ag: LOW SULPHIDATION H05

by Andre Panteleyev[1]
modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: (Epithermal) adularia-sericite; quartz-adularia, Comstock, Sado-type; bonanza Au-Ag; alkali chloride (hydrothermal).

COMMODITIES (*BYPRODUCTS*): Au, Ag (*Pb, Zn, Cu*).

EXAMPLES **(Yukon): Grew Creek (105K 009), Mt. Skukum Mine (105D 158);**
(British Columbia - *International*): Toodoggone district deposits - Lawyers (94E066), Baker (94E026), Shas (94E050); Blackdome (92O050-053); Premier Gold (Silbak Premier), (104B054); Cinola (103F034); *Comstock, Aurora (Nevada, USA), Bodie (California, USA), Creede (Colorado, USA), Republic (Washington, USA), El Bronce (Chile), Guanajuato (Mexico), Sado, Hishikari (Japan), Colqui (Peru), Baguio (Philippines) Ladolam (Lihir, Papua-New Guinea).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Quartz veins, stockworks and breccias carrying gold, silver, electrum, argentite and pyrite with lesser and variable amounts of sphalerite, chalcopyrite, galena, rare tetrahedrite and sulphosalt minerals form in high-level (epizonal) to near-surface environments. The ore commonly exhibits open-space filling textures and is associated with volcanic-related hydrothermal to geothermal systems.

TECTONIC SETTING: Volcanic island and continent-margin magmatic arcs and continental volcanic fields with extensional structures. **In Yukon, the Grew Creek deposit is associated with magmatism emplaced along the crustal-scale Tintina strike-slip fault.**

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: High-level hydrothermal systems from depths of ~1 km to surficial hotspring settings. Regional-scale fracture systems related to grabens, (resurgent) calderas, flow-dome complexes and rarely, maar diatremes. Extensional structures in volcanic fields (normal faults, fault splays, ladder veins and cymoid loops, etc.) are common; locally graben or caldera-fill clastic rocks are present. High-level (subvolcanic) stocks and/or dykes and pebble breccia diatremes occur in some areas. Locally resurgent or domal structures are related to underlying intrusive bodies.

AGE OF MINERALIZATION: Any age. Tertiary deposits are most abundant; in B.C. Jurassic deposits are important. Deposits of Paleozoic age are described in Australia. Closely related to the host volcanic rocks but invariably slightly younger in age (0.5 to 1 Ma, more or less). **The Grew Creek and Mt. Skukum deposits in Yukon have Tertiary ages.**

HOST/ASSOCIATED ROCK TYPES: Most types of volcanic rocks; calcalkaline andesitic compositions predominate. Some deposits occur in areas with bimodal volcanism and extensive subaerial ashflow deposits. A less common association is with alkalic intrusive rocks and shoshonitic volcanics. Clastic and epiclastic sediments in intra-volcanic basins and structural depressions.

[1] British Columbia Geological Survey, Victoria, B.C., Canada

Bimodal volcanic rocks of the early Tertiary Ross Suite host the Grew Creek deposit and andesitic flow rocks are associated with the Mt. Skukum deposit.

DEPOSIT FORM: Ore zones are typically localized in structures, but may occur in permeable lithologies. Upward-flaring ore zones centred on structurally controlled hydrothermal conduits are typical. Large (> 1 m wide and hundreds of metres in strike length) to small veins and stockworks are common with lesser disseminations and replacements. Vein systems can be laterally extensive but ore shoots have relatively restricted vertical extent. High-grade ores are commonly found in dilational zones in faults at flexures, splays and in cymoid loops.

TEXTURE/STRUCTURE: Open-space filling, symmetrical and other layering, crustification, comb structure, colloform banding and multiple brecciation.

ORE MINERALOGY (Principal and *subordinate*): Pyrite, electrum, gold, silver, argentite; *chalcopyrite, sphalerite, galena, tetrahedrite, silver sulphosalt and/or selenide minerals.* Deposits can be strongly zoned along strike and vertically. Deposits are commonly zoned vertically over 250 to 350 m from a base-metal-poor, Au-Ag-rich top to a relatively Ag-rich base metal zone and an underlying base-metal-rich zone grading at depth into a sparse base metal, pyritic zone. From surface to depth, metal zones contain: Au-Ag-As-Sb-Hg, Au-Ag-Pb-Zn-Cu, Ag-Pb-Zn. In alkalic host rocks tellurides, V-mica (roscoelite) and fluorite may be abundant, with lesser *molybdenite*.

GANGUE MINERALOGY (Principal and *subordinate*): Quartz, amethyst, chalcedony, quartz pseudomorphs after calcite, calcite; *adularia, sericite, barite, fluorite, Ca-Mg-Mn-Fe carbonate minerals such as rhodochrosite, hematite and chlorite.*

ALTERATION MINERALOGY: Silicification is extensive in ores as multiple generations of quartz and chalcedony are commonly accompanied by adularia and calcite. Pervasive silicification in vein envelopes is flanked by sericite-illite-kaolinite assemblages. Intermediate argillic alteration [kaolinite-illite-montmorillonite (smectite)] formed adjacent to some veins; advanced argillic alteration (kaolinite-alunite) may form along the tops of mineralized zones. Propylitic alteration dominates at depth and peripherally.

WEATHERING: Weathered outcrops are commonly characterized by resistant quartz ± alunite 'ledges' and extensive flanking bleached, clay-altered zones with supergene alunite, jarosite and other limonite minerals.

ORE CONTROLS: In some districts the epithermal mineralization is tied to a specific metallogenetic event, either structural, magmatic, or both. The veins are emplaced within a restricted stratigraphic interval generally within 1 km of the paleosurface. Mineralization near surface takes place in hotspring systems, or the deeper underlying hydrothermal conduits. At greater depth it can be postulated to occur above, or peripheral to, porphyry and possibly skarn mineralization. Normal faults, margins of grabens, coarse clastic caldera moat-fill units, radial and ring dyke fracture sets and both hydrothermal and tectonic breccias are all ore fluid channeling structures. Through-going, branching, bifurcating, anastamosing and intersecting fracture systems are commonly mineralized. Ore shoots form where dilational openings and cymoid loops develop, typically where the strike or dip of veins change. Hanging-wall fractures in mineralized structures are particularly favourable for high-grade ore.

GENETIC MODEL: These deposits form in both subaerial, predominantly felsic, volcanic fields in extensional and strike-slip structural regimes and island arc or continental andesitic stratovolcanoes above active subduction zones. Near-surface hydrothermal systems, ranging from hotspring at surface to deeper, structurally and permeability focused fluid flow zones are the sites of mineralization. The ore fluids are relatively dilute and cool solutions that are mixtures of magmatic and meteoric fluids. Mineral deposition takes place as the solutions undergo cooling and degassing by fluid mixing, boiling and decompression.

ASSOCIATED DEPOSIT TYPES: Epithermal Au-Ag: high sulphidation (H04); hotspring Au-Ag (H03); porphyry Cu±Mo±Au (L04) and related polymetallic veins (I05); placer gold (C01, C02).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Elevated values in rocks of Au, Ag, Zn, Pb, Cu and As, Sb, Ba, F, Mn; locally Te, Se and Hg.

GEOPHYSICAL SIGNATURE: VLF has been used to trace structures; radiometric surveys may outline strong potassic alteration of wall rocks. Detailed gravity surveys may delineate boundaries of structural blocks with large density contrasts.

OTHER EXPLORATION GUIDES: Silver deposits generally have higher base metal contents than Au and Au-Ag deposits. Drilling feeder zones to hotsprings and siliceous sinters may lead to identification of buried deposits. Prospecting for mineralized siliceous and silica-carbonate float or vein material with diagnostic open-space textures is effective.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: The following data describe the median deposits based on worldwide mines and U.S.A. models:

- Au-Ag deposits (41 Comstock-type 'bonanza' deposits) - 0.77 Mt with 7.5 g/t Au, 110 g/t Ag and minor Cu, Zn and Pb. The highest base metal contents in the top decile of deposits all contain <0.1% Cu, Zn and 0.1% Pb
- Au-Cu deposits (20 Sado-type deposits) - 0.3 Mt with 1.3% g/t Au, 38 g/t Ag and >0.3% Cu; 10 % of the deposits contain, on average, about 0.75% Cu with one having >3.2% Cu.

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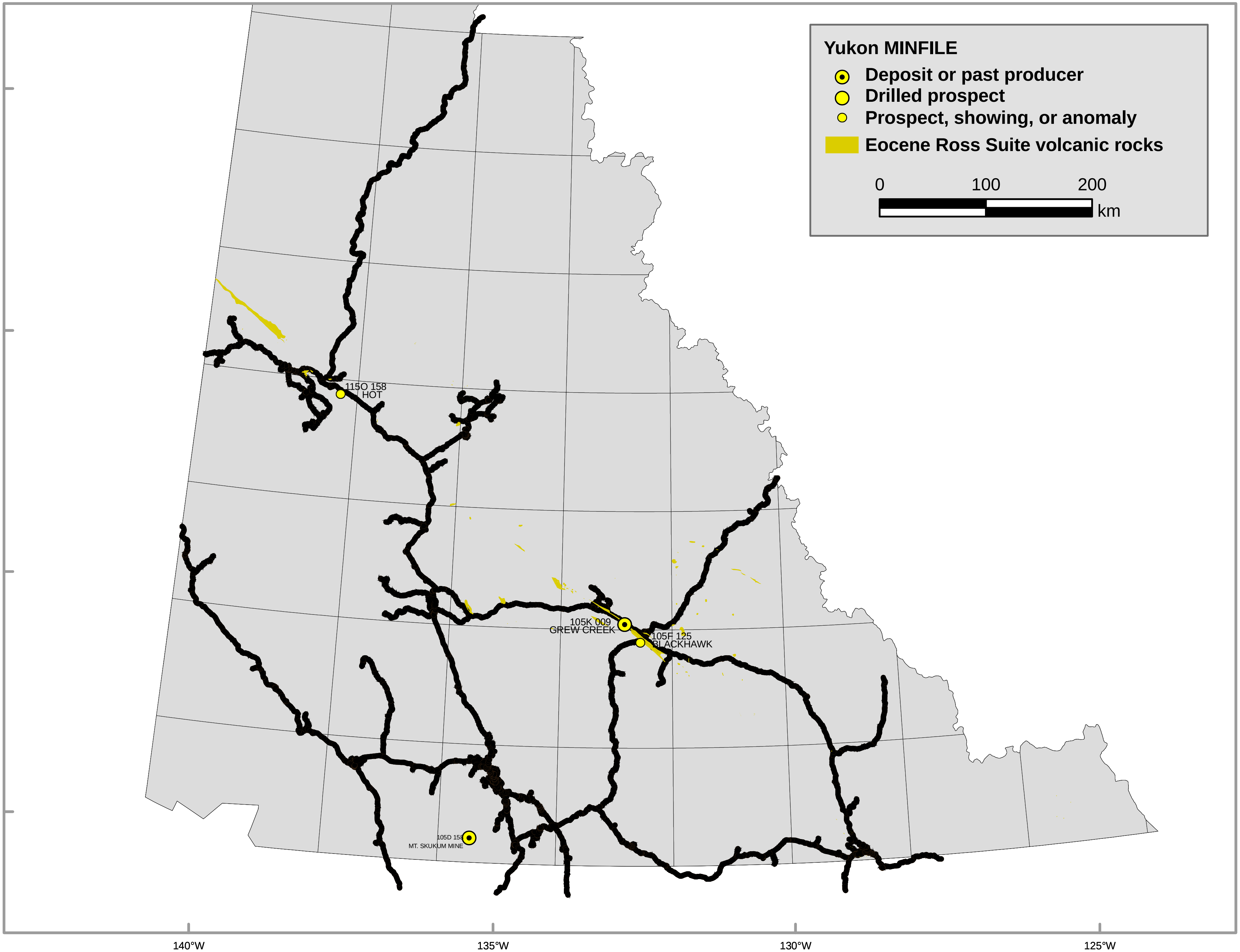
H05 - Epitheraml Au-Ag: Low Sulphidation
BC and Yukon deposits

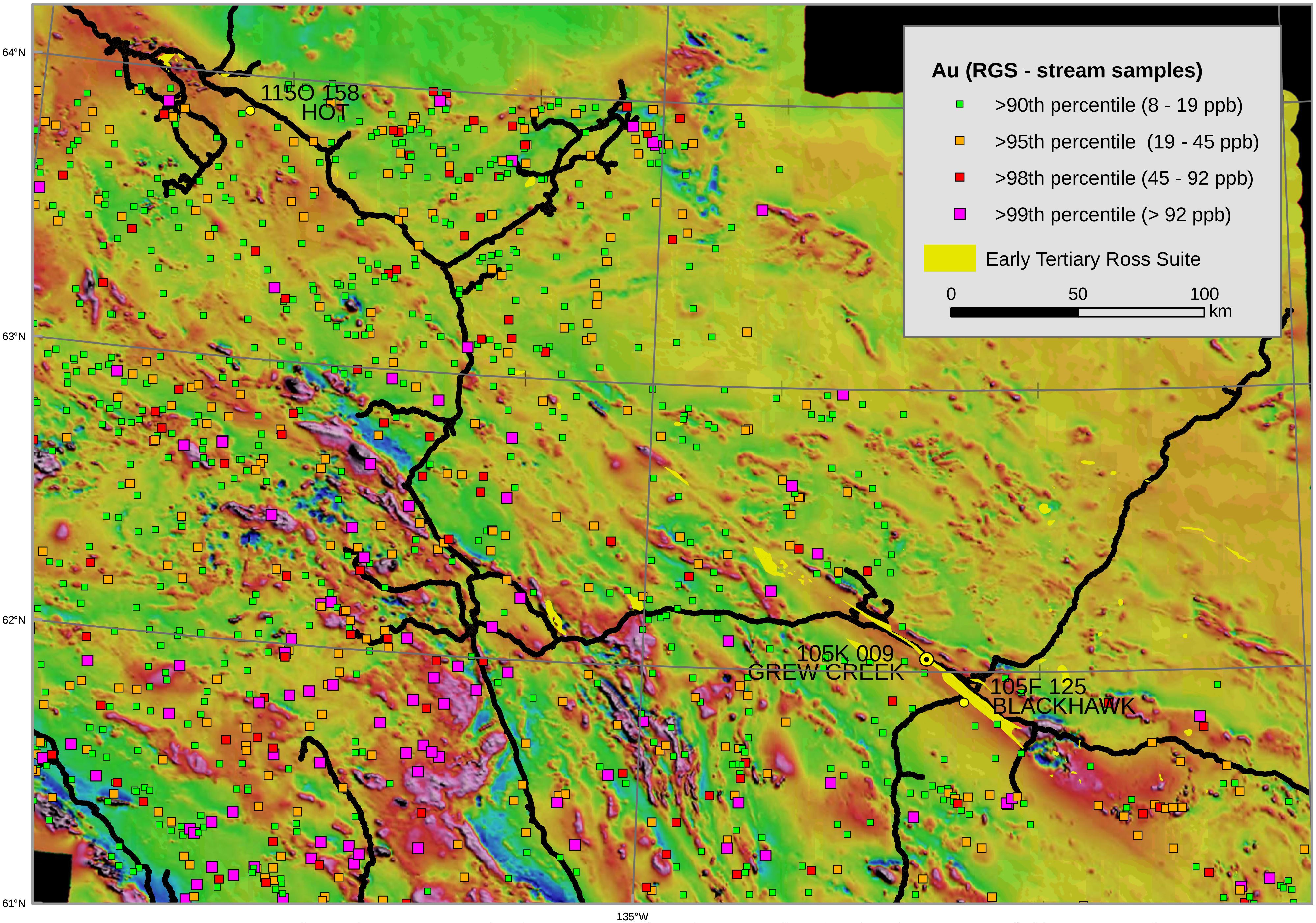
Deposit	country	tonnes	Au (g/t)	Ag (g/t)
DUSTY	CNBC	93 392	6.49	112.99
BAKER	CNBC	120 449	17.87	269.67
METSR	CNBC	144 000	11.30	0.00
VAULT	CNBC	152 000	14.00	0.00
GOLD WEDGE	CNBC	329 000	24.90	201.20
BLACKDOME	CNBC	368 343	21.48	78.86
GOLDEN	CNBC	500 000	2.70	0.00
LAWYER	CNBC	528 337	8.42	168.29
NEW MOON	CNBC	609 900	0.99	15.43
GREW CREEK	CNYK	773 012	8.90	33.60
SHASTA	CNBC	1 071 033	4.09	217.50
SULPHUR	CNBC	1 437 000	11.50	783.60
SILBAK	CNBC	7 065 528	9.03	188.92
CINOLA	CNBC	23 800 000	2.47	3.10

Yukon MINFILE

MINFILE NO	NAMES	STATUS
105F 125	BLACKHAWK	PROSPECT
105G 150	SPICE	ANOMALY
105J 038	FLOOD	ANOMALY
105K 091	EL PINO, LYON	ANOMALY
105F 051	JOE	UNKNOWN
105K 014	TILLMAN, DOE, DOLL, JESS	UNKNOWN



Map of Yukon showing low sulphidation epithermal Au occurrences and Eocene Ross Suite volcanic rocks



Map of part of eastern Yukon showing Au geochemistry, the Ross Suite volcanic rocks and regional airborne magnetics

Au-QUARTZ VEINS I01

by Chris Ash[1] and Dani Alldrick[1]

Modified for Yukon by A. Fonseca

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYMS: Mother Lode veins, greenstone gold, Archean lode gold, mesothermal gold-quartz veins, shear-hosted lode gold, low-sulphide gold-quartz veins, lode gold.

COMMODITIES (*BYPRODUCTS*): Au (Ag, Cu, Sb).

EXAMPLES: **(Yukon): Caribou Creek (115I 049), Venus (105D 005), Big Thing (105D 009), Tally-Ho (105D 030), Mt. Reid/Skukum Creek (105D 022), Violet (115O 073), Virgin (116B 007), Silvercity (116B 037);**
(British Columbia (MINFILE #) - *Canada/ International*):

- <u>Phanerozoic:</u> Bralorne-Pioneer (092JNE001), Erickson (104P029), Taurus (104P012), Polaris-Taku (104K003), Mosquito Creek (093H010), Cariboo Gold Quartz (093H019), Midnight (082FSW119); *Carson Hill, Jackson-Plymouth, Mother Lode district; Empire Star and Idaho-Maryland, Grass Valley district (California, USA); Alaska-Juneau, Jualin, Kensington (Alaska, USA), Ural Mountains (Russia).*
- <u>Archean:</u> *Hollinger, Dome, McIntyre and Pamour, Timmins camp; Lake Shore, Kirkland Lake camp; Campbell, Madsen, Red Lake camp; Kerr-Addison, Larder Lake camp (Ontario, Canada), Lamaque and Sigma, Val d'Or camp (Quebec, Canada); Granny Smith, Kalgoorlie and Golden Mile (Western Australia); Kolar (Karnataka, India), Blanket-Vubachikwe (Zimbabwe, Africa).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Gold-bearing quartz veins and veinlets with minor sulphide minerals crosscut a wide variety of hostrocks and are localized along major regional faults and related splays. The wallrock is typically altered to silica, pyrite and muscovite within a broader carbonate alteration halo.

TECTONIC SETTINGS:

- <u>Phanerozoic:</u> Contained in moderate to gently dipping fault/suture zones related to continental margin collisional tectonism. Suture zones are major crustal breaks which are characterized by dismembered ophiolitic remnants between diverse assemblages of island arcs, subduction complexes and continental-margin clastic wedges.
- <u>Archean:</u> Major transcrustal structural breaks within stable cratonic terranes. May represent remnant terrane collisional boundaries.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Veins form within fault and joint systems produced by regional compression or transpression (terrane collision), including major listric reverse faults, second and third-order splays. Gold is deposited at crustal levels within and near the brittle-ductile transition zone at depths of 6-12 km, pressures between 1 to 3 kilobars and

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[1] British Columbia Geological Survey, Victoria, B.C., Canada

temperatures from 200^o to 400 ^{o}C. Deposits may have a vertical extent of up to 2 km, and lack pronounced zoning.

AGE OF MINERALIZATION: Mineralization is post-peak metamorphism (*i.e.*, late syncollisional) with gold-quartz veins particularly abundant in the Late Archean and Mesozoic.

- Phanerozoic: In the North America Cordillera gold veins are post-Middle Jurassic and appear to form immediately after accretion of oceanic terranes to the continental margin. In British Columbia deposits are mainly Middle Jurassic (~ 165-170 Ma) and Late Cretaceous (~ 95 Ma). In the Mother Lode belt they are Middle Jurassic (~ 150 Ma) and those along the Juneau belt in Alaska are of Early Tertiary (~56-55 Ma).
- Archean: Ages of mineralization for Archean deposits are well constrained for both the Superior Province, Canadian Shield (~ 2.68 to 2.67 Ga) and the Yilgarn Province, Western Australia (~ 2.64 to 2.63 Ga).

HOST/ASSOCIATED ROCK TYPES: Lithologically highly varied, usually of greenschist metamorphic grade, ranging from virtually undeformed to totally schistose.

- Phanerozoic: Mafic volcanics, serpentinite, peridotite, dunite, gabbro, diorite, trondhjemite/plagiogranites, graywacke, argillite, chert, shale, limestone and quartzite, felsic and intermediate intrusions.
- Archean: Granite-greenstone belts - mafic, ultramafic (komaitiitic) and felsic volcanics, intermediate and felsic intrusive rocks, graywacke and shale.

DEPOSIT FORM: Tabular fissure veins in more competent host lithologies, veinlets and stringers forming stockworks in less competent lithologies. Typically occur as a system of en echelon veins on all scales. Lower grade bulk-tonnage styles of mineralization may develop in areas marginal to veins with gold associated with disseminated sulphides. May also be related to broad areas of fracturing with gold and sulphide minerals associated with quartz veinlet networks.

TEXTURE/STRUCTURE: Veins usually have sharp contacts with wallrocks and exhibit a variety of textures, including massive, ribboned or banded and stockworks with anastamosing gashes and dilations. Textures may be modified or destroyed by subsequent deformation.

ORE MINERALOGY: [Principal and *subordinate*]: Native gold, pyrite, arsenopyrite, *galena, sphalerite, chalcopyrite, pyrrhotite, tellurides, scheelite, bismuth, cosalite, tetrahedrite, stibnite, molybdenite, gersdorffite (NiAsS), bismuthimite* (Bi_2S_2), *tetradymite* (Bi_2Te_2S).

GANGUE MINERALOGY: [Principal and *subordinate*]: Quartz, carbonates (ferroan-dolomite, ankerite ferroan-magnesite, calcite, siderite), *albite, mariposite (fuchsite), sericite, muscovite, chlorite, tourmaline, graphite.*

ALTERATION MINERALOGY: Silicification, pyritization and potassium metasomatism generally occur adjacent to veins (usually within a metre) within broader zones of carbonate alteration, with or without ferroan dolomite veinlets, extending up to tens of metres from the veins. Type of carbonate alteration reflects the ferromagnesian content of the primary host lithology; ultramafics rocks - talc, Fe-magnesite; mafic volcanic rocks - ankerite, chlorite; sediments - graphite and pyrite; felsic to intermediate intrusions - sericite, albite, calcite, siderite, pyrite. Quartz-carbonate altered rock (listwanite) and pyrite are often the most prominent alteration minerals in the wallrock. Fuchsite, sericite, tourmaline and scheelite are common where veins are associated with felsic to intermediate intrusions.

WEATHERING: Distinctive orange-brown limonite due to the oxidation of Fe-Mg carbonates cut by white veins and veinlets of quartz and ferroan dolomite. Distinctive green Cr-mica may also be present. Abundant quartz float in overburden.

ORE CONTROLS: Gold-quartz veins are found within zones of intense and pervasive carbonate alteration along second order or later faults marginal to transcrustal breaks. They are commonly closely associated with, late syncollisional, structurally controlled intermediate to felsic magmatism. Gold veins are more commonly economic where hosted by relatively large, competent units, such as intrusions or blocks of obducted oceanic crust. Veins are usually at a high angle to the primary collisional fault zone.

- Phanerozoic: Secondary structures at a high angle to relatively flat-lying to moderately dipping collisional suture zones.

- Archean: Steep, transcrustal breaks; best deposits overall are in areas of greenstone.

ASSOCIATED DEPOSIT TYPES: Gold placers (C01, C02), sulphide manto Au (J04), silica veins (I07); iron formation Au (I04) in the Archean.

GENETIC MODEL: Gold quartz veins form in lithologically heterogeneous, deep transcrustal fault zones that develop in response to terrane collision. These faults act as conduits for CO_2-H_2O-rich (5-30 mol% CO_2), low salinity (<3 wt% NaCl) aqueous fluids, with high Au, Ag, As, (± Sb, Te, W, Mo) and low Cu, Pb, Zn metal contents. These fluids are believed to be tectonically or seismically driven by a cycle of pressure build-up that is released by failure and pressure reduction followed by sealing and repetition of the process (Sibson *et al.*, 1988). Gold is deposited at crustal levels within and near the brittle-ductile transition zone with deposition caused by sulphidation (the loss of H_2S due to pyrite deposition) primarily as a result of fluid-wallrock reactions, other significant factors may involve phase separation and fluid pressure reduction. The origin of the mineralizing fluids remains controversial, with metamorphic, magmatic and mantle sources being suggested as possible candidates. Within an environment of tectonic crustal thickening in response to terrane collision, metamorphic devolitization or partial melting (anatexis) of either the lower crust or subducted slab may generate such fluids.

COMMENTS: These deposits may be a difficult deposit to evaluate due to "nugget effect", hence the adage, “Drill for structure, drift for grade”. These veins have also been mined in British Columbia as a source of silica for smelter flux.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Elevated values of Au, Ag, As, Sb, K, Li, Bi, W, Te and B ± (Cd, Cu, Pb, Zn and Hg) in rock and soil, Au in stream sediments.

GEOPHYSICAL SIGNATURE: Faults indicated by linear magnetic anomalies. Areas of alteration indicated by negative magnetic anomalies due to destruction of magnetite as a result of carbonate alteration.

OTHER EXPLORATION GUIDES: Placer gold or elevated gold in stream sediment samples is an excellent regional and property-scale guide to gold-quartz veins. Investigate broad 'deformation envelopes' adjacent to regional listric faults where associated with carbonate alteration. Alteration and structural analysis can be used to delineate prospective ground. Within carbonate alteration zones, gold is typically only in areas containing quartz, with or without sulphide minerals. Serpentinite bodies, if present, can be used to delineate favourable regional structures. Largest concentrations of free gold are commonly at, or near, the intersection of quartz veins with serpentinized and carbonate-altered ultramafic rocks.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Individual deposits average 30 000 t with grades of 16 g/t Au and 2.5 g/t Ag (Berger, 1986) and may be as large as 40 Mt. Many major producers in the Canadian Shield range from 1 to 6 Mt at grades of 7 g/t Au (Thorpe and Franklin, 1984). The largest gold-quartz vein deposit in British Columbia is the Bralorne-Pioneer which produced in excess of 117 800 kilograms of Au from ore with an average grade of 9.3 g/t.

ECONOMIC LIMITATIONS: These veins are usually less than 2 m wide and therefore, only amenable to underground mining.

IMPORTANCE: These deposits are a major source of the world’s gold production and account for approximately a quarter of Canada’s output. They are the most prolific gold source after the ores of the Witwatersrand basin.

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I01 - Au-quartz veins - BC deposits

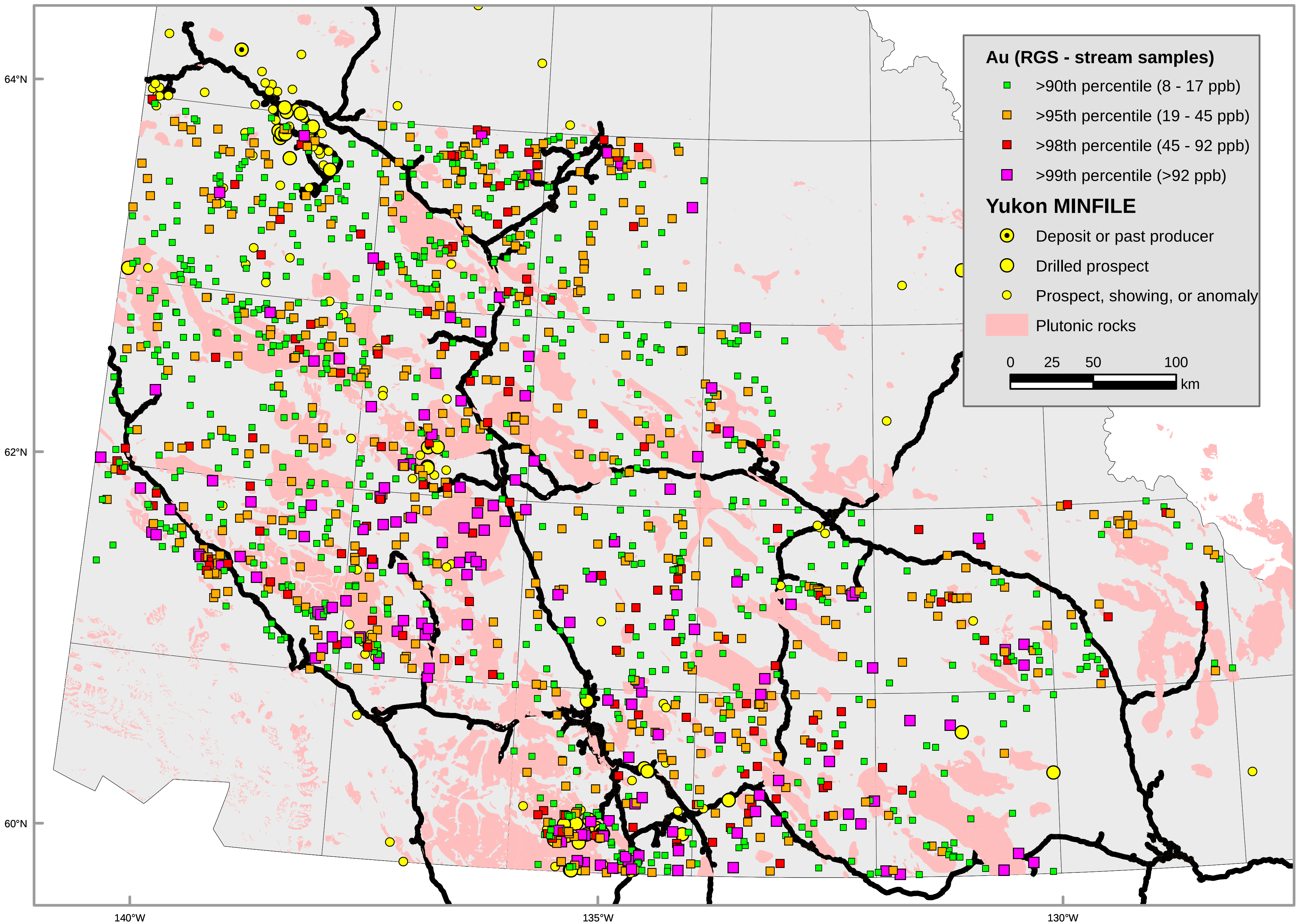
Au-quartz vein deposits (BC)

Deposit	country	tonnage	Au (g/t)	Ag (g/t)	Cu %	Pb %	Zn %
VALENTINE	CNBC	30 706	14.70	0.08	0.00	0.00	0.00
ATHABASCA	CNBC	59 924	13.14	4.83	0.00	0.02	0.03
CARIBOO HUDS	CNBC	66 640	13.60	15.18	0.00	0.00	0.00
MT. ZEBALLOS	CNBC	74 268	12.75	5.98	0.00	0.02	0.00
BAYON	CNBC	81 903	16.01	45.82	0.00	0.05	0.03
MERIDIAN	CNBC	88 762	6.13	1.86	0.00	0.00	0.00
B.C.	CNBC	93 874	0.33	71.00	4.36	0.00	0.00
HUNTER	CNBC	94 003	12.01	0.00	0.00	0.00	0.00
CENTRAL ZEBA	CNBC	104 381	12.05	24.63	0.01	0.01	0.14
MORNINGSTAR	CNBC	110 273	3.94	42.99	0.01	0.08	0.00
CARIBOO-AMEL	CNBC	124 451	20.39	8.11	0.00	0.04	0.07
WAYSIDE	CNBC	137 069	4.25	0.67	0.00	0.00	0.00
RELIANCE	CNBC	139 000	6.68	0.00	0.00	0.00	0.00
BANBURY	CNBC	174 360	10.18	2.27	0.01	0.00	0.00
GRANITE-POOR	CNBC	181 118	11.18	5.25	0.00	0.01	0.01
CONGRES	CNBC	193 581	9.21	1.38	0.00	0.00	0.00
ALPINES	CNBC	206 251	14.39	14.10	0.00	0.31	0.02
SNOWBIRD	CNBC	226 000	6.86	0.00	0.00	0.00	0.00
GOLD BELT	CNBC	236 502	10.63	4.49	0.00	0.00	0.00
YELLOWGIANT	CNBC	246 980	17.32	0.00	0.00	0.00	0.00
CONGRESS	CNBC	267 505	11.31	0.00	0.00	0.00	0.00
GEORGIA RIVER	CNBC	290 751	28.79	22.50	0.73	0.00	0.00
DOME MOUNTAIN	CNBC	294 372	12.53	67.36	0.00	0.00	0.00
KOOTENAY	CNBC	305 608	11.47	4.27	0.00	0.02	0.02
SPUD VALLEY	CNBC	414 754	11.95	3.02	0.00	0.00	0.00
TAURUS	CNBC	436 315	7.19	1.00	0.00	0.00	0.00
RENO NUGGET	CNBC	455 208	17.71	8.09	0.00	0.02	0.02
DEBBIE	CNBC	472 321	6.23	0.00	0.00	0.00	0.00
PRIVATE	CNBC	527 311	16.17	7.68	0.01	0.02	0.00
TAMARA	CNBC	560 046	4.50	0.00	0.00	0.00	0.00
QUEEN	CNBC	653 160	14.47	4.78	0.00	0.00	0.00
ERICKSON	CNBC	741 405	15.96	4.03	0.00	0.00	0.00
CPW	CNBC	838 004	1.95	0.00	0.00	0.00	0.00
SURF INLET	CNBC	973 427	13.28	6.97	0.33	0.00	0.00
ISLAND	CNBC	1 011 875	12.13	1.78	0.00	0.00	0.00
EDYEPASS	CNBC	1 443 182	6.99	3.65	0.01	0.00	0.00
STEMWIND	CNBC	1 549 675	3.76	40.75	0.00	0.01	0.00
CAROLIN	CNBC	1 916 425	2.78	0.11	0.00	0.00	0.00
CARIBOO GOLD	CNBC	2 057 944	13.26	1.39	0.00	0.00	0.00
POLARIS-TAKU	CNBC	3 283 357	13.68	0.11	0.00	0.00	0.00
BRALORNE	CNBC	8 260 230	16.74	3.38	0.00	0.00	0.00
FRASER GOLD	CNBC	12 000 000	1.90	0.00	0.00	0.00	0.00

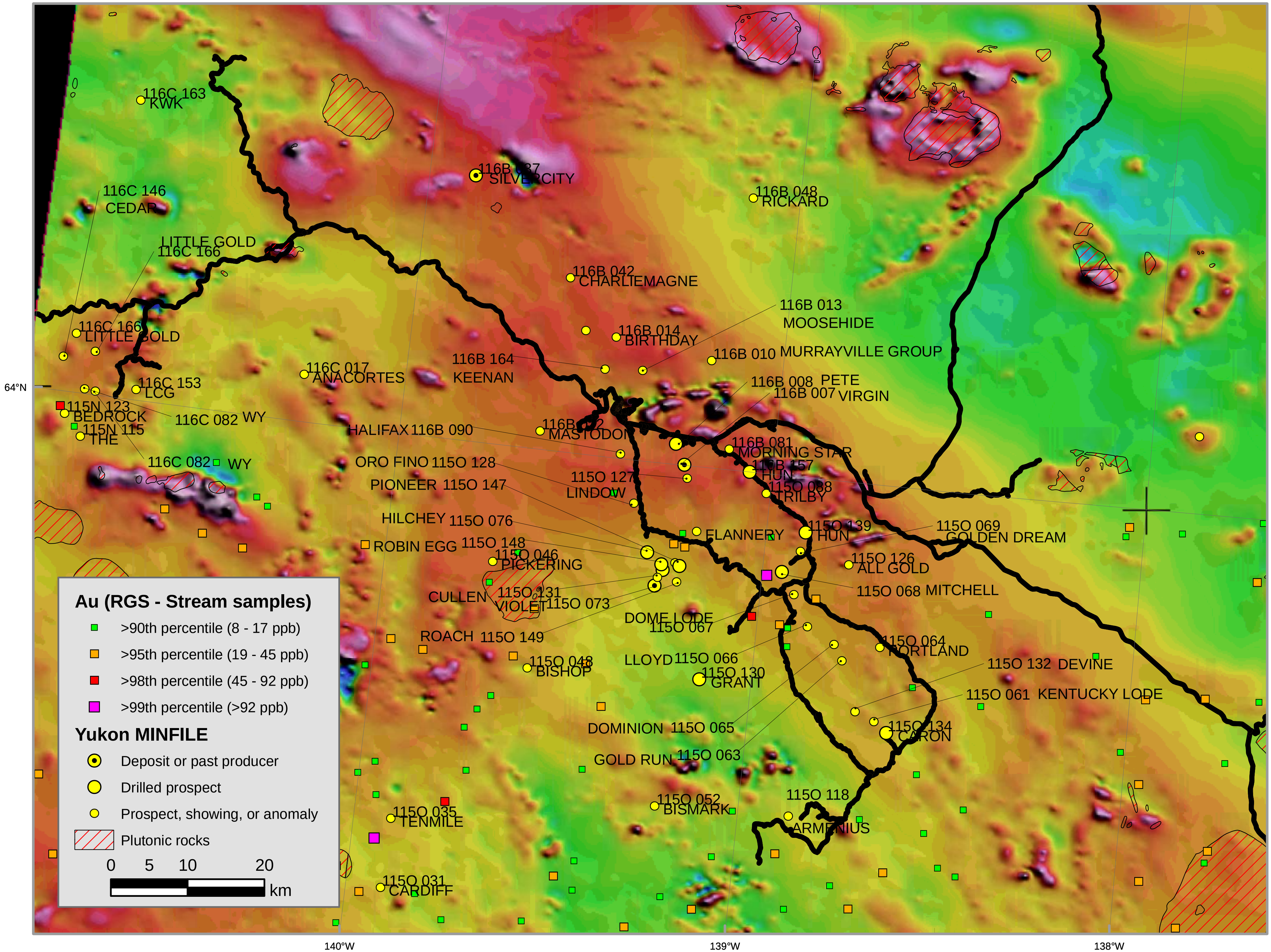
I01 - Au-quartz veins - Yukon MINFILE

MINFILE	NAMES	STATUS
105D 158	SKUKUM, MT. SKUKUM MINE	UNDERGROUND PAST PRODUCER
115O 073	VIOLET	UNDERGROUND PAST PRODUCER
116B 007	VIRGIN, GORDON, JEAN, OPHIR	UNDERGROUND PAST PRODUCER
116B 037	SILVERCITY, CARBONATE, YUKON BEAUTY	UNDERGROUND PAST PRODUCER
115I 049	CARIBOU CREEK	OPEN PIT PAST PRODUCER
105C 028	DALAYEE, TOG, JUBE	DRILLED PROSPECT
105D 006	MONTANA, JOE PETTY	DRILLED PROSPECT
105D 008	JEAN	DRILLED PROSPECT
105D 020	CHARLESTON, MASCOT	DRILLED PROSPECT
105D 029	MT. ANDERSON, TYCOON, WHIRLWIND	DRILLED PROSPECT
105D 032	BUFFALO HUMP	DRILLED PROSPECT
105D 033	MT. STEVENS, HAWK EYE, MIDNIGHT, HIDDEN ORE	DRILLED PROSPECT
105D 036	GOLD HILL, DAIL	DRILLED PROSPECT
105D 047	CUTOFF	DRILLED PROSPECT
105D 090	ADASTRAL, RUBY	DRILLED PROSPECT
105D 127	CUTLER	DRILLED PROSPECT
105D 136	CLEFT	DRILLED PROSPECT
105D 157	PENNYCOOK, JUBILEE	DRILLED PROSPECT
105D 161	VESUVIUS	DRILLED PROSPECT
105D 166	ARSCOTT, SAID	DRILLED PROSPECT
105F 121	SEAGULL CREEK, TAY-LP	DRILLED PROSPECT
105O 032	NEVE, BRICK	DRILLED PROSPECT
115H 047	SHUT, KILLER GOLD, RUBY RANGE PROJECT	DRILLED PROSPECT
115H 055	LIB, KILLER GOLD, RUBY RANGE PROJECT	DRILLED PROSPECT
115I 068	DIVIDE, VIC, DISCOVERY CREEK	DRILLED PROSPECT
115I 112	WHALE	DRILLED PROSPECT
115O 068	MITCHELL	DRILLED PROSPECT
115O 076	HILCHEY	DRILLED PROSPECT
115O 077	BUCKLAND	DRILLED PROSPECT
115O 130	GRANT	DRILLED PROSPECT
115O 134	CARON	DRILLED PROSPECT
115O 139	HUN	DRILLED PROSPECT
115O 148	ROBIN EGG	DRILLED PROSPECT
115O 150	PIONEER	DRILLED PROSPECT
116B 008	MACLEAN, GOLDEN AGE, KLEAN, PETE	DRILLED PROSPECT
116B 157	BEN LEVY, BLUEBELL, PRED, DAWSON, HUN	DRILLED PROSPECT
105D 018	ROSE	PROSPECT
105D 040	LEGAL TENDER, MINERAL HILL, LUCKY BOY	PROSPECT
105D 177	BENALL	PROSPECT
105O 051	DALL, HARLAN	PROSPECT
115A 049	DOLLIS, CHARLIE, CHUCK, JIM, JEAN, ROBIN, BURGER	PROSPECT
115G 106	BERDAHL	PROSPECT
115H 060	MOM	PROSPECT
115O 031	CARDIFF	PROSPECT
115O 046	PICKERING	PROSPECT
115O 061	PAYNE, AIME, KENTUCKY LODE	PROSPECT
115O 063	GOLD RUN	PROSPECT
115O 064	PORTLAND	PROSPECT
115O 066	LLOYD	PROSPECT
115O 067	HUNKER DOME, DOME LODE	PROSPECT
115O 069	FAWCETT, ALPHONSE, BRANDON, HILLSBOROUGH	PROSPECT
115O 118	ARMENIUS	PROSPECT
115O 132	DEVINE, KENTUCKY LODE	PROSPECT
116A 031	AUSSIE, AREA 5	PROSPECT
116B 010	LEPINE, MURRAYVILLE GROUP, WELLS GROUP, KLEP	PROSPECT
116C 163	KINK, KWK	PROSPECT
116C 166	LITTLE GOLD	PROSPECT
095D 033	CUZ, HYLAND	SHOWING
105C 055	EAGLENEST	SHOWING
105D 019	BOSTOCK	SHOWING
105D 112	COMBS	SHOWING
105D 184	MOVEMENT	SHOWING
105D 188	MIC-MAC	SHOWING
105D 189	MT. BYNG	SHOWING
105D 197	JOE CREEK	SHOWING
105D 198	NLC	SHOWING

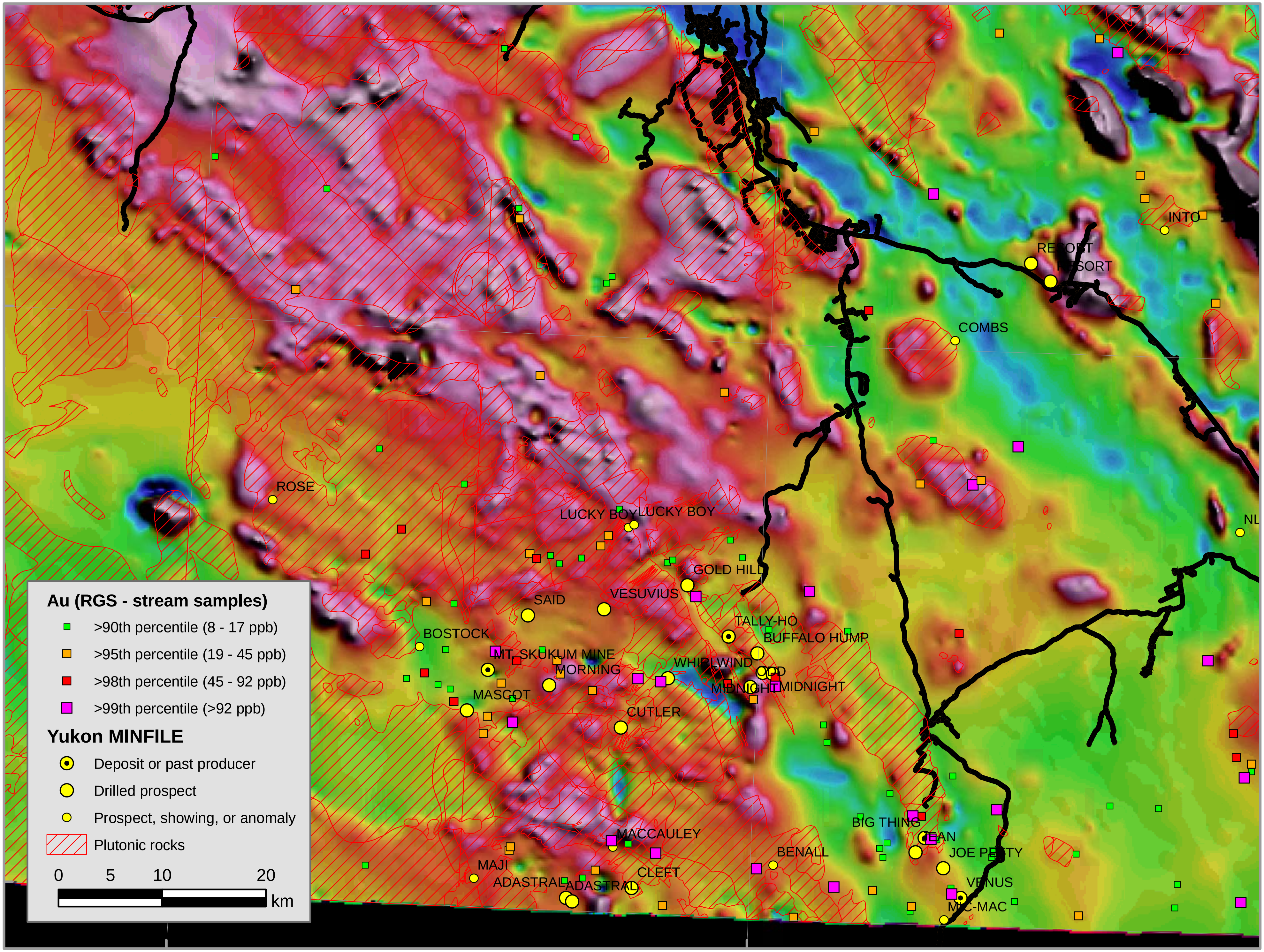
MINFILE	NAMES	STATUS
105D 203	GRUMPY	SHOWING
105E 026	MUSTARD, GEM	SHOWING
105F 032	PONY	SHOWING
105F 044	WATERFALL	SHOWING
105F 045	DANGER	SHOWING
105F 046	KINDLE	SHOWING
105F 118	QUILLO	SHOWING
105G 031	ROB	SHOWING
105H 102	FER	SHOWING
105H 103	SUGAR BOWL	SHOWING
105J 039	WENDY	SHOWING
105J 043	VG	SHOWING
105O 004	ALP	SHOWING
105O 049	FAENZI	SHOWING
106D 028	ELLIS	SHOWING
115A 036	ARCHIBALD, JS, GREEN, COLTON	SHOWING
115H 045	AL	SHOWING
115I 015	LYDEN	SHOWING
115I 046	LIL	SHOWING
115I 084	LONELY	SHOWING
115I 101	PANTHER	SHOWING
115I 106	HAPPY	SHOWING
115I 121	STODDART, SEYMOUR	SHOWING
115I 122	GRIZZLY	SHOWING
115J 098	SIZZLER	SHOWING
115J 102	NOWHERE	SHOWING
115N 123	BEDROCK	SHOWING
115O 010	TREVA	SHOWING
115O 035	TENMILE	SHOWING
115O 065	DOMINION, PATTERSON, QUEEN DOME	SHOWING
115O 126	ALL GOLD	SHOWING
115O 127	LINDOW	SHOWING
115O 128	ORO FINO	SHOWING
115O 131	CULLEN	SHOWING
115O 147	PARNELL	SHOWING
115O 149	ROACH	SHOWING
116A 028	STROKER	SHOWING
116B 072	MASTODON, BIG CONTACT, BIG JOE, JOE	SHOWING
116C 153	GLASMACHER, LCG	SHOWING
105D 137	MACCAULEY	ANOMALY
115H 049	MT. BARK	ANOMALY
115H 051	MACINTOSH, MAG, JIMBO	ANOMALY
115H 053	BOWEN, ARC	ANOMALY
115H 058	MCKINLEY	ANOMALY
115O 052	BISMARK	ANOMALY
115O 075	MARIPOSA	ANOMALY
115O 093	FLANNERY	ANOMALY
115P 049	PIRATE	ANOMALY
116C 082	YAREMICO	ANOMALY
116C 146	CEDAR, BIRCH	ANOMALY
117C 026	FIRTH	ANOMALY
115A 050	CASHIN, KID, JUNIOR	UNKNOWN
115I 028	MINNESOTA	UNKNOWN
115N 096	STADNYK	UNKNOWN
115N 115	THE	UNKNOWN
115O 005	COOPER	UNKNOWN
115O 012	NORTHERN LIGHTS	UNKNOWN
115O 048	BISHOP	UNKNOWN
115O 106	HAKONSON	UNKNOWN
116B 013	MOOSEHIDE, BROADLEDGE, DAWSON NUGGET, TELLURIUM	UNKNOWN
116B 014	RELIANCE, BIRTHDAY, MORNING STAR, JOHN MORRIS	UNKNOWN
116B 042	CHARLIEMAGNE, JOSEPHINE GROUP, MARY GROUP	UNKNOWN
116B 048	RICKARD	UNKNOWN
116B 081	HATTIE, MORNING STAR	UNKNOWN
116B 090	HALIFAX, MCDONALD, DERNIER, DUNDAS, SPEC	UNKNOWN
116B 092	HALE, STARBRIGHT, RIVERSIDE, CHALMERS, NOBLE	UNKNOWN
116B 164	KEENAN	UNKNOWN
116C 017	ANACORTES	UNKNOWN



Map of Yukon showing Au regional geochemistry, Au quartz vein MINFILE occurrences and the distribution of plutonic rocks



Map of the Klondike region, western Yukon showing Au quartz vein occurrences, Au regional geochemistry, regional magnetics and plutonic rocks



Map of the Wheaton River region, south central Yukon showing Au quartz vein occurrences, Au regional geochemistry, regional magnetics and plutonic rocks

POLYMETALLIC VEINS Ag-Pb-Zn±Au I05

by David Lefebure[1] and B.N. Church[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Clastic metasediment-hosted silver-lead-zinc veins, silver/base metal epithermal deposits.

COMMODITIES (BYPRODUCTS): Ag, Pb, Zn (Cu, Au, Mn).

EXAMPLES **(Yukon): United Keno Hill (105M 001), Porcupine Vein (105M 008), Yukeno (105M 018), Mt. Keno (105M 016), Hart (105B 021), Logjam (105B 038), Plata (105N 003), Tintina (105G 006)**;
(British Columbia - *Canada/International*):

- Metasedimentary host: Silvana (082FNW050) and Lucky Jim (082KSW023), Slocan-New Denver-Ainsworth district, St. Eugene (082GSW025), Silver Cup (082KNW027), Trout Lake camp; *Hector-Calumet and Elsa, Mayo district (Yukon, Canada); Coeur d'Alene district (Idaho, USA); Harz Mountains and Freiberg district (Germany); Príbram district (Czechoslavakia).*
- Igneous host: Wellington (082ESE072) and Highland Lass - Bell (082ESW030, 133), Beaverdell camp; Silver Queen (093L002), Duthie (093L088), Cronin (093L127), Porter-Idaho (103P089), Indian (104B031); *Sunnyside and Idorado, Silverton district and Creede (Colorado, USA), Pachuca (Mexico).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Sulphide-rich veins containing sphalerite, galena, silver and sulphosalt minerals in a carbonate and quartz gangue. These veins can be subdivided into those hosted by metasedimentary rocks and another group hosted by volcanic or intrusive rocks. The latter type of mineralization is typically contemporaneous with emplacement of a nearby intrusion.

TECTONIC SETTINGS: These veins occur in virtually all tectonic settings except oceanic, including continental margins, island arcs, continental volcanics and cratonic sequences.

DEPOSITIONAL ENVIRONMENT/GEOLOGICAL SETTING:

- Metasedimentary host: Veins are emplaced along faults and fractures in sedimentary basins dominated by clastic rocks that have been deformed, metamorphosed and intruded by igneous rocks. Veins postdate deformation and metamorphism.
- Igneous host: Veins typically occur in country rock marginal to an intrusive stock. Typically veins crosscut volcanic sequences and follow volcano-tectonic structures, such as caldera ring-faults or radial faults. In some cases the veins cut older intrusions.

AGE OF MINERALIZATION: Proterozic or younger; mainly Cretaceous to Tertiary in British Columbia. **Polymetallic veins of the Keno Hill district in Yukon are related to, but distal from, mid-Cretaceous intrusions.**

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[1] British Columbia Geological Survey, Victoria, B.C., Canada

HOST/ASSOCIATED ROCK TYPES: These veins can occur in virtually any host. Most commonly the veins are hosted by thick sequences of clastic metasedimentary rocks or by intermediate to felsic volcanic rocks. In many districts there are felsic to intermediate intrusive bodies and mafic igneous rocks are less common. Many veins are associated with dykes following the same structures. **Most deposits and prospects of the Keno Hill District, Yukon are hosted in the Mississippian Keno Hill Quartzite.**

DEPOSIT FORM: Typically steeply dipping, narrow, tabular or splayed veins. Commonly occur as sets of parallel and offset veins. Individual veins vary from centimetres up to more than 3 m wide and can be followed from a few hundred to more than 1000 m in length and depth. Veins may widen to tens of metres in stockwork zones.

TEXTURE/STRUCTURE: Compound veins with a complex paragenetic sequence are common. A wide variety of textures, including cockade texture, colloform banding and crustifications and locally druzy. Veins may grade into broad zones of stockwork or breccia. Coarse-grained sulphide minerals as patches and pods, and fine-grained disseminations are confined to veins.

ORE MINERALOGY [Principal and *subordinate*]: Galena, sphalerite, tetrahedrite-tennantite, *other sulphosalts including pyrargyrite, stephanite, bournonite and acanthite, native silver, chalcopyrite, pyrite, arsenopyrite, stibnite*. Silver minerals often occur as inclusions in galena. *Native gold and electrum in some deposits.* Rhythmic compostional banding sometimes present in sphalerite. Some veins contain more chalcopyrite and gold at depth and Au grades are normally low for the amount of sulphide minerals present**. High grade veins in the Silver King zone of United Keno Hill mine, Yukon consist of native silver, ruby silver and galena, whereas lower grade veins in Bellekeno zone consist of siderite-galena-sphalerite.**

GANGUE MINERALOGY [Principal and *subordinate*]:

- <u>Metasedimentary host:</u> Carbonates (most commonly siderite with minor dolomite, ankerite and calcite), quartz, *barite, fluorite, magnetite, bitumen*.
- <u>Igneous host:</u> Quartz, carbonate (rhodochrosite, siderite, calcite, dolomite), *sometimes specular hematite, hematite, barite, fluorite.* Carbonate species may correlate with distance from source of hydrothermal fluids with proximal calcium and magnesium-rich carbonates and distal iron and manganese-rich species.

ALTERATION MINERALOGY: Macroscopic wall rock alteration is typically limited in extent (measured in metres or less). The metasedimentary rocks typically display sericitization, silicification and pyritization. Thin veining of siderite or ankerite may be locally developed adjacent to veins. In the Coeur d'Alene camp a broader zone of bleached sedimentary rocks is common. In volcanic and intrusive hostrocks the alteration is argillic, sericitic or chloritic and may be quite extensive.

WEATHERING: Black manganese oxide stains, sometimes with whitish melanterite, are common weathering products of some veins. The supergene weathering zone associated with these veins has produced major quantities of manganese. Galena and sphalerite weather to secondary Pb and Zn carbonates and Pb sulphate. In some deposits supergene enrichment has produced native and horn silver.

ORE CONTROLS: Regional faults, fault sets and fractures are an important ore control; however, veins are typically associated with second order structures. In igneous rocks the faults may relate to volcanic centers. Significant deposits restricted to competent lithologies. Dikes are often emplaced along the same faults and in some camps are believed to be roughly contemporaneous with mineralization. Some polymetallic veins are found surrounding intrusions with porphyry deposits or prospects.

GENETIC MODELS: Historically these veins have been considered to result from differentiation of magma with the development of a volatile fluid phase that escaped along faults to form the veins. More recently researchers have preferred to invoke mixing of cooler, upper crustal hydrothermal or meteoric waters with rising fluids that could be metamorphic, groundwater heated by an intrusion or expelled directly from a differentiating magma. Any development of genetic models is complicated by the presence of other types of veins in many districts. For example, the Freiberg district has veins carrying F-Ba, Ni-As-Co-Bi-Ag and U.

COMMENTS: Ag-tetrahedrite veins, such as the Sunshine and Galena mines in Idaho, contain very little sphalerite or galena. These may belong to this class of deposits or possibly the five-element veins. The styles of alteration, mineralogy, grades and different geometries can usually be used to distinguish the polymetallic veins from stringer zones found below syngenetic massive sulphide deposits. **The Keno Hill silver district, Yukon has over 65 polymetallic veins and prospects within an area 26 km long by 6.4 km wide.**

ASSOCIATED DEPOSIT TYPES:

- Metasedimentary host: Polymetallic mantos (M01).
- Igneous host: May occur peripheral to virtually all types of porphyry mineralization (L01, L03, L04, L05, L06, L07, L08) and some skarns (K02, K03).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Elevated values of Zn, Pb, Ag, Mn, Cu, Ba and As. Veins may be within arsenic, copper, silver, mercury aureoles caused by the primary dispersion of elements into wallrocks or broader alteration zones associated with porphyry deposit or prospects.

GEOPHYSICAL SIGNATURE: May have elongate zones of low magnetic response and/or electromagnetic, self potential or induced polarization anomalies related to ore zones.

OTHER EXPLORATION GUIDES: Strong structural control on veins and common occurrence of deposits in clusters can be used to locate new veins.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE : Individual vein systems range from several hundred to several million tonnes grading from 5 to 1500 g/t Ag, 0.5 to 20% Pb and 0.5 to 8% Zn. Average grades are strongly influenced by the minimum size of deposit included in the population. For B.C. deposits larger than 20 000 t the average size is 161 000 t with grades of 304 g/t Ag, 3.47 % Pb and 2.66 % Zn. Copper and gold are reported in less than half the occurrences, with average grades of 0.09 % Cu and 4 g/t Au. **The Keno Hill district, Yukon has the largest polymetallic vein deposits in the Canadian Cordillera, with a geological resource (pre-mining) of 5,816,423 tonnes.**

ECONOMIC LIMITATIONS: These veins usually support small to medium-size underground mines. The mineralization may contain arsenic which typically reduces smelting credits.

IMPORTANCE: The most common deposit type in British Columbia with over 2000 occurrences; these veins were a significant source of Ag, Pb and Zn until the 1960s. They have declined in importance as industry focused more on syngenetic massive sulphide deposits. Larger polymetallic vein deposits are still attractive because of their high grades and relatively easy benefication. They are potential sources of cadmium and germanium. **Keno Hill was an important mining district in Yukon for more than six decades (1924 to 1989).**

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I05 - Polymetallic veins Ag-Pb-Zn-Au - BC and Yukon deposits

Deposit	country	tonnes	Au (g/t)	Ag (g/t)	Cu %	Pb %	Zn %
VIRGINIA	CNBC	20 060	1.0	2,950	0.00	4.40	2.19
HOWARD	CNBC	20 091	11.0	81	0.00	5.27	1.71
SUNRISE	CNBC	20 527	0.0	295	0.00	14.83	4.95
PORCUPINE VEIN	CNYT	24 339		1,426		8.6	2.61
RICHMOND	CNBC	36 650	0.0	681	0.00	6.34	2.08
NOBLE FI	CNBC	39 812	0.0	376	0.00	5.45	3.99
YUKENO	CNYT	40 092		554		6.96	10.67
IVANHOE	CNBC	40 293	0.0	353	0.00	5.87	0.82
TEDDY	CNBC	44 005	5.0	161	0.00	7.90	6.80
SURPRISE	CNBC	44 384	0.0	1,348	0.00	12.63	7.97
DUNWELLE	CNBC	46 689	7.0	220	0.03	1.80	2.38
EMERALD	CNBC	49 142	1.0	348	0.02	6.73	9.69
CENTER	CNBC	51 460	8.0	57	0.00	1.88	0.92
MAMIER	CNBC	55 340	33.0	141	9.00	0.00	112.00
SKYLARK	CNBC	57 913	3.0	593	0.04	0.41	0.15
ATLIN	CNBC	57 982	0.0	638	0.00	5.00	5.00
RUTH-HOP	CNBC	60 605	0.0	1,271	0.00	16.55	2.65
BOSUN	CNBC	63 222	0.0	1,098	0.00	7.76	4.98
LOGJAM	CNYT	69 854	3.0	392			
ENTERPRI	CNBC	71 304	4.0	109	0.07	1.46	0.33
CRONIN	CNBC	73 048	1.0	388	0.12	7.04	7.25
MINTO	CNBC	80 650	7.0	20	0.01	0.07	0.00
GALENA	CNBC	84 098	0.0	209	0.00	3.40	5.52
SPOKANE	CNBC	85 360	0.0	53	0.00	5.02	1.83
HIGHLAND	CNBC	89 228	0.0	118	0.00	10.50	0.43
DUTHIE	CNBC	93 862	2.0	631	0.02	4.84	4.76
HART	CNYT	97 000	0.0	1,025	0.00	0.00	0.00
WAGNER	CNBC	99 901	0.0	418	0.00	8.79	3.78
HEWITT	CNBC	108 554	0.0	550	0.00	1.59	2.49
ESTELLA	CNBC	109 518	0.0	58	0.00	4.73	8.98
SILVER	CNBC	111 400	6.0	382	0.00	0.17	0.39
TEDIER	CNBC	138 210	1.0	78	0.59	1.81	2.70
PAYNER	CNBC	140 604	0.0	837	0.00	12.36	2.34
VICTOR	CNBC	149 425	1.0	864	0.00	14.55	9.52
SPIDER	CNBC	153 465	3.0	391	0.06	8.09	8.56
MOLLY	CNBC	160 185	0.0	551	0.00	3.34	2.07
TREASURE	CNBC	160 987	0.0	858	0.00	4.83	5.01
UNION	CNBC	171 165	10.0	251	0.01	0.10	0.17
GROUSE	CNBC	181 443	0.0	20	0.53	0.00	4.50
ARLINGTON	CNBC	182 826	11.0	62	0.00	0.75	0.65
RAMBLERO	CNBC	189 564	0.0	560	0.00	5.56	1.40
CORK	CNBC	193 244	0.0	86	0.00	3.06	4.84
SILVER	CNBC	205 033	2.0	1,158	0.10	3.88	5.99
JOHNNY MT	CNBC	205 397	13.0	19	0.49	0.00	0.00
CHAPUT	CNBC	257 471	4.0	7	0.00	0.03	0.02
ZONE3T	CNBC	258 847	0.0	12	0.18	1.69	4.80
SILVER	CNBC	277 050	0.0	579	2.99	0.25	0.00
VANROI	CNBC	284 705	0.0	304	0.00	2.84	2.67
YMIROI	CNBC	327 647	10.0	44	0.00	1.46	0.25
SILVERSM	CNBC	355 047	0.0	656	0.33	9.07	3.36
WOLFER	CNBC	392 200	0.0	305	0.00	0.12	0.59
HIGHLAND	CNBC	396 927	0.0	67	0.00	5.55	1.31
HORN SILVER	CNBC	433 177	1.0	294	0.01	0.08	0.09
RUTH	CNBC	450 122	0.0	180	0.01	3.47	4.37
WHITEWATER	CNBC	471 063	0.0	231	0.00	2.96	4.91
SILVANA	CNBC	490 784	0.0	467	0.00	5.49	5.04
NORTH	CNBC	536 569	11.0	52	0.08	1.12	3.35
FIREWEED	CNBC	580 544	0.0	342	0.00	1.34	2.22
SNOWFLAKE	CNBC	660 697	0.0	91	0.00	2.26	1.15
STANDARD	CNBC	745 418	0.0	373	0.00	5.31	6.62
PORTER-I	CNBC	853 729	1.0	733	0.97	3.07	1.94
ZETA	CNYT	980 000		558			
LUCKY JIM	CNBC	1 065 798	0.0	17	0.00	0.35	7.49
GROUSE	CNBC	1 100 003	0.0	19	0.40	0.00	2.00
BEAVERDEL	CNBC	1 198 829	0.0	877	0.00	0.93	1.16
DUNDEE	CNBC	1 245 334	10.0	140	0.00	5.78	6.00
VINEEE	CNBC	1 300 000	2.0	36	0.11	3.12	0.76
ST.EUGENE	CNBC	1 475 266	0.0	124	0.00	7.66	0.98
SILVER Q	CNBC	1 907 643	3.0	304	0.02	0.04	5.87
DOLLY VARDEN	CNBC	2 161 314	0.0	435	0.00	0.38	0.02
UNITED KENO HILL	CNYT	5 816 423	1	63	1.76	2.46	4.6

I05 - Polymetallic veins Ag-Pb-Zn-Au - Yukon MINFILE

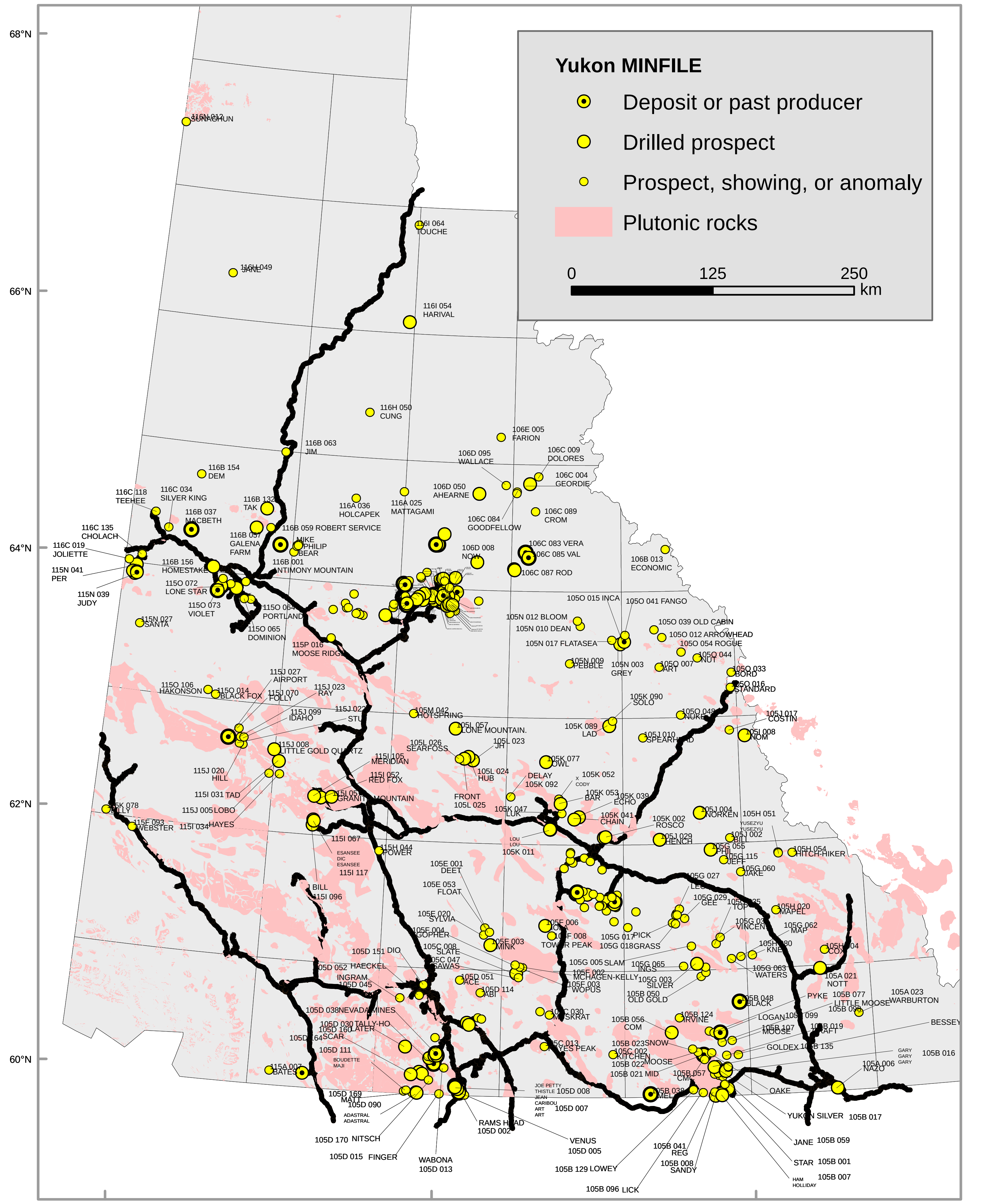
MINFILE	NAMES	STATUS
105B 007	DALE	UNDERGROUND PAST PRODUCER
105D 005	VENUS	UNDERGROUND PAST PRODUCER
105D 009	BIG THING, ARCTIC, CARIBOU, SUGARLOAF HILL	UNDERGROUND PAST PRODUCER
105D 038	UNION MINES, EXPORT, IDAHO HILL, LOST MINES	UNDERGROUND PAST PRODUCER
105F 053	KEY, KEY 3, SILVER RIDGE	UNDERGROUND PAST PRODUCER
105M 001	UNITED KENO HILL	UNDERGROUND PAST PRODUCER
105M 003	DUNCAN	UNDERGROUND PAST PRODUCER
105M 008	COMSTOCK, PORCUPINE VEIN	UNDERGROUND PAST PRODUCER
105M 010	VANGUARD	UNDERGROUND PAST PRODUCER
105M 014	MAYBRUN	UNDERGROUND PAST PRODUCER
105M 016	RUNER, MT. KENO	UNDERGROUND PAST PRODUCER
105M 018	FORMO, YUKENO	UNDERGROUND PAST PRODUCER
105M 020	PADDY	UNDERGROUND PAST PRODUCER
105M 024	CREAM AND JEAN	UNDERGROUND PAST PRODUCER
105M 032	MT HALDANE, LOOKOUT	UNDERGROUND PAST PRODUCER
105M 062	SEGSWORTH, CARIBOU HILL	UNDERGROUND PAST PRODUCER
105M 069	GAMBLER	UNDERGROUND PAST PRODUCER
106D 038	MCKAY HILL	UNDERGROUND PAST PRODUCER
115J 027	BOMBER, HELICOPTER, AIRPORT	UNDERGROUND PAST PRODUCER
105M 034	COBALT	OPEN PIT PAST PRODUCER
105N 003	PLATA	OPEN PIT PAST PRODUCER
105O 015	INCA	OPEN PIT PAST PRODUCER
115A 003	KANE, MARY, JOHNS, CHRISTMAS, SUPRISE, MOWHAK, TUF	OPEN PIT PAST PRODUCER
115N 039	LERNER, LUBRA, JUDY, GOLDEN CRAG	OPEN PIT PAST PRODUCER
115N 040	CONNAUGHT, MOSQUITE CREEK	OPEN PIT PAST PRODUCER
105B 021	HART, BASTILLE, MID, CMC, BRX	DEPOSIT
105B 038	LOGJAM, KP, MEL, MAC	DEPOSIT
105B 099	LOGAN	DEPOSIT
105F 057	KETZAKEY, KEY 18B	DEPOSIT
106C 083	VERA	DEPOSIT
106D 021	PESO	DEPOSIT
105A 005	WATSON	DRILLED PROSPECT
105A 006	NAZO	DRILLED PROSPECT
105A 021	NOTT	DRILLED PROSPECT
105B 001	STAR, LORD	DRILLED PROSPECT
105B 008	HOLLIDAY, RANSON, SWITCHBACK, SHIPMENT,	DRILLED PROSPECT
105B 016	KODIAK, PUNCHO, CARIBO, MAYO, HI-BOY, DEC	DRILLED PROSPECT
105B 017	HARDTACK, KODIAK, DEE, HI, YUKON SILVER, ROXY, ORO	DRILLED PROSPECT
105B 056	ZAK, COM	DRILLED PROSPECT
105B 098	QB, LITTLE MOOSE	DRILLED PROSPECT
105B 102	FREER, HOLLIDAY, LUCKY	DRILLED PROSPECT
105B 133	SCHELLENBURG, LIZ, BESSEY	DRILLED PROSPECT
105C 008	SLATE	DRILLED PROSPECT
105D 026	PORTER, FLEMING, EMPIRE	DRILLED PROSPECT
105D 037	GOLD REEF	DRILLED PROSPECT
105D 102	ROSSBANK, RESORT	DRILLED PROSPECT
105D 121	TENNEY	DRILLED PROSPECT
105D 156	ROOTS, ART	DRILLED PROSPECT
105D 160	LATER	DRILLED PROSPECT
105D 164	SCAR	DRILLED PROSPECT
105D 202	BEE	DRILLED PROSPECT
105E 003	LOON, BEAVER, MINK	DRILLED PROSPECT
105F 006	IOLA	DRILLED PROSPECT
105F 022	GRAYLING, CONE, RAM	DRILLED PROSPECT
105F 054	LAPRAIRIE, LAP 10, STRIKE 8A	DRILLED PROSPECT
105F 055	HOEY, F2 ZONE, GALENA	DRILLED PROSPECT
105F 056	STUMP, A-1 ZONE	DRILLED PROSPECT
105F 074	PINNACLE, H, PEAK	DRILLED PROSPECT
105F 120	BOBBY	DRILLED PROSPECT
105G 003	BLUEBERRY, SILVER	DRILLED PROSPECT
105G 055	PHIL	DRILLED PROSPECT
105I 008	NOM	DRILLED PROSPECT
105J 004	NORKEN	DRILLED PROSPECT
105K 002	WOP, URSULA, DAN, TIN, ROSS, ROSCO, BOB	DRILLED PROSPECT
105K 011	LYN, PELLY RIDGE, PUG, JO, TELE, LOU, BUIE, KEY	DRILLED PROSPECT
105K 039	CUB	DRILLED PROSPECT
105K 041	ABRAHAM	DRILLED PROSPECT
105K 051	ACTION, JRV	DRILLED PROSPECT
105K 053	MUR, JRV	DRILLED PROSPECT
105K 077	OWL	DRILLED PROSPECT
105K 089	LAD, ANDREW	DRILLED PROSPECT
105L 023	MUIR, JH	DRILLED PROSPECT
105L 024	HUB	DRILLED PROSPECT
105L 025	FRONT, PINE	DRILLED PROSPECT
105M 004	GOLDEN QUEEN	DRILLED PROSPECT
105M 011	HOMESTAKE	DRILLED PROSPECT
105M 017	WERNECKE, RAILROAD	DRILLED PROSPECT
105M 021	EAGLE	DRILLED PROSPECT
105M 025	NORD	DRILLED PROSPECT
105M 026	GERLITZKI	DRILLED PROSPECT
105M 027	TITAN	DRILLED PROSPECT
105M 028	SHANGHAI, NORHT LIMB	DRILLED PROSPECT
105M 046	MOON	DRILLED PROSPECT
105M 052	MT HINTON	DRILLED PROSPECT
105M 063	IRON CLAD	DRILLED PROSPECT
105M 070	HAVRENAK	DRILLED PROSPECT
105M 072	BELEY	DRILLED PROSPECT
106C 004	GEORDIE	DRILLED PROSPECT
106C 087	ROD	DRILLED PROSPECT
106D 008	NOW, WON	DRILLED PROSPECT
106D 016	RAMBLER	DRILLED PROSPECT
106D 022	BARKER	DRILLED PROSPECT
106D 039	GREY COPPER HILL	DRILLED PROSPECT
106D 050	AHEARNE	DRILLED PROSPECT
106D 081	LUCKNOW	DRILLED PROSPECT
115I 031	TAD	DRILLED PROSPECT

I05 - Polymetallic veins Ag-Pb-Zn-Au - Yukon MINFILE

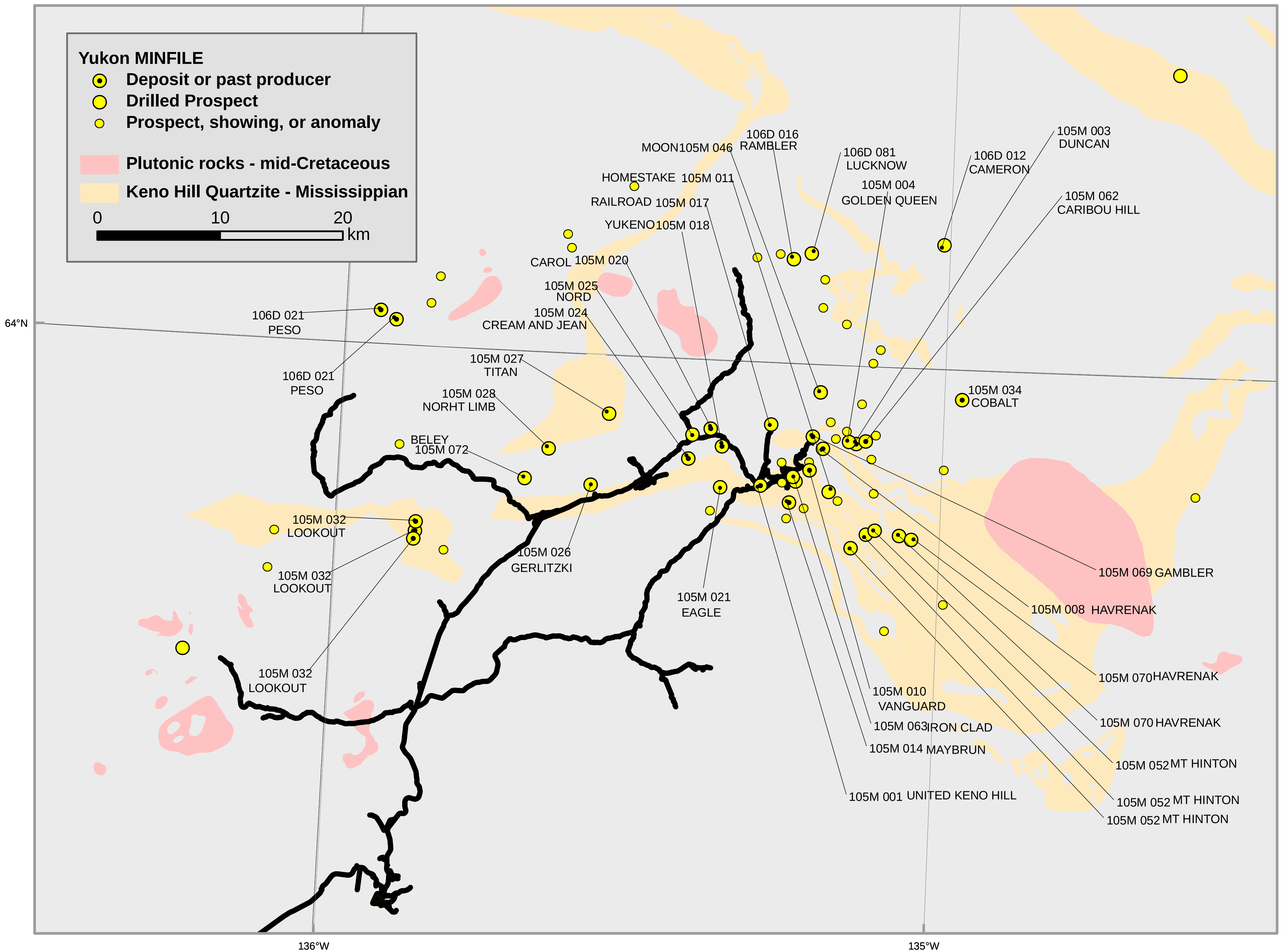
MINFILE	NAMES	STATUS
115I 034	FROG, PROSPECTOR MOUNTAIN	DRILLED PROSPECT
115I 052	RED FOX	DRILLED PROSPECT
115I 057	GRANITE MOUNTAIN	DRILLED PROSPECT
115I 067	ESANSEE, TAWA	DRILLED PROSPECT
115I 096	RUSK, J BILL	DRILLED PROSPECT
115I 105	MERIDIAN	DRILLED PROSPECT
115N 041	PER	DRILLED PROSPECT
115P 003	SCHEELITE DOME PROJECT, HAWTHORNE	DRILLED PROSPECT
116B 001	INDEX, ANTIMONY MOUNTAIN	DRILLED PROSPECT
116B 057	SPOTTED FAWN, LITTLE TWELVE MILE, GALENA FARM	DRILLED PROSPECT
116B 132	BLACKSTONE	DRILLED PROSPECT
116B 156	TYNDALL, HOMESTAKE, SUNDAY	DRILLED PROSPECT
116I 054	HARIVAL	DRILLED PROSPECT
105B 059	FAG, LUCKY STRIKE	PROSPECT
105B 124	SILVER CREEK, IRVINE, SOURCE	PROSPECT
105D 002	LULU, RAMS HEAD	PROSPECT
105D 051	ACE	PROSPECT
105D 098	DONKEY	PROSPECT
105D 114	TEXEL, ABI	PROSPECT
105D 115	WORBETTS	PROSPECT
105D 144	EVIEW	PROSPECT
105F 003	WOPUS	PROSPECT
105F 004	GOPHER	PROSPECT
105F 014	SONNY	PROSPECT
105F 016	SHARON	PROSPECT
105F 024	TYRO	PROSPECT
105F 035	AMBROSE	PROSPECT
105F 040	CANUSA	PROSPECT
105F 052	MT. MISERY	PROSPECT
105F 122	WHYTE	PROSPECT
105G 001	MONT	PROSPECT
105G 027	LEO	PROSPECT
105G 115	JEFF, ANDY	PROSPECT
105K 052	MYE, JRV	PROSPECT
105L 026	SEARFOSS	PROSPECT
105M 005	SILVER BASIN	PROSPECT
105M 012	CHRISTINE	PROSPECT
105M 031	STREBCHUK, JOUMBIRA	PROSPECT
105O 033	KELVIN, BORD	PROSPECT
105O 041	FANGO	PROSPECT
105O 054	ROGUE	PROSPECT
106C 009	DOLORES	PROSPECT
106D 017	RUSTY	PROSPECT
106D 023	MEILECKE	PROSPECT
106D 063	NAT, LUCKY BEAR	PROSPECT
115A 007	BATES, IRON CREEK	PROSPECT
115K 078	CHAIR, ICE, BILLY, RAIN	PROSPECT
115O 071	BOX CAR	PROSPECT
115P 008	EAST RIDGE, BOULDER CREEK, SNARK, TEE	PROSPECT
115P 056	MAY CREEK, ORE	PROSPECT
115P 057	QUEST	PROSPECT
116A 012	HAMILTON, LORRIE, MIKE	PROSPECT
116A 036	HOLCAPEK	PROSPECT
116C 118	FORTYMILE, ROSE, QUEEN OF NORTH, GOLDEN GATE	PROSPECT
105A 023	WARBURTON	SHOWING
105B 002	STERLING, JRS, BIMBO, LEE, SILVER, HG, RF, OLIE	SHOWING
105B 005	ANNE, RANCH, CAT, JANE	SHOWING
105B 006	LENA, BEVERLY, ED, TYIN, BOB, REG, B, BESSY, C, SPE	SHOWING
105B 012	SHILSKY, DOT, JAKE, A	SHOWING
105B 018	KERNS, EAST, ALCAN, BEAVER, OWL, BOB, CUB, MARS	SHOWING
105B 019	BRODHAGEN, BILLY, GLADYS, JOHNY, CRAFT, MEISTER	SHOWING
105B 041	POULIN, CAT, REG	SHOWING
105B 048	MOOSELICK, BLACK, RUTH	SHOWING
105B 050	OLD GOLD, LIARD	SHOWING
105B 057	ROY, BUC, BOY	SHOWING
105B 058	BINGY, CABIN CREEK	SHOWING
105B 060	DEATH, RAY	SHOWING
105B 096	LICK	SHOWING
105B 107	MOOSE, PIGSKIN	SHOWING
105B 122	ABBOTT, LENA	SHOWING
105B 129	LOWEY	SHOWING
105C 002	KITCHEN	SHOWING
105C 047	SAWAS	SHOWING
105D 007	THISTLE	SHOWING
105D 013	WABONA	SHOWING
105D 045	INGRAM	SHOWING
105D 111	BOUDETTE, NAIAD	SHOWING
105D 151	DIO, DUST	SHOWING
105D 169	MATT	SHOWING
105D 170	NITSCH	SHOWING
105D 173	MAJI	SHOWING
105E 001	LIVINGSTON, FLOAT	SHOWING
105E 020	SYLVIA	SHOWING
105E 053	DEET	SHOWING
105F 002	MOBS, MCHAGEN-KELLY	SHOWING
105F 008	TOWER PEAK	SHOWING
105F 039	MCNEE	SHOWING
105F 041	CYR	SHOWING
105F 043	LAPIE	SHOWING
105F 058	MAGUNDY	SHOWING
105F 066	CONNELL	SHOWING
105F 069	KIRWAN	SHOWING
105F 070	DROC	SHOWING
105F 083	FOX	SHOWING
105F 090	SPURT	SHOWING
105G 005	SLAM	SHOWING
105G 010	HILLER	SHOWING
105G 011	AXE	SHOWING

I05 - Polymetallic veins Ag-Pb-Zn-Au - Yukon MINFILE

MINFILE	NAMES	STATUS
105G 017	PICK	SHOWING
105G 018	GRASS	SHOWING
105G 021	ZIELINSKI	SHOWING
105G 029	GEE	SHOWING
105G 035	TOP	SHOWING
105G 039	VINCENT	SHOWING
105G 062	MAP	SHOWING
105G 063	WATERS	SHOWING
105H 020	MAPEL	SHOWING
105H 080	KNEIL	SHOWING
105J 002	BILL	SHOWING
105J 010	SPEARHEAD	SHOWING
105J 017	COSTIN	SHOWING
105K 047	WANN	SHOWING
105K 090	SOLO	SHOWING
105K 092	GALWAY, PARAGON, BEYON, DELAY	SHOWING
105L 057	LONE MOUNTAIN.	SHOWING
105L 064	JASPY	SHOWING
105M 002	FAITH	SHOWING
105M 006	NABOB, LAURASIA, RUM TUM	SHOWING
105M 007	MONUMENT	SHOWING
105M 009	APEX	SHOWING
105M 013	MO	SHOWING
105M 015	HOGAN	SHOWING
105M 042	HOTSPRING	SHOWING
105M 047	MT. ALBERT	SHOWING
105M 048	MCKIM	SHOWING
105M 050	NERO	SHOWING
105M 053	AVENUE	SHOWING
105M 055	YONO	SHOWING
105M 057	GUSTAVUS	SHOWING
105M 061	CHRISTAL, DOROTHY	SHOWING
105M 073	BEMA	SHOWING
105N 010	DEAN	SHOWING
105N 012	BLOOM	SHOWING
105O 007	ART	SHOWING
105O 012	ARROWHEAD	SHOWING
105O 016	STANDARD	SHOWING
105O 039	OLD CABIN	SHOWING
105O 048	NUKE	SHOWING
105O 059	SCRONK	SHOWING
106B 013	ECONOMIC	SHOWING
106C 084	GOODFELLOW	SHOWING
106C 089	CROM	SHOWING
106D 013	STAND-TO	SHOWING
106D 030	LUCKY STRIKE, QCQUESTON PASS	SHOWING
106D 037	WHITE HILL	SHOWING
106D 091	DAVIDSON	SHOWING
106D 093	ZAHN	SHOWING
106D 095	WALLACE	SHOWING
115H 044	POWER	SHOWING
115I 043	COMBO	SHOWING
115I 117	DIC	SHOWING
115J 005	PRIDE, VEE, LOBO, LILYPAD	SHOWING
115J 022	RUDE CREEK, GRUBSTAKE, READY BULLION, DISCOVERY	SHOWING
115J 023	NORDEX, CAPE, RAY, PASS	SHOWING
115J 070	MARQUERITE, SUN, ARM, CARLO, FOLLY, FREDS, MAR	SHOWING
115J 099	IDAHO	SHOWING
115N 027	SANTA	SHOWING
115O 014	BLACK FOX	SHOWING
115P 002	SEATTLE	SHOWING
115P 007	SPRAGUE, MAHTIN	SHOWING
115P 010	RIDGE, STERLING	SHOWING
115P 016	MOOSE RIDGE	SHOWING
115P 024	BOULDER	SHOWING
116A 021	PHILIP	SHOWING
116A 025	MATTAGAMI	SHOWING
116A 033	BEAR, AREA ONE, CIRQUE LAKE	SHOWING
116B 063	CHAPMAN, BOO, JIM, DIDLO	SHOWING
116C 019	MILLER	SHOWING
116C 034	JOLLY, SILVER KING, SILVER QUEEN	SHOWING
116C 135	CHOLACH	SHOWING
116H 050	CUNG	SHOWING
116I 064	TOUCHE	SHOWING
105B 051	RAINBOW, LIARD	ANOMALY
105B 077	PYKE, COM	ANOMALY
105B 109	OAKE	ANOMALY
105B 135	GOLDEX	ANOMALY
105C 016	MOOSE HILL	ANOMALY
105C 030	MUSKRAT	ANOMALY
105D 154	INTO	ANOMALY
105M 022	FISHER	ANOMALY
105M 033	LAYSIER	ANOMALY
105N 017	FLATASA	ANOMALY
106D 014	FORBES	ANOMALY
106D 029	LYNX	ANOMALY
115F 093	WEBSTER	ANOMALY
115J 020	HAXE	ANOMALY
115O 074	LEOTTA	ANOMALY
115O 079	FORK	ANOMALY
115P 001	JAYBEE	ANOMALY
116B 059	ROBERT SERVICE	ANOMALY
116N 012	SUNAGHUN	ANOMALY
105B 023	SNOW, SAB	UNKNOWN
105D 052	HAECKEL	UNKNOWN
105H 004	COX	UNKNOWN
105M 065	NADAR	UNKNOWN
105N 009	PEBBLE	UNKNOWN
115P 035	CLEMENT	UNKNOWN



Map of Yukon showing polymetallic vein occurrences and the distribution of plutonic rocks



Map of the Keno Hill region, central Yukon showing polymetallic vein occurrences, plutonic rocks and the Keno Hill Quartzite

Cu±Ag QUARTZ VEINS I06

by David V. Lefebure[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Churchill-type vein copper, vein copper

COMMODITY (*BYPRODUCTS*): Cu (Ag, rarely Au).

EXAMPLES: (British Columbia - *Canada/International*): Davis-Keays (094K012, 050), Churchill Copper (Magnum, 094K003), Bull River (082GNW002), Copper Road (092K060), Copper Star (092HNE036), Copper Standard (092HNE079), Rainbow (093L044); *Bruce Mines and Crownbridge (Ontario, Canada), Blue Wing and Seaboard (North Carolina, USA), Matahambre (Cuba), Inyati (Zimbabwe), Copper Hills (Western Australia), Tocopilla area (Chile), Burgas district (Bulgaria), Butte (Montana, USA), Rosario (Chile).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Quartz-carbonate veins containing patches and disseminations of chalcopyrite with bornite, tetrahedrite, covellite and pyrite. These veins typically crosscut clastic sedimentary or volcanic sequences, however, there are also Cu quartz veins related to porphyry Cu systems and associated with felsic to intermediate intrusions.

TECTONIC SETTINGS: A diversity of tectonic settings reflecting the wide variety of hostrocks including extensional sedimentary basins (often Proterozoic) and volcanic sequences associated with rifting or subduction-related continental and island arc settings.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Veins emplaced along faults; they commonly postdate major deformation and metamorphism. The veins related to felsic intrusions form adjacent to, and are contemporaneous with, mesozonal stocks.

AGE OF MINERALIZATION: Any age; can be much younger than host rocks. **In Yukon, most prospects are associated with Mesozoic intrusions.**

HOST/ASSOCIATED ROCK TYPES: Cu±Ag quartz veins occur in virtually any rocks although the most common hosts are clastic metasediments and mafic volcanic sequences. Mafic dykes and sills are commonly spatially associated with metasediment-hosted veins. These veins are also found within and adjacent to felsic to intermediate intrusions.

DEPOSIT FORM: The deposits form simple to complicated veins and vein sets which typically follow high-angle faults which may be associated with major fold sets. Single veins vary in thickness from centimetres up to tens of metres. Major vein systems extend hundreds of metres along strike and down dip. In some exceptional cases the veins extend more than a kilometre along the maximum dimension.

[1] British Columbia Geological Survey, Victoria, B.C., Canada

TEXTURE/STRUCTURE: Sulphide minerals are irregularly distributed as patches and disseminations. Vein breccias and stockworks are associated with some deposits.

ORE MINERALOGY (Principal and *subordinate*):

- Metasedimentary and volcanic-hosted: Chalcopyrite, pyrite, chalcocite*; bornite, tetrahedrite, argentite, pyrrhotite, covellite, galena.*
- Intrusion-related: Chalcopyrite, bornite, chalcocite, pyrite, pyrrhotite; *enargite, tetrahedrite-tennantite, bismuthinite, molybdenite, sphalerite, native gold and electrum.*

GANGUE MINERALOGY (Principal and *subordinate)*: Quartz and carbonate (calcite, dolomite, ankerite or siderite); *hematite, specularite, barite.*

ALTERATION MINERALOGY: Wallrocks are typically altered for distances of centimetres to tens of metres outwards from the veins.

- Metasediment and volcanic-hosted: The metasedimentary rocks display carbonatization and silicification. At the Churchill and Davis-Keays deposits, decalcification of limy rocks and zones of disseminated pyrite in roughly stratabound zones are reported. The volcanic hostrocks exhibit abundant epidote with associated calcite and chlorite.
- Intrusion-related: Sericitization, in places with clay alteration and chloritization.

WEATHERING: Malachite or azurite staining; silicified linear "ridges".

ORE CONTROLS: Veins and associated dykes follow faults. Ore shoots commonly localized along dilational bends within veins. Sulphide minerals may occur preferentially in parts of veins which crosscut carbonate or other favourable lithologies. Intersections of veins are an important locus for ore.

GENETIC MODEL: The metasediment and volcanic-hosted veins are associated with major faults related to crustal extension which control the ascent of hydrothermal fluids to suitable sites for deposition of metals. The fluids are believed to be derived from mafic intrusions which are also the source for compositionally similar dikes and sills associated with the veins. Intrusion-related veins, like Butte in Montana and Rosario in Chile, are clearly associated with high-level felsic to intermediate intrusions hosting porphyry Cu deposits or prospects.

ASSOCIATED DEPOSIT TYPES:

- Metasediment and volcanic-hosted: Possibly related to sediment-hosted Cu (E04) and basaltic Cu (D03).
- Intrusion-related: High sulphidation (H04), copper skarns (K01), porphyries (L01?, L03, L04) and polymetallic veins (I05).

COMMENTS: Cu±Ag quartz veins are common in copper metallogenetic provinces; they commonly are more important as indicators of the presence of other types of copper deposits. **Yukon has no known Cu+/-Ag quartz vein type deposits, but this type of mineralization occurs associated with other deposit types.**

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: High Cu and Ag in regional silt samples. The Churchill-type deposits appear to have very limited wallrock dispersion of pathfinder elements; however, alteration halos of silica and carbonate addition or depletion might prove useful. Porphyry-related veins exhibit many of the geochemical signatures of porphyry copper systems.

GEOPHYSICAL SIGNATURE: Large veins with conductive massive sulphides may show up as electromagnetic conductors, particularly on ground surveys. Associated structures may be defined by ground magnetic, very low frequency or electromagnetic surveys. Airborne surveys may identify prospective major structures.

OTHER EXPLORATION GUIDES: Commonly camp-scale or regional structural controls define a dominant orientation for veins.

ECONOMIC FACTORS

GRADE AND TONNAGE: Typically range from 10 000 to 100 0000 t with grades of 1 to 4% Cu, nil to 300 g/t Ag. The Churchill deposit has reserves of 90 000 t of 3 % Cu and produced 501 019 t grading 3% Cu and the Davis-Keays deposit has reserves of 1 119 089 t grading 3.43 % Cu. The Big Bull deposit has reserves of 732 000 t grading 1.94% Cu. The intrusion-related veins range up to millions of tonnes with grades of up to 6% Cu. The Butte veins in Montana have produced several hundred million tonnes of ore with much of this production from open-pit operations.

ECONOMIC LIMITATIONS: Currently only the large and/or high-grade veins (usually associated with porphyry deposits) are economically attractive.

IMPORTANCE: From pre-historic times until the early 1900s, high-grade copper veins were an important source of this metal. With hand sorting and labour-intensive mining they represented very attractive deposits.

ACKNOWLEDGEMENTS

This deposit profile represents the results of a literature review. It benefited from comments by David Sinclair and Vic Preto.

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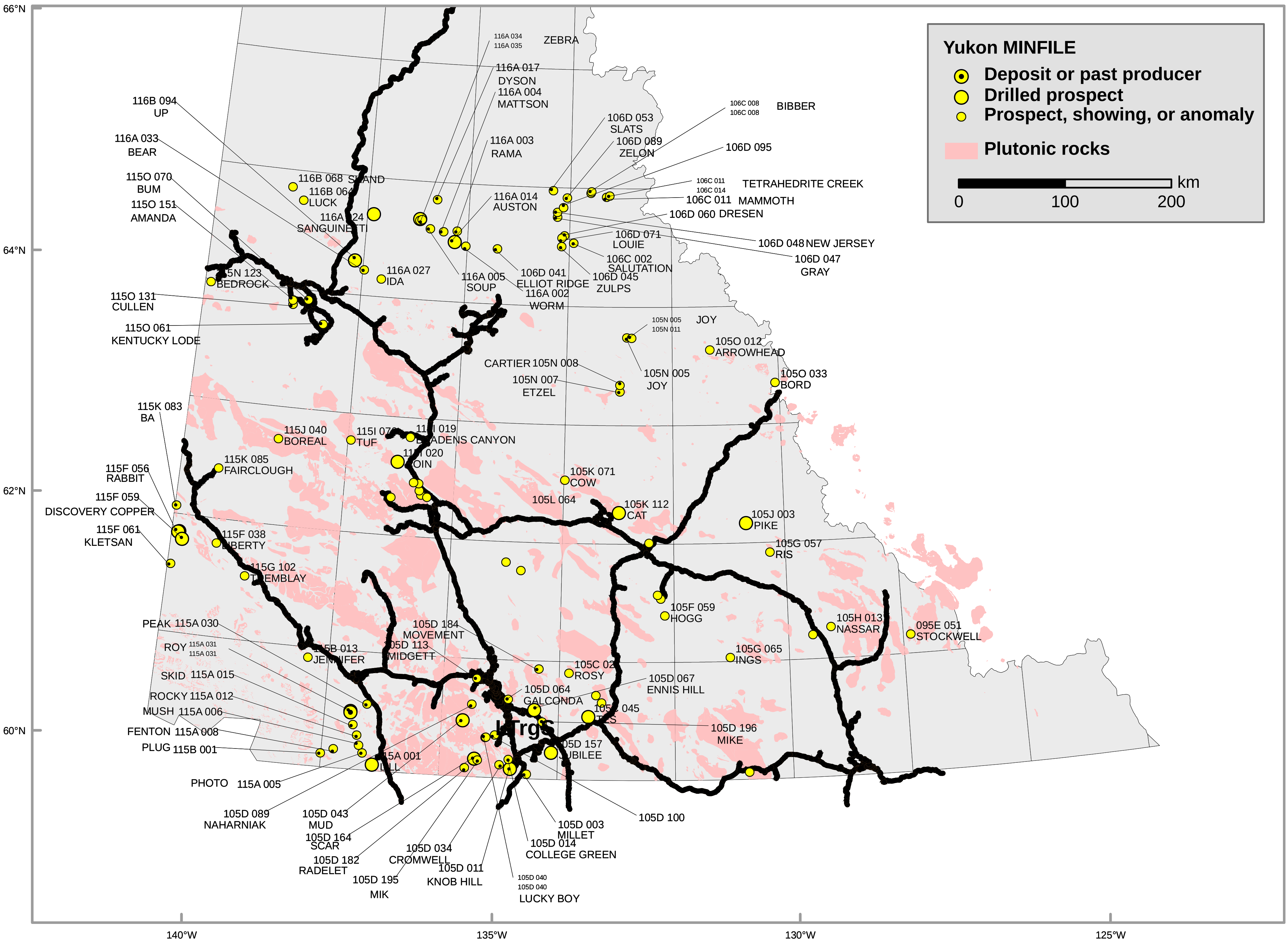
I06 - Cu+/-Ag quartz veins - BC deposits

Deposit	Country	tonnes	Au (g/t)	Ag (g/t)	Cu	Pb	Zn
Dusty Macs	CNBC	93 392	6.49	112.99	0.00	0.00	0.00
Baker	CNBC	120 449	17.87	269.67	0.00	0.00	0.00
Mets	CNBC	144 000	11.30	0.00	0.00	0.00	0.00
Vault	CNBC	152 000	14.00	0.00	0.00	0.00	0.00
Gold Wedge	CNBC	329 000	24.90	201.20	0.00	0.00	0.00
Black Dome	CNBC	368 343	21.48	78.86	0.00	0.00	0.00
Golden Stranger	CNBC	500 000	2.70	0.00	0.00	0.00	0.00
Lawyer	CNBC	528 337	8.42	168.29	0.00	0.00	0.00
New Moon	CNBC	609 900	0.99	15.43	0.00	0.00	0.00
Shasta	CNBC	1 071 033	4.09	217.50	0.00	0.00	0.00
Sulphur	CNBC	1 437 000	11.50	783.60	0.00	0.00	0.00
Silba	CNBC	7 065 528	9.03	188.92	0.03	0.40	0.14
Cinola	CNBC	23 800 000	2.47	3.10	0.00	0.00	0.00

Yukon MINFILE

MINFILE	NAMES	STATUS
115A 031	JOHOBO, JAC, MOOSE, ROY, JEAN	OPEN PIT PAST PRODUCER
105J 003	PIKE	DEPOSIT
105C 045	TES	DRILLED PROSPECT
105D 011	KNOB HILL	DRILLED PROSPECT
105D 067	MCCLINTOCK, ENNIS HILL	DRILLED PROSPECT
105K 112	STARLIGHT	DRILLED PROSPECT
115A 001	JACKPOT, PET, KEM, KAY, ALDER HILL, TATS, LILL	DRILLED PROSPECT
115F 056	RABBIT	DRILLED PROSPECT
115I 020	COIN	DRILLED PROSPECT
116A 014	AUSTON	DRILLED PROSPECT
116B 094	O'BRIEN, AJ	DRILLED PROSPECT
105D 064	GALCONDA	PROSPECT
105F 018	KOPINEC	PROSPECT
105F 067	FURY	PROSPECT
106D 045	ZULPS	PROSPECT
115A 006	MUSH	PROSPECT
115B 013	JENNIFER	PROSPECT
115I 010	BONANZA CREEK, WILLIAMS & MERRICE CREEKS	PROSPECT
115I 019	BRADENS CANYON	PROSPECT
115O 070	BUM	PROSPECT
116A 027	IDA	PROSPECT
095E 051	STOCKWELL	SHOWING
105C 018	MT. GRANT	SHOWING
105C 024	ROSY	SHOWING
105D 003	MILLET	SHOWING
105D 014	COLLEGE GREEN	SHOWING
105D 034	CROMWELL	SHOWING
105D 089	NAHARNIAK	SHOWING
105D 113	MIDGETT	SHOWING
105D 182	RADELET	SHOWING
105D 195	MIK	SHOWING
105D 196	MIKE	SHOWING
105E 014	SEMENOF	SHOWING
105E 016	CASSIER BAR	SHOWING
105F 059	HOGG	SHOWING
105G 057	RIS	SHOWING
105G 065	INGS	SHOWING
105H 013	FRANCES, MINK, LUCKY, SU, NIPRO, JOE	SHOWING
105H 015	DOUG, EVA	SHOWING
105K 003	RAGS, KO	SHOWING
105L 065	GLAD	SHOWING
105N 007	ETZEL	SHOWING

MINFILE	NAMES	STATUS
105N 008	CARTIER	SHOWING
105N 011	AUREOLE	SHOWING
106C 002	SALUTATION	SHOWING
106C 008	BIBBER	SHOWING
106C 011	MAMMOTH	SHOWING
106C 094	CAROL	SHOWING
106D 041	ELLIOT RIDGE	SHOWING
106D 047	GRAY	SHOWING
106D 048	NEW JERSEY	SHOWING
106D 053	SLATS	SHOWING
106D 060	DRESEN	SHOWING
106D 071	LOUIE	SHOWING
106D 089	ZELON	SHOWING
115A 005	PHOTO	SHOWING
115A 008	FENTON	SHOWING
115A 015	BELOUD, ELLEN, DORTHY ANN, SKID, EARLY	SHOWING
115F 038	LIBERTY	SHOWING
115F 061	KLETSAN	SHOWING
115I 009	MERRICE, HOMESTAKE	SHOWING
115I 013	HOOCHEKOO	SHOWING
115I 051	CASTLE	SHOWING
115I 077	CROSSING	SHOWING
115I 095	BLUFF	SHOWING
115K 083	RIP, ELDORADO, BEAVER, BA	SHOWING
115K 085	FAIRCLOUGH	SHOWING
115O 151	AMANDA	SHOWING
116A 002	WORM	SHOWING
116A 003	RAMA	SHOWING
116A 004	MATTSON	SHOWING
116A 005	SOUP	SHOWING
116A 034	HAWLEY	SHOWING
116A 035	BRIDEN	SHOWING
116B 064	FIFTEEN MILE, JOE, LUCK, CHAMOX, GEM, MOVIE	SHOWING
116B 068	SHAND, SHAND LODE	SHOWING
105L 066	FRENCHMAN	ANOMALY
105N 005	JOY	ANOMALY
115B 001	PLUG	ANOMALY
105C 042	THOM	UNKNOWN
105K 071	COWARD, TAY, COW	UNKNOWN
115G 102	TREMBLAY	UNKNOWN



Map of Yukon showing Cu-Ag vein occurrences and the distribution of plutonic rocks

STIBNITE VEINS and DISSEMINATIONS I09

by Andre Panteleyev[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Quartz-stibnite, simple antimony, syntectonic stibnite, mesothermal Sb-Au.

COMMODITIES (*BYPRODUCTS*): Sb (*Au*).

EXAMPLES: **(Yukon): Yukon Antimony (Becker-Cochrane 105D 027)**;

(British Columbia - *Canada/International*): a) Veins - Minto (092JNE075) and Congress (092JNE029), Bridge River area; Snowbird (093K036); *Lake George (New Brunswick, Canada), Beaver Brook (Newfoundland, Canada*), *Murchison Range deposits (South Africa), Caracota and numerous other deposits in the Cordillera Occidental (Bolivia);* b) Disseminated - *Caracota and Espiritu Santo (Bolivia), many deposits (Turkey).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Stibnite veins, pods, disseminations and stibnite-bearing quartz and quartz-carbonate veins occur in, or adjacent to, shears, fault zones and brecciated rocks in sedimentary or metasedimentary sequences.

TECTONIC SETTING: Any orogenic area, particularly where large-scale fault structures are present

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Fault and shear zones, notably in fault splays and fault-related breccias in which shallow to intermediate-depth hydrothermal systems have been operative.

AGE OF MINERALIZATION: Deposits range from Paleozoic to Tertiary age.

HOST/ASSOCIATED ROCK TYPES: Any faulted lithologies with a wide variety of rock types; sedimentary and metasedimentary rocks are commonly present. British Columbia deposits tend to be near major fault zones with attendant serpentinized mafic and ultramafic rocks.

DEPOSIT FORM: Stibnite occurs in veins; also as fine to coarse grains in sheared or brecciated rocks. Some stibnite is disseminated in carbonate-altered wallrocks surrounding structures and may form within pressure shadows at crests of folds. Massive stibnite-pyrite replacements which may form pods or lenses up to tens of metres long, are relatively uncommon, but are sources of rich ore.

TEXTURE/STRUCTURE: Veins have fine to coarse-grained, commonly euhedral bladed crystals of stibnite, quartz and carbonate in masses of stibnite. Quartz and quartz-carbonate gangue minerals range from fine to coarse grained, commonly with white 'bull quartz" present.

[1] British Columbia Geological Survey, Victoria, B.C., Canada

ORE MINERALOGY [Principal and *subordinate*]: Stibnite, pyrite, arsenopyrite; *sphalerite, galena, tetrahedrite, marcasite, chalcopyrite, jamesonite, berthierite, gold, cinnabar, scheelite, argentite and sulphosalt minerals. Other than stibnite, the overall sulphide content of the veins is low.*

GANGUE MINERALOGY [Principal and *subordinate*]: Quartz, calcite, dolomite; *chalcedony, siderite, rare barite and fluorite.*

ALTERATION MINERALOGY: Quartz-carbonate envelopes on veins; some silicification, sericite, and intermediate argillic alteration. Chlorite, serpentinization and 'listwanite' (quartz-carbonate-talc-chromian mica-sulphide minerals) green-coloured alteration may be present when mafic and untramafic rocks are involved.

WEATHERING: Stibnite weathers to various oxides of yellowish (kermsite) or whitish (cerrantite or stibiconite) colour.

ORE CONTROLS: Fissure, shear zones and breccia associated with faults. Some open-space filling in porous rocks and structurally induced openings (joints, saddle reefs, ladder veins). Minor replacement in limestones.

GENETIC MODEL: The origin is not well documented. Deposits are spatially closely associated with, and in many ways resemble, low-sulphide gold-quartz (mesothermal) veins. Their (mutual) origin is thought to be from dilute, CO_2 rich fluids generated by metamorphic dehydration. Structural channelways focus the hydrothermal fluids during regional deformation. Some deposits are associated with felsic intrusive bodies, for example a Tertiary rhyolite plug at Becker-Cochran deposit, Yukon, and with porphyry W-Mo mineralization in granitic rocks at the Lake George Sb deposit, New Brunswick.

ASSOCIATED DEPOSIT TYPES: Quartz-carbonate gold (low-sulphide gold-quartz vein or I01), polymetallic vein Ag-Pb-Zn (I05), epithermal Au-Ag: low sulphidation (H05), hotspring Au-Ag (H03), Sn-W vein (??), W-Mo porphyry (L07); silica-carbonate Hg (I08), placer gold (C01, C02); possibly Carlin-type sediment-hosted Ag-Ag (E03).

COMMENTS: Occurrences of typical stibnite veins in the Bridge River gold camp in British Columbia were thought to be part of a regional deposit zoning pattern. The deposits are now known to be younger than the gold deposits by about 15-20 Ma. Farther north, the Snowbird deposit near Stuart Lake, has been shown to be Middle Jurassic in age by radiometric dating and is interpreted to be related to large-scale crustal structures. This deformation possibly involves the Pinchi fault system in which the largest known mercury deposits in the province are found.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Sb, As, Au, Ag, Pb, Zn; locally W or Hg.

GEOPHYSICAL SIGNATURE: VLF surveys may detect faults.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Veins typically have high grade but small ore shoots; the disseminated deposits are also relatively small. Grade-tonnage data from 81 "typical" vein deposits (predominately, hand-sorted ore from USA mines) is 180 t with 35 % Sb; 10 % of the deposits contained > 1 g/t Au and > 16 g/t Ag. The disseminated deposits average 88 000 t with an average grade of 3.6 % Sb. **The Yukon Antimony deposit is larger than average, with 127 000 tonnes at 4% Sb.**

ECONOMIC LIMITATIONS: Antimony is currently a low-priced metal so only high-grade deposits are mined. Deposits (veins and disseminations) containing gold offer the best potential.

IMPORTANCE: Bolivia, Turkey and China dominate the antimony market; Cordilleran production will likely be only as a byproduct from precious metal bearing deposits.

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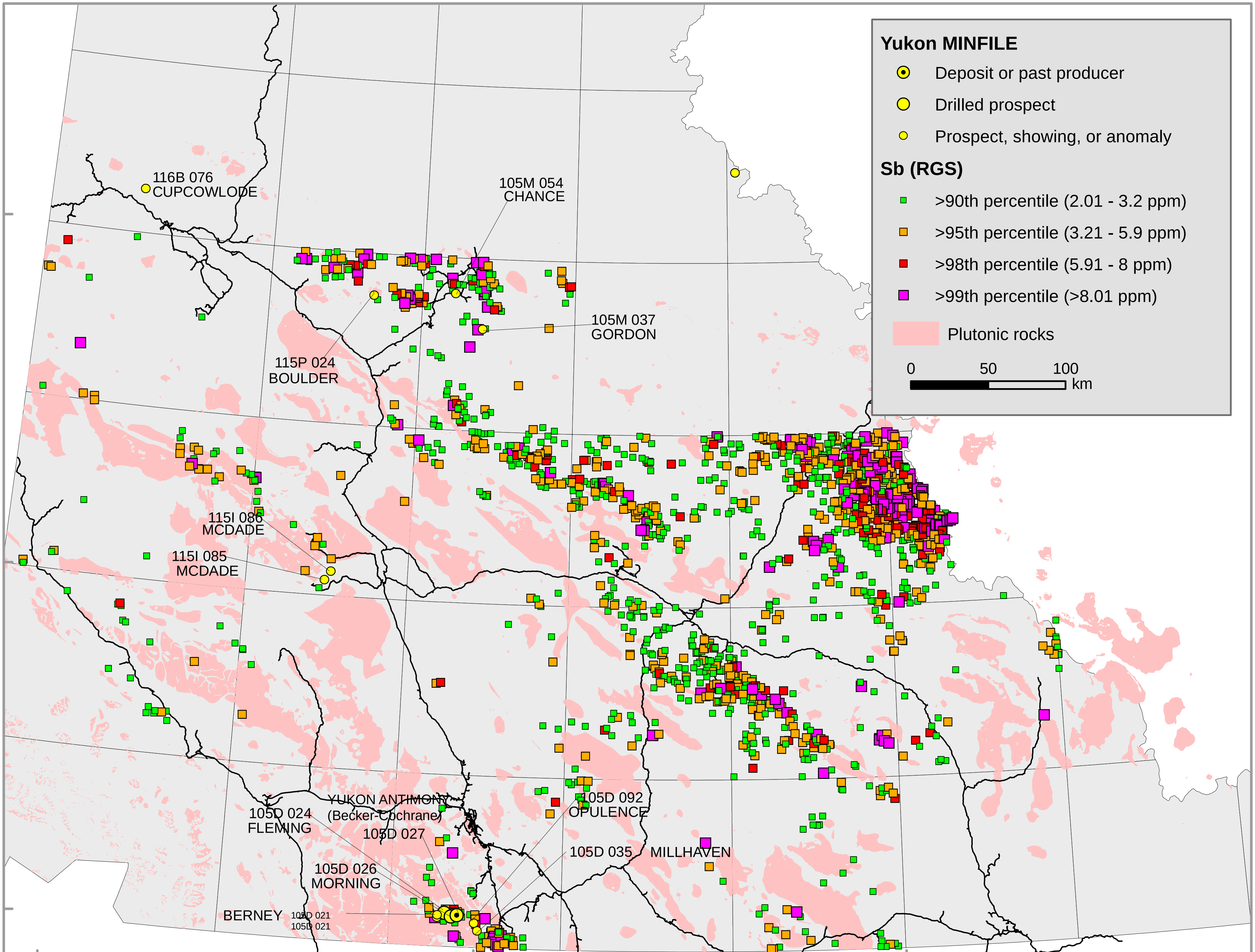
I09 - Stibnite veins and disseminations - BC deposits

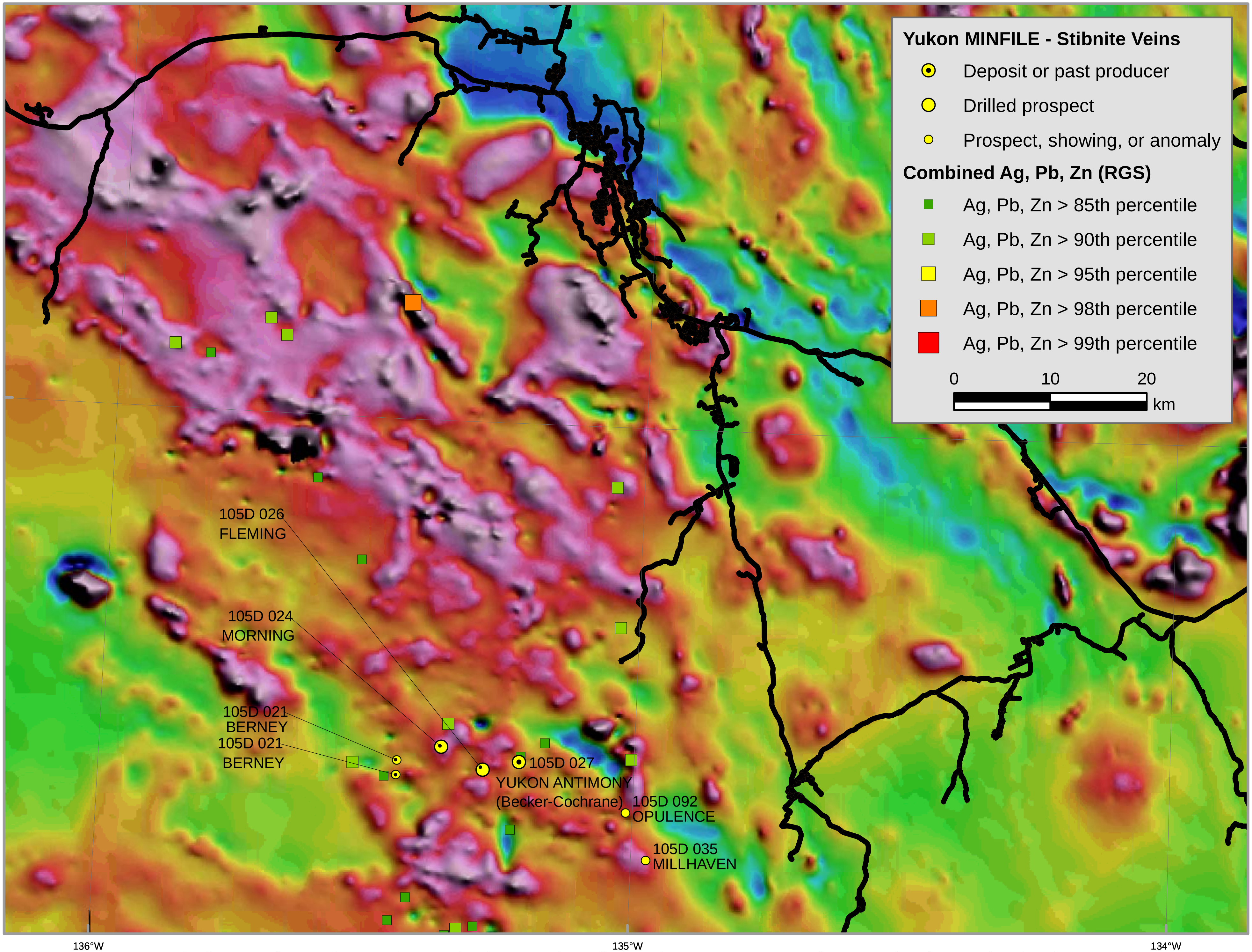
Deposit	country	tonnes	Sb %
MINTO	CNBC		
CONGRESS	CNBC		
SNOWBIRD	CNBC		
YUKON ANTIMONY	CNYT	127 000	4

Yukon MINFILE

MINFILE	NAMES	STATUS
105D 027	BECKER-COCHRAN, YUKON ANTIMONY	DEPOSIT
105D 024	CHIEFTAIN HILL, OCEAN, MORNING	DRILLED PROSPECT
115I 085	CAR, MCDADE	PROSPECT
105M 037	GORDON	PROSPECT
105D 035	MILLHAVEN	SHOWING
105D 092	OPULENCE	SHOWING
115I 086	ROWLINSON, MCDADE, LEE	SHOWING
105M 054	CHANCE	SHOWING
105D 021	BERNEY	ANOMALY
116B 076	LAWRENCE, CUPCOWLODE	UNKNOWN



Map of Yukon showing Stibnite vein occurrences, Sb regional geochemistry and the distribution of plutonic rocks



Map of Wheaton River region, south central Yukon showing stibnite vein occurrences, Ag-Pb-Zn geochemistry and regional magnetics

POLYMETALLIC MANTOS Ag-Pb-Zn[1] J01

by J.L. Nelson[2]

Modified for Yukon by A. Fonseca and G. Bradshaw

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYM: Polymetallic replacement deposits.

COMMODITIES (*BYPRODUCTS*): Ag, Pb, Zn (Au, Cu, Sn, Bi).

EXAMPLES: **(Yukon): Hyland Gold (095D 006), McMillan (095D 011), Groundhog (105F 029), Ketza River (105F 019), Tintina/Eagle (105G 006), Clark (106D 011);** (British Columbia - *Canada/International*): Midway (104O038) and Bluebell (082ENW026), *Prairie Creek (Northwest Territories, Canada), Leadville District (Colorado, USA), East Tintic District (Utah, USA), Eureka District (Nevada, USA), Santa Eulalia, Naica, Fresnillo, Velardena, Providencia (Mexico).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Irregularly shaped, conformable to crosscutting bodies, such as massive lenses, pipes and veins, of sphalerite, galena, pyrite and other sulphide and sulphosalt minerals in carbonate hosts; distal to skarns and to small, high-level felsic intrusions.

TECTONIC SETTING: Intrusions emplaced into miogeoclinal to platformal, continental settings.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: In northern Mexico, most are hosted by Cretaceous limestones. In Colorado, the principal host is the Devonian-Mississippian Leadville limestone; in Utah, the Permian Torweap Formation hosts the Deer Trail deposit. The most favourable hosts in the Canadian Cordillera are massive Lower Cambrian and Middle Devonian limestones, rather than impure carbonates and dolostone-quartzite units.

AGE OF MINERALIZATION: Canadian Cordilleran examples are Cretaceous to Eocene age; those in the southern Cordillera are typically Tertiary.

HOST/ASSOCIATED ROCK TYPES: Hosted by limestone and dolostone. The carbonates are typically within a thick sediment package with siliciclastic rocks that is cut by granite, quartz monzonite and other intermediate to felsic hypabyssal, porphyritic lithologies. There may be volcanic rocks in the sequence, or more commonly above, which are related to the intrusive rocks.

DEPOSIT FORM: Irregular: mantos (cloak shaped), lenses, pipes, chimneys, veins; in some deposits the chimneys and/or mantos are stacked.

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[1] Manto is a Spanish mining term denoting a blanket-shaped ore body which is widely used for replacement deposits of Mexico. It has been used to describe the orientation of individual lenses and also to describe a class of ore bodies.

[2] British Columbia Geological Survey, Victoria, B.C., Canada

TEXTURE/STRUCTURE: Massive to highly vuggy, porous ore. In some cases fragments of wallrock are incorporated into the ore. Some deposits have breccias: fragments of wallrock and also of sulphide ore within a sulphide matrix.

ORE MINERALOGY (Principal and subordinate): Sphalerite, galena, pyrite, chalcopyrite, marcasite; arsenopyrite, pyrargyrite/proustite, enargite, tetrahedrite, geocronite, electrum, digenite, jamesonite, jordanite, bournonite, stephanite, polybasite, rhodochrosite, sylvanite, calaverite. Chimneys may be more Zn-rich, Pb-poor than mantos.

GANGUE MINERALOGY (Principal and *subordinate*): Quartz, barite, gypsum; minor *calc-silicate minerals*.

ALTERATION MINERALOGY: Limestone wall rocks are commonly dolomitized and/or silicified, whereas shale and igneous rocks are argillized and chloritized. Jasperoid occurs in some U.S. examples.

WEATHERING: In some cases, a deep oxidation zone is developed. Mexican deposits have well developed oxide zones with cassiterite, hematite, Cu and Fe carbonates, cerusite and smithsonite.

ORE CONTROLS: The irregular shapes of these deposits and their occurrence in carbonate hosts emphasize the importance of ground preparation in controlling fluid channels and depositional sites. Controlling factors include faults, fault intersections, fractures, anticlinal culminations, bedding channelways (lithologic contrasts), karst features and pre-existing permeable zones. In several districts karst development associated with unconformities is believed to have led to development of open spaces subsequently filled by ore. Some deposits are spatially associated with dikes.

GENETIC MODEL: Manto deposits are high-temperature replacements as shown by fluid inclusion temperatures in excess of 300 °C, high contents of Ag, presence of Sn, W and complex sulphosalts, and association with skarns and small felsic intrusions. They are the product of pluton-driven hydrothermal solutions that followed a variety of permeable pathways, such as bedding, karst features and fracture zones.

ASSOCIATED DEPOSIT TYPES: There is probably an overall outward gradation from granite-hosted Mo-Cu porphyries (L04), endoskarns (K) and possibly W- and Sn mineralization (L06?), through exoskarns (K01, K02) and into Ag-Pb-Zn veins (I05), mantos (J01) and possibly Carlin-type sediment-hosted Au-Ag deposits (E03). Only some, or possibly one, of these types may be manifest in a given district. Ag-Pb-Zn vein, manto and skarn deposits belong to a continuum which includes many individual occurrences with mixed characteristics.

COMMENTS: In the Canadian Cordillera, most mantos are located in the miogeocline (western Ancestral North America, Cassiar and Kootenay terranes) because of the essential coincidence of abundant carbonate and presence of felsic intrusions. There is one known example in Upper Triassic limestone on Vancouver Island, which probably formed distal to skarn mineralization related to a mid-Jurassic intrusion. Most mantos in the Canadian Cordillera are Late Cretaceous to Eocene, coinciding with the age of youngest, F-rich intrusions of the A-type (anorogenic) granite suite. In Mexico, mantos are associated with Early to mid-Tertiary volcanic rocks and cogenetic intrusions. The Colorado deposits may be associated with Tertiary sills, and the Deer Trail deposit in Utah has given a 12 Ma sericite age. **The Ketza River deposit in central Yukon is a gold-rich polymetallic manto deposit for which silver and base metal grades have not been quoted. Recent work at the Hyland Gold deposit revealed some attributes characteristic of Carlin-type sediment-hosted gold-silver deposits.**

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: B.C.: Ag, Pb, Zn, Sn in stream silts, F in waters. U.S.: Districts show outward zoning from Cu-rich core through broad Ag-Pb zone to Zn-Mn fringe. Locally Au, As, Sb, Bi. Jasperoid contains elevated Ba + Ag.

GEOPHYSICAL SIGNATURE: Subsurface granite associated with Midway deposit has negative magnetic signature.

OTHER EXPLORATION GUIDES: Concentration of Ag-Pb-Zn vein deposits in or near carbonates.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Individual deposits average about a million tonnes grading tens to hundreds of grams/tonne Ag and approximately 5 to 20% combined Pb-Zn. Mexico: Santa Eulalia district produced about 24 Mt in this century, grading about 300 g/t Ag, 8% Pb, 9% Zn. U.S.: Leadville deposit mined 30 Mt 70-130 g/t Ag, 12-15% Pb-Zn. B.C.: Midway geological resource is 1 Mt grading 400 g/t Ag 7% Pb, 9.6% Zn. In many mining districts the early production came from oxidized ore zones that can have higher grades and be easier to mine.

ECONOMIC LIMITATIONS: Generally, although not always, these deposits tend to be small, highly irregular and discontinuous. The Mexican deposits have yielded large quantities of ore because, due to low labour costs, mining provided an effective and low-cost exploration tool.

IMPORTANCE: As sources of base metals, manto deposits are overshadowed on a world scale by the giant syngenetic classes such as sedimentary exhalitive and volcanogenic massive sulphides. However, because of their high precious metal contents, they provide exciting targets for small producers.

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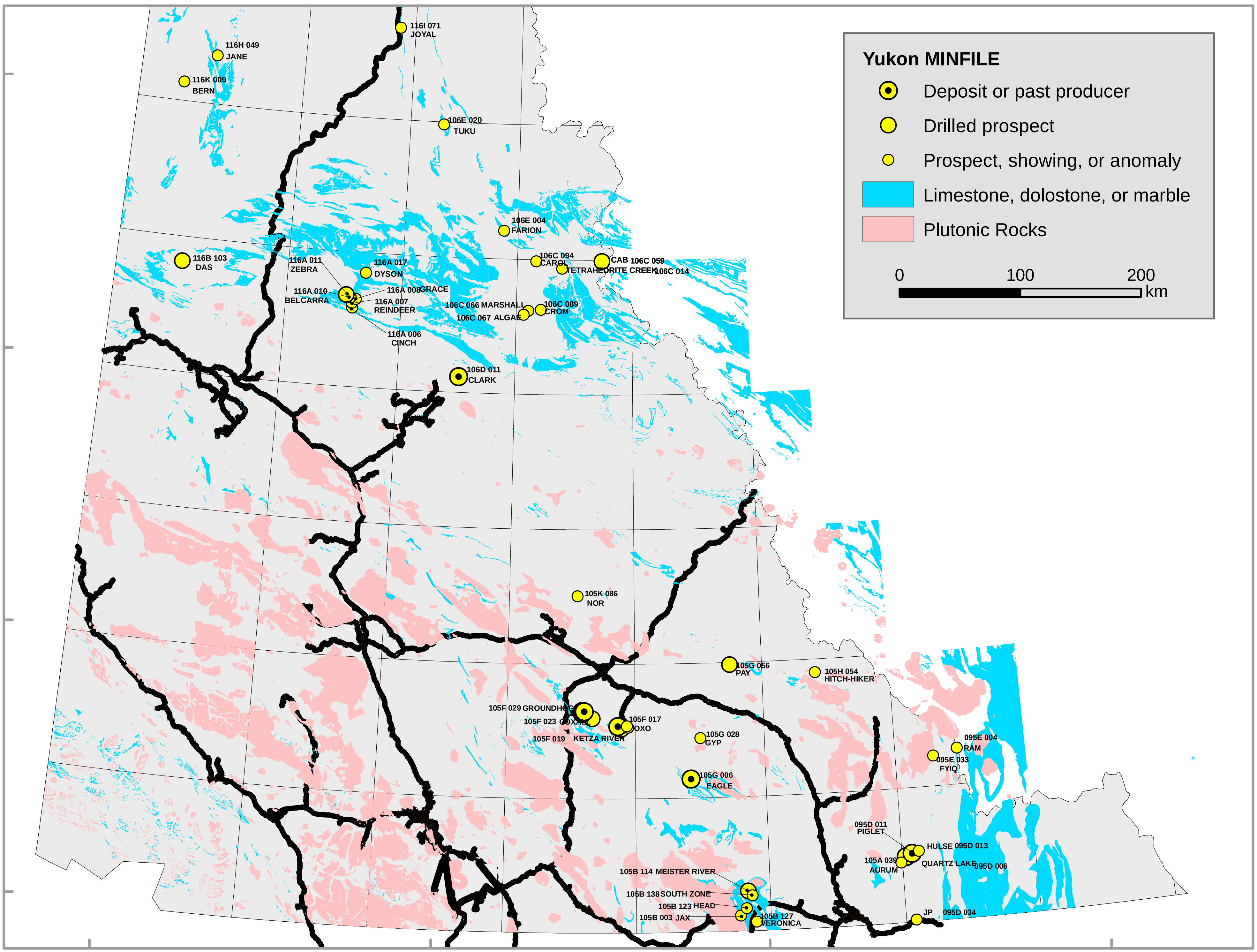
J01 - Polymetallic mantos Ag-Pb-Zn - BC and Yukon deposits

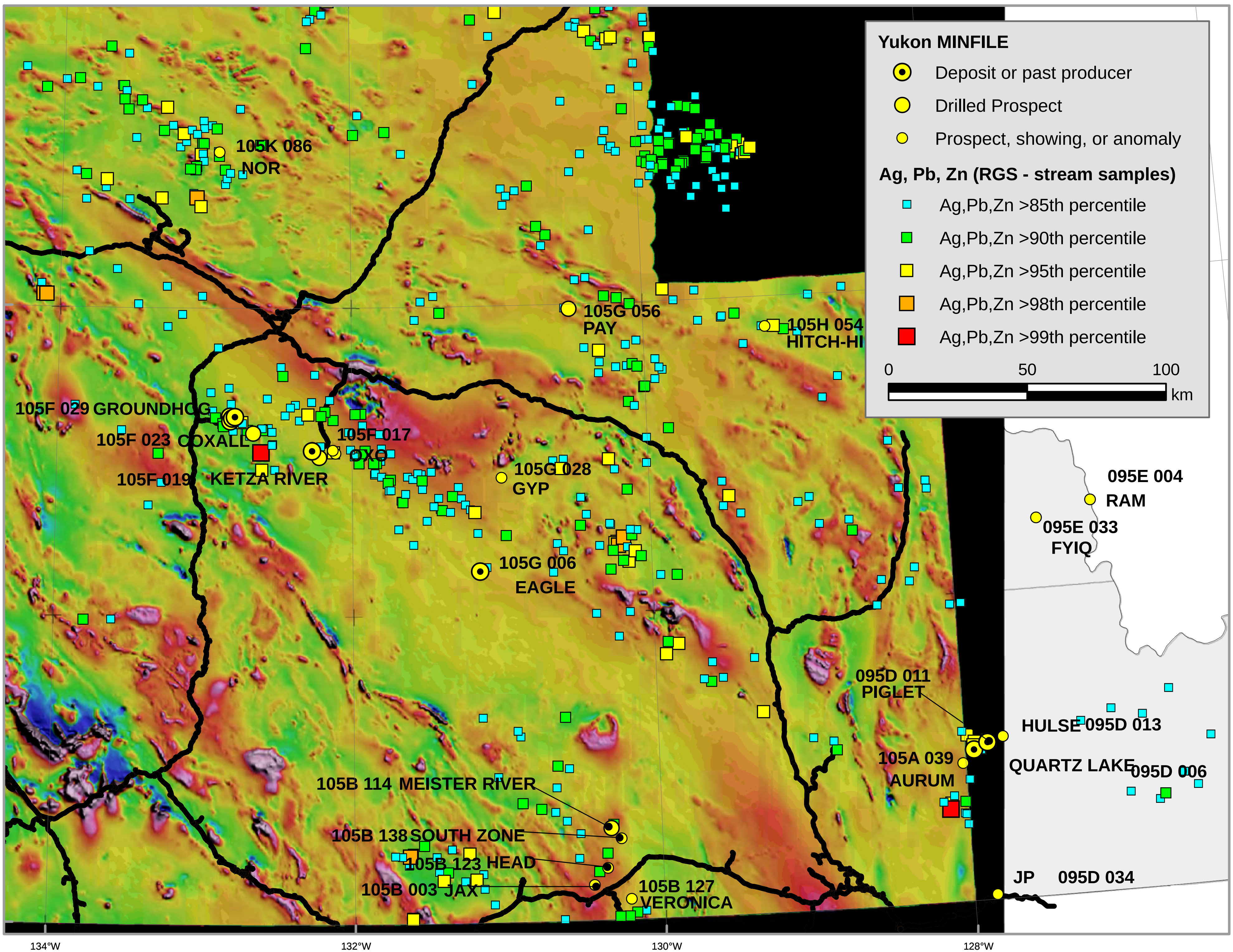
Deposit	country	tonnes	Au (g/t)	Ag (g/t)	Cu %	Pb %	Zn %
PARADISE	CNBC	64 635	0.0	354.7	0.00	11.21	5.61
EAGLE/TINTINA	CNYT	90 900	0.0	686.0	0.00	6.00	10.00
KOOTENAY	CNBC	115 679	0.0	51.3	0.00	5.47	1.14
GROUNDHOG	CNYT	200 951	0.0	91.9	0.00	3.18	4.01
BAMTENAY	CNBC	270 000	0.0	0.0	0.76	0.00	0.00
CLARK	CNYT	327 050	0.0	255.0	0.00	4.59	4.60
QUARTZ LAKE	CNYT	400 000	0.0	214.0	0.00	9.30	1.70
KETZA RIVER	CNYT	1 000 000	13.7	0.0	0.00	0.00	0.00
QUARTZ LAKE/MCMILLAN	CNYT	1 100 000	0.0	62.0	0.00	4.10	8.30
MIDWAY	CNBC	1 180 000	0.0	404.5	0.00	7.90	9.60
SILVERTIP	CNBC	2 570 000	0.6	325.0	0.00	6.40	8.80
BLUEBELL	CNBC	4 820 029	0.0	0.0	0.06	4.85	5.17
HYLAND GOLD	CNYT	6 750 000	2.0	0.0	0.00	0.00	0.00
MEL	CNYT	6 800 000	0.0	0.0	0.00	2.00	7.10

Yukon MINFILE

MINFILE	NAMES	STATUS
105F 019	KETZA, PEEL, 3B, BOOM	UNDERGROUND PAST PRODUCER
095D 006	MCMILLAN, QUARTZ LAKE	DEPOSIT
105F 029	GROUNDHOG	DEPOSIT
105G 006	TINTINA, EAGLE	DEPOSIT
106D 011	CLARK	DEPOSIT
105B 114	MEISTER, WEST ZONE, MEISTER RIVER, MR	DRILLED PROSPECT
105F 017	OXO	DRILLED PROSPECT
105F 023	COXALL	DRILLED PROSPECT
106D 012	CAMERON	DRILLED PROSPECT
116A 011	ZEBRA	DRILLED PROSPECT
095D 013	HULSE	PROSPECT
095E 004	TWIN, RAM, DELL, SUNSET, U2, NEIL, FOX	PROSPECT
105B 003	LUCK, JAX	PROSPECT
105G 028	GYP	PROSPECT
095E 033	HOOPER, FYIQ	SHOWING
105B 127	VERONICA	SHOWING
105B 138	HAIRSINE, SOUTH ZONE	SHOWING
105F 068	REGEHR, SOUTH FAULT, F4 ZONE, F6 ZONE	SHOWING
105H 054	HITCH-HIKER	SHOWING
105K 086	MARKS, ZEUS, ZED, NOR	SHOWING
106C 066	MARSHALL	SHOWING
106C 067	ALGAE	SHOWING
116A 007	REINDEER	SHOWING
116A 010	BELCARRA	SHOWING
116A 017	DYSON	SHOWING
105A 039	AURUM	ANOMALY
105B 123	HEAD, TACKLE	ANOMALY
116A 006	CINCH	ANOMALY
116A 008	GRACE	ANOMALY
116H 049	JANE	ANOMALY
116I 071	JOYAL	ANOMALY



Map of Yukon showing plutonic rocks, carbonate rocks and possible polymetallic manto occurrences



Map of southeast Yukon showing polymetallic manto occurrences, Ag-Pb-Zn geochemistry and regional magnetics

Cu SKARNS K01

by Gerald E. Ray[1]

modified for Yukon by A. Fonseca

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYMS: Pyrometasomatic and contact metasomatic copper deposits.

COMMODITIES (*BYPRODUCTS*): Cu (*Au, Ag, Mo, W, magnetite*)

EXAMPLES: **(Yukon): Cowley Park, Little Chief, Black Cub, Gem, Keewenaw, Arctic Chief, Best Chance-Grafter, Pueblo, War Eagle, Copper King-Carlisle (105D 053; Whitehorse Copper Belt), Marn (116B 147)**;
(British Columbia - *Canada/International*): Craigmont (092ISE 035), Phoenix (082ESE 020), Old Sport (092L 035), Queen Victoria (082FSW 082); *Mines Gaspé deposits (Québec, Canada), Ruth, Mason Valley and Copper Canyon (Nevada, USA), Carr Fork (Utah, USA), Ok Tedi (Papua New Guinea), Rosita (Nicaragua*).

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Cu-dominant mineralization (generally chalcopyrite) genetically associated with a skarn gangue (includes calcic and magnesian Cu skarns).

TECTONIC SETTING: They are most common where Andean-type plutons intrude older continental-margin carbonate sequences. To a lesser extent (but important in British Columbia), they are associated with oceanic island arc plutonism.

AGE OF MINERALIZATION: Mainly Mesozoic, but may be any age. In British Columbia they are mostly Early to mid-Jurassic. **In Yukon, the Whitehorse Copper Belt deposits are associated with mid-Cretaceous Whitehorse-Coffee Creek Suite intrusions, and the Marn deposit is associated with mid-Cretaceous Tombstone Suite intrusions.**

HOST/ASSOCIATED ROCK TYPES: Porphyritic stocks, dykes and breccia pipes of quartz diorite, granodiorite, monzogranite and tonalite composition, intruding carbonate rocks, calcareous volcanics or tuffs. Cu skarns in oceanic island arcs tend to be associated with more mafic intrusions (quartz diorite to granodiorite), while those formed in continental margin environments are associated with more felsic material.

DEPOSIT FORM: Highly varied; includes stratiform and tabular orebodies, vertical pipes, narrow lenses, and irregular ore zones that are controlled by intrusive contacts.

TEXTURES: Igneous textures in endoskarn. Coarse to fine-grained, massive granoblastic to mineralogically layered textures in exoskarn. Some hornfelsic textures.

ORE MINERALOGY (Principal and *subordinate*): Moderate to high sulphide content. Chalcopyrite ± pyrite ± magnetite in inner garnet-pyroxene zone. Bornite ± chalcopyrite ± sphalerite ± tennantite

[1] British Columbia Geological Survey, Victoria, B.C., Canada

in outer wollastonite zone. Either hematite, pyrrhotite or magnetite may predominate (depending on oxidation state). Scheelite and traces of *molybdenite, bismuthinite, galena, cosalite, arsenopyrite, enargite, tennantite, loellingite, cobaltite and tetrahedrite* may be present.

ALTERATION MINERALOGY: Exoskarn alteration: high garnet:pyroxene ratios. High Fe, low Al, Mn andradite garnet (Ad_{35-100}), and diopsidic clinopyroxene (Hd_{2-50}). The mineral zoning from stock out to marble is commonly: diopside + andradite (proximal); wollastonite ± tremolite ± garnet ± diopside ± vesuvianite (distal). Retrograde alteration to actinolite, chlorite and montmorillonite is common. In British Columbia, skarn alteration associated with some of the alkalic porphyry Cu-Au deposits contains late scapolite veining. Magnesian Cu skarns also contain olivine, serpentine, monticellite and brucite.
Endoskarn alteration: Potassic alteration with K-feldspar, epidote, sericite ± pyroxene ± garnet. Retrograde phyllic alteration generates actinolite, chlorite and clay minerals.

ORE CONTROLS: Irregular or tabular orebodies tend to form in carbonate rocks and/or calcareous volcanics or tuffs near igneous contacts. Pendants within igneous stocks can be important. Cu mineralization is present as stockwork veining and disseminations in both endo and exoskarn; it commonly accompanies retrograde alteration.

COMMENTS: Calcic Cu skarns are more economically important than magnesian Cu skarns. Cu skarns are broadly separable into those associated with strongly altered Cu-porphyry systems, and those associated with barren, generally unaltered stocks; a continuum probably exists between these two types (Einaudi *et al*., 1981). Copper skarn deposits related to mineralized Cu porphyry intrusions tend to be larger, lower grade, and emplaced at higher structural levels than those associated with barren stocks. Most Cu skarns contain oxidized mineral assemblages, and mineral zoning is common in the skarn envelope. Those with reduced assemblages can be enriched in W, Mo, Bi, Zn, As and Au. Over half of the 340 Cu skarn occurrences in British Columbia lie in the Wrangellia Terrane of the Insular Belt, while another third are associated with intraoceanic island arc plutonism in the Quesnellia and Stikinia terranes. Some alkalic and calcalkalic Cu and Cu-Mo porphyry systems in the province (e.g. Copper Mountain, Mount Polley) are associated with variable amounts of Cu-bearing skarn alteration. **In Yukon, Cu skarns of the Whitehorse Copper Belt are associated with plutonism in Stikine Terrane. Limestone of the Upper Triassic Aksala formation hosts the deposits.**

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Rock analyses may show Cu-Au-Ag-rich inner zones grading outward through Au-Ag zones with high Au:Ag ratios to an outer Pb-Zn-Ag zone. Co-As-Sb-Bi-Mo-W geochemical anomalies are present in the more reduced Cu skarn deposits.

GEOPHYSICAL SIGNATURE: Magnetic, electromagnetic and induced polarization anomalies.

ASSOCIATED DEPOSIT TYPES: Porphyry Cu deposits (L04), Au (K04), Fe (K03) and Pb-Zn (K02) skarns, and replacement Pb-Zn-Ag deposits (M01).

ECONOMIC FACTORS

GRADE AND TONNAGE: Average 1 to 2 % copper. Worldwide, they generally range from 1 to 100 Mt, although some exceptional deposits exceed 300 Mt. Craigmont, British Columbia's largest Cu skarn, contained approximately 34 Mt grading 1.3 % Cu. **Most deposits of the Whitehorse Copper Belt are smaller than a million tonnes, and gold grades are not reported. The Little Chief deposit contained 7.25 Mt grading 0.7 g/t Au and 13 g/t Ag.**

IMPORTANCE: Historically, these deposits were a major source of copper, although porphyry deposits have become much more important during the last 30 years. However, major Cu skarns are still worked throughout the world, including in China and the U.S.

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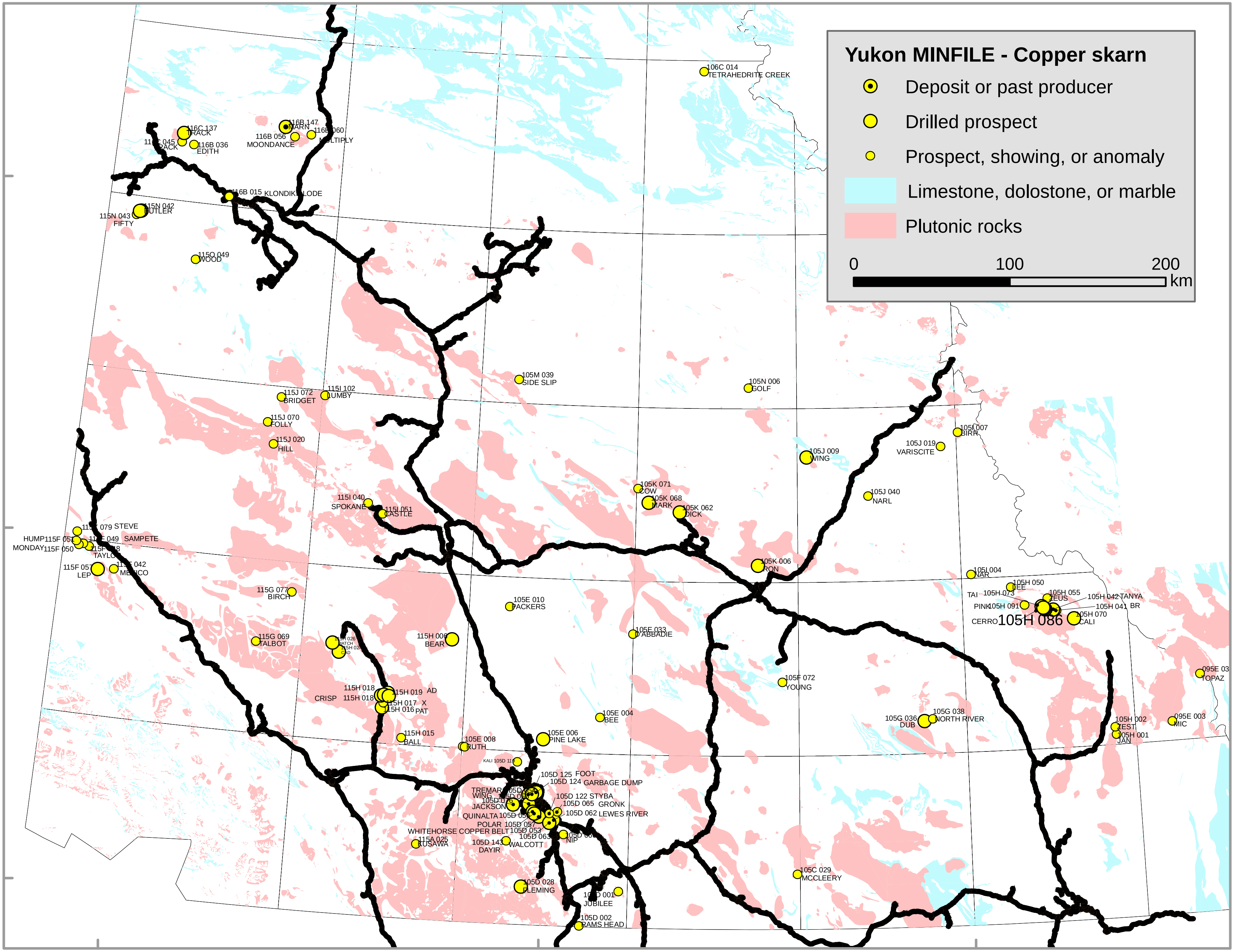
K01 - Cu Skarns - BC and Yukon deposits

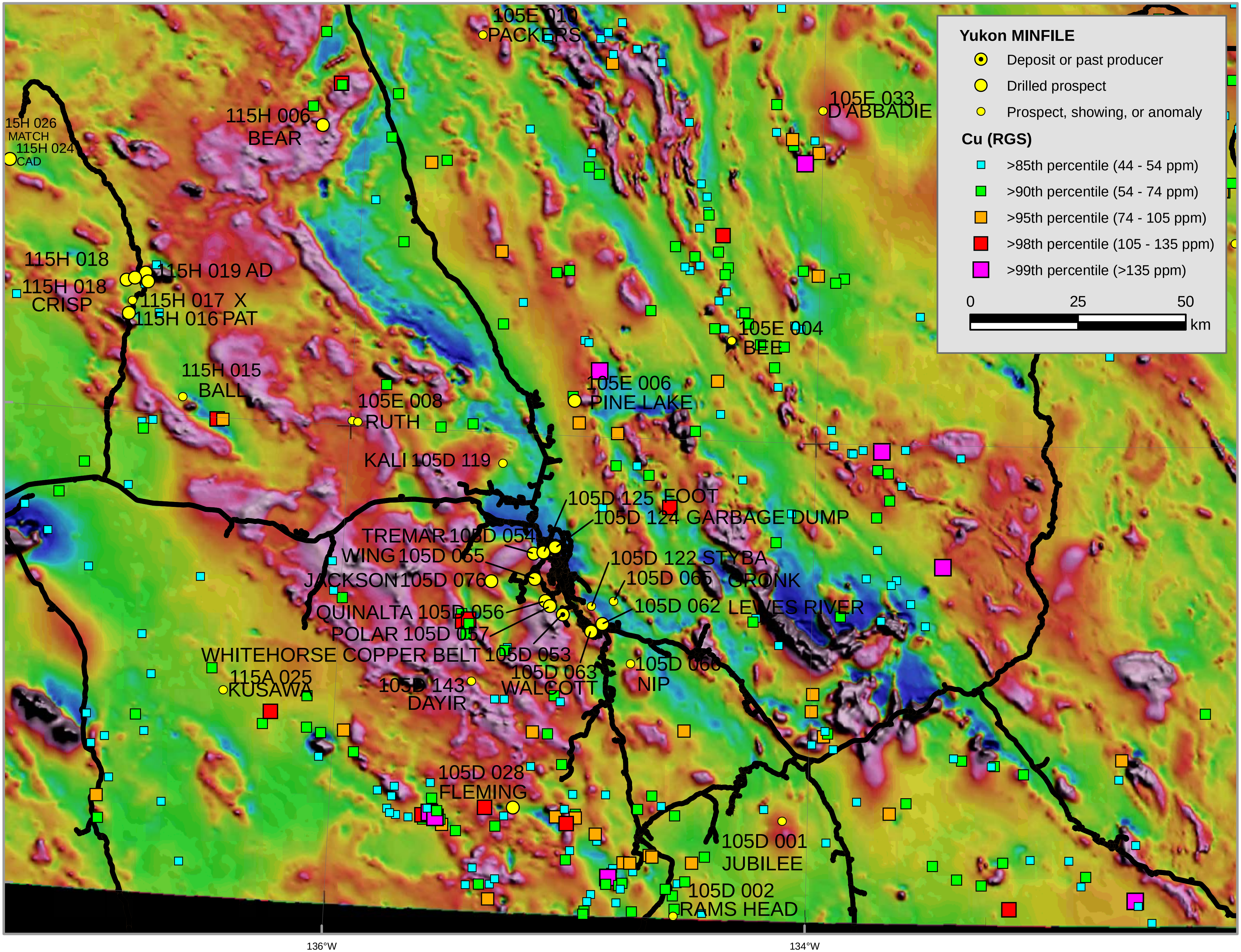
Deposit	country	tonnes	Au (g/t)	Ag (g/t)	Cu (%)
LILY	CNBC	36 085	3.82	64.33	2.56
QUEEN VICTORIA	CNBC	45 352	0.17	20.95	1.48
ORO DENORO	CNBC	124 001	0.94	7.69	1.36
YREKA	CNBC	145 334	0.34	31.22	2.71
EMMA	CNBC	241 538	0.88	10.08	0.97
LITTLE BILLIE	CNBC	245 133	10.10	30.26	1.81
BLUE GROUSE	CNBC	249 298	0.00	10.06	2.73
MARBLE BAY	CNBC	286 028	5.44	44.13	2.37
INDIAN CHIEF	CNBC	1 973 608	0.31	23.20	1.50
OLDSPORT BENS	CNBC	2 721 980	1.44	4.49	1.56
MOTHERLODE	CNBC	5 457 201	1.03	4.30	0.70
LONDONLODE	CNBC	6 500 000	0.00	0.00	0.66
PHOENIX	CNBC	23 006 360	1.35	8.52	1.09
CRAIGMONT	CNBC	33 514 360	0.00	0.01	1.20
MARN	CNYT	275 000	8.60	17.00	1.00
COWLEY PARK	CNYT	1 552 000	0.00	0.00	0.98
LITTLE CHIEF	CNYT	9 070 000	0.70	13.00	2.00
BLACK CUB	CNYT	187 000	0.00	12.34	1.30
GEM	CNYT	625 000	0.00	0.00	1.00
KEEWENAW	CNYT	361 000	0.00	0.00	1.00
ARCTIC CHIEF	CNYT	201 801	0.00	17.14	1.44
BEST CHANCE-GRAFTER	CNYT	459 200	0.00	0.00	0.85
PUEBLO	CNYT	127 635	0.00	0.00	3.50
WAR EAGLE	CNYT	899 900	0.00	8.63	1.25
COPPER KING-CARLISLE	CNYT	5 300	0.00	0.00	2.76

K01 - Cu Skarns - Yukon MINFILE

MINFILE	NAMES	STATUS
105D 053	WHITEHORSE COPPER	UNDERGROUND PAST PRODUCER
116B 147	MARN	DEPOSIT
105D 028	FLEMING	DRILLED PROSPECT
105D 054	TREMAR	DRILLED PROSPECT
105D 055	WING	DRILLED PROSPECT
105D 056	QUINALTA	DRILLED PROSPECT
105D 057	POLAR	DRILLED PROSPECT
105D 062	LEWES RIVER	DRILLED PROSPECT
105D 063	WALCOTT	DRILLED PROSPECT
105D 076	JACKSON, GROUSE	DRILLED PROSPECT
105D 124	GARBAGE DUMP	DRILLED PROSPECT
105D 125	FOOT,	DRILLED PROSPECT
105E 006	LABERGE, PINE LAKE	DRILLED PROSPECT
105K 006	OLGIE, SNOWCAP, SOUTH, EM, RON, MAL, CHAP, TER	DRILLED PROSPECT
105K 062	FLAGSTONE	DRILLED PROSPECT
105K 068	RESERVE	DRILLED PROSPECT
115F 048	TAYLOR, ARN	DRILLED PROSPECT
115F 051	AZ, HUMP	DRILLED PROSPECT
115F 057	LEP	DRILLED PROSPECT
115H 006	MACK'S COPPER, RANCH, EAGLENEST, BEAR	DRILLED PROSPECT
115H 016	GILTANA, PETE, GOOLDE HOPE, CHEIF, ANN, CON, PAT	DRILLED PROSPECT
115H 018	JANISIW, MYRTLE, DISCOVERY, PAN, CANYON, ANN	DRILLED PROSPECT
115H 019	HOPKINS, LEN, BARRY, BRIAN, HM, PONY, YUCCA, ACME	DRILLED PROSPECT
115H 024	SEKULMUN, CAD	DRILLED PROSPECT
115H 026	THATCH, HATCH, PATCH, MATCH, CATCH	DRILLED PROSPECT
115N 042	BUTLER	DRILLED PROSPECT
116C 137	TRACK, RAIL, ROAD, POINJAR	DRILLED PROSPECT
105D 200	ANACONDA, ZIRCON	PROSPECT
105H 001	JAN, GOLD, PRINCESS, PATRICIA, ZEBRA	PROSPECT
105O 010	HORN	PROSPECT
115F 049	SAMPETE	PROSPECT
115F 050	MONDAY	PROSPECT
115H 015	MORAINE, MOOSEHIDE, FOX, OX, BALL, AH, HIGHBALL	PROSPECT
115H 017	AISHIHIK, WILLOW, X, BLACK, VALLEY	PROSPECT
115K 079	NUTZOTIN, HENRY, FRANKIE, STEVE, GOLD, RJ	PROSPECT
116B 015	WEST DAWSON, #702, AVORA, KLONDIKE LODE, COPPER	PROSPECT
095E 003	ZORA, MIC, NOWA	SHOWING
105C 029	MCCLEERY	SHOWING
105D 001	JUBILEE	SHOWING
105D 065	GRONK	SHOWING
105D 066	NIP	SHOWING
105D 119	KALI, BYNG	SHOWING
105D 143	DAYIR	SHOWING
105E 008	RUTH	SHOWING
105E 010	PACKERS	SHOWING
105F 072	YOUNG	SHOWING
105G 038	NORTH RIVER	SHOWING
105H 002	MIDAS, LF, ZULU, ZEST, ZEBRA	SHOWING
105H 091	PINK	SHOWING
105I 007	BIRR	SHOWING
105J 019	VARISCITE	SHOWING
105M 039	SIDE SLIP	SHOWING
105N 006	GOLF	SHOWING
106C 014	TETRAHEDRITE CREEK	SHOWING
115A 025	KUSAWA, KUS, AWA	SHOWING
115F 042	MEXICO	SHOWING
115G 077	BIRCH	SHOWING
115O 049	WOOD	SHOWING
116B 056	TRIX, MOONDANCE	SHOWING
116B 060	MULTIPLY	SHOWING
116C 045	ETHELDA, ETHELDA COPPER	SHOWING
105D 199	OJ	ANOMALY
105E 033	D'ABBADIE	ANOMALY
105G 036	DUB	ANOMALY
115I 040	SPOKANE	ANOMALY
115N 043	FIFTY	ANOMALY
105D 122	STYBA	UNKNOWN
105E 004	BEE	UNKNOWN



Map of Yukon showing Cu skarn occurrences and the distribution of plutonic and carbonate rocks



Map of the Whitehorse region showing Cu skarn occurrences, Cu regional geochemistry and regional magnetics

Pb-Zn SKARNS K02

by Gerald E. Ray[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Pyrometasomatic or contact metasomatic Pb-Zn deposits.

COMMODITIES (*BYPRODUCTS*): Pb, Zn, Ag (*Cu, Cd, W, Au*).

EXAMPLES **(Yukon): Mount Hundere (Sa Dena Hes 105A 012; Ritco; 105A 013)**; (British Columbia - *Canada/International*): Piedmont (082FNW 129), Contact (104P 004), *Groundhog (New Mexico, USA), Darwin (California, USA) San Antonio, Santa Eulalia and Naica (Mexico), Yeonhwa-Ulchin deposits (South Korea), Nakatatsu deposits (Japan), Shuikoushan and Tienpaoshan (China).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Galena and/or sphalerite-dominant mineralization genetically associated with a skarn gangue.

TECTONIC SETTING: Along continental margins where they are associated with late orogenic plutonism. Pb-Zn skarns occur at a wide range of depths, being associated with subvolcanic aphanitic dykes and high-level breccia pipes, as well as deep-level batholiths. In British Columbia, some Pb-Zn skarns are found in oceanic island arcs where they form distally to larger calcic Fe or Cu skarn systems.

AGE OF MINERALIZATION: Mainly Mesozoic, but may be any age. In British Columbia, the 80 Pb-Zn skarn occurrences identified have a wide age range; over 40 % are Early to mid-Jurassic, 22 % are Cretaceous, and a further 17 % are Eocene-Oligocene in age. **In Yukon, the majority of lead-zinc skarn occurrences are associated with mid-Cretaceous plutonic rocks.**

HOST/ASSOCIATED ROCK TYPES: Variable; from high-level skarns in thick limestones, calcareous tuffs and sediment to deeper level skarns in marbles and calcsilicate-bearing migmatites. Associated intrusive rocks are granodiorite to leucogranite, diorite to syenite (mostly quartz monzonite). Pb-Zn skarns tend to be associated with small stocks, sills and dykes and less commonly with larger plutons. The composition of the intrusions responsible for many distal Pb-Zn skarns is uncertain.

DEPOSIT FORM: Variable; commonly occurs along igneous or stratigraphic contacts. Can develop as subvertical chimneys or veins along faults and fissures and as subhorizontal blankets. Pb-Zn skarn deposits formed either at higher structural levels or distal to the intrusions tend to be larger and more Mn-rich compared to those formed at greater depths or more proximal.

TEXTURES: Igneous textures in endoskarn. Coarse to fine-grained, massive granoblastic to mineralogically layered textures in exoskarn.

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[1] British Columbia Geological Survey, Victoria, B.C., Canada

ORE MINERALOGY (Principal and *subordinate*): Sphalerite ± galena ± pyrrhotite ± pyrite ± magnetite ± arsenopyrite ± chalcopyrite ± bornite. Other trace minerals reported include *scheelite, bismuthinite, stannite, cassiterite, tetrahedrite, molybdenite, fluorite, and native gold*. Proximal skarns tend to be richer in Cu and W, whereas distal skarns contain higher amounts of Pb, Ag and Mn.

ALTERATION MINERALOGY: Exoskarn alteration: Mn-rich hedenbergite (Hd30-90, Jo10-50), andraditic garnet (Ad20-100, Spess2-10) ± wollastonite ± bustamite ± rhodonite. Late-stage Mn-rich actinolite ± epidote ± ilvaite ± chlorite ± dannermorite ± rhodochrosite ± axinite. Endoskarn alteration: highly variable in development, and in many of the distal Pb-Zn skarns the nature of the endoskarn is unknown. However, Zn-rich skarns formed near stocks are often associated with abundant endoskarn that may equal or exceed the exoskarn (Einaudi et al., 1981). Endoskarn mineralogy is dominated by epidote ± amphibole ± chlorite ± sericite with lesser rhodonite ± garnet ± vesuvianite ± pyroxene ± K-feldspar ± biotite and rare topaz. Marginal phases may contain greisen and/or tourmaline.

ORE CONTROLS: Carbonate rocks, particularly along structural and/or lithological contacts (e.g. shale-limestone contacts or pre-ore dikes). Deposits may occur considerable distances (100-1000 m) from the source intrusions.

ASSOCIATED DEPOSIT TYPES: Pb-Zn-Ag veins (I05), Cu skarns (K01) and Cu porphyries (L03, L04). In B.C. small Pb-Zn skarns occur distally to some Fe (K03) and W (K04) skarns.

COMMENTS: Pb-Zn skarn occurrences are preferentially developed in: (1) continental margin sedimentary rocks of the Cassiar and Ancestral North America terranes, (2) oceanic island arc rocks of the Quesnellia and Stikinia terranes, and (3) arc rocks of the Wrangellia Terrane. Their widespread terrane distribution partly reflects their formation as small distal mineralized occurrences related to other skarns (notably Cu, Fe and W skarns), as well as some porphyry systems. British Columbia is endowed with some large and significant Pb-Zn reserves classified as manto deposits (Nelson, 1991; Dawson et al., 1991). These deposits lack skarn gangue, but are sometimes grouped with the Pb-Zn skarns.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Pb, Zn, Ag, Cu, Mn, As, Bi, W, F, Sn, Mo, Co, Sb, Cd and Au geochemical anomalies.

GEOPHYSICAL SIGNATURE: Generally good induced polarization response. Galena-rich ore bodies may be marked by gravity anomalies whereas pyrrhotite-rich mineralization may be detected by magnetic surveys. CS-AMT may also be a useful exploration system.

OTHER EXPLORATION GUIDES: Thick limestones distal to small granitoid stocks; structural traps and lithological contacts; exoskarns with low garnet/pyroxene ratios.

ECONOMIC FACTORS

GRADE AND TONNAGE: Pb-Zn skarns tend to be small (<3 Mt) but can reach 45 Mt, grading up to 15 % Zn, 10 % Pb and > 150 g/t Ag with substantial Cd. Cu grades are generally < 0.2 %. Some deposits (e.g. Naica (Mexico) and Falun (Sweden)) contain Au. The 80 British Columbia Pb-Zn skarn occurrences are generally small and have had no major metal production. **The Sa Dena Hes deposit in Yukon had proven and probable reserves of 3.9 Mt (pre-production) grading 3.9% Pb, 12.7% Zn, and 58 g/t Ag prior to mining.**

IMPORTANCE: Important past and current producers exist in Mexico, China, U.S.A (New Mexico and California), and Argentina. No large productive Pb-Zn skarns have been discovered in B.C.

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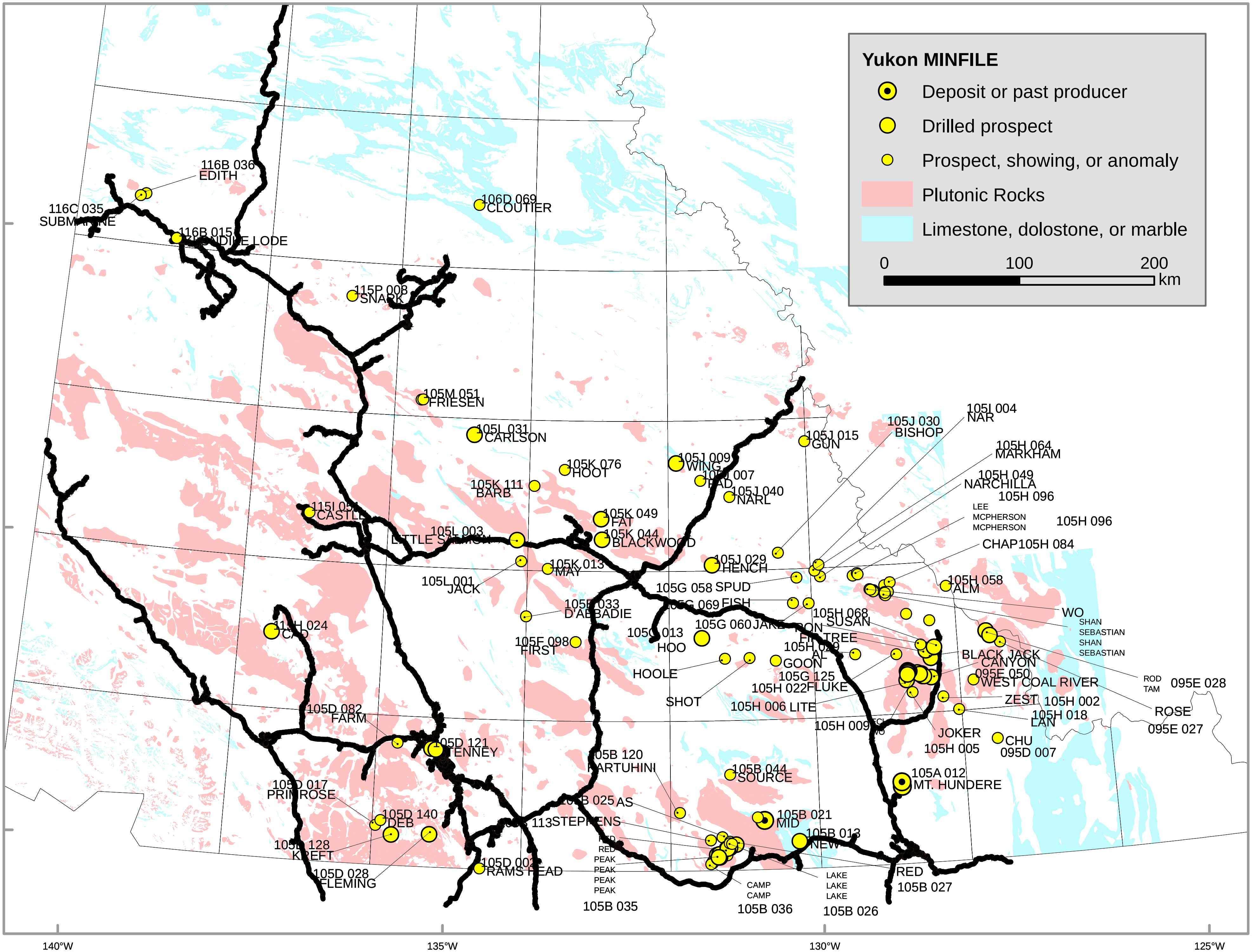
K02 - Pb-Zn Skarns - BC and Yukon deposits

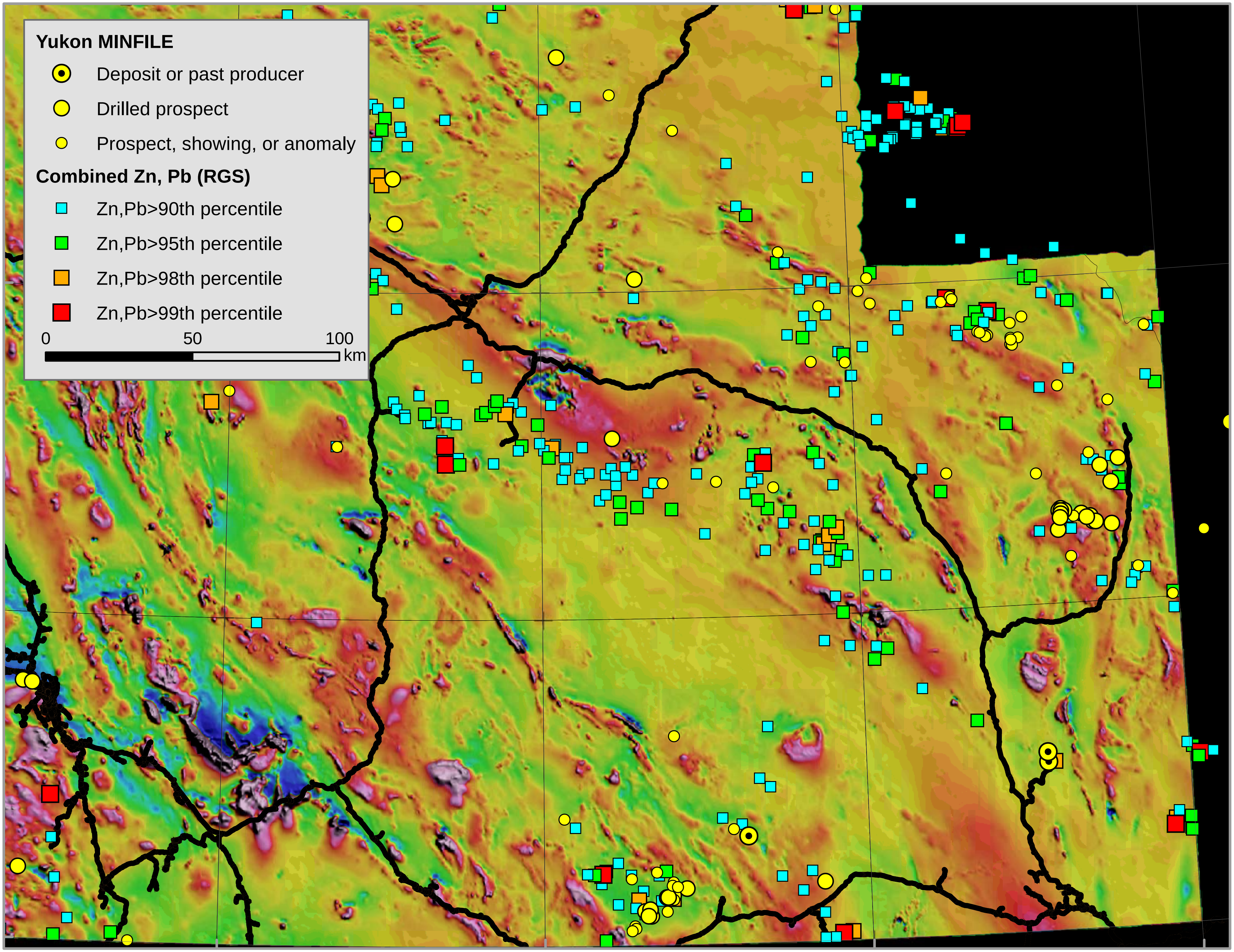
Deposit	country	tonnes	Ag (g/t)	Pb (%)	Zn (%)
CALEDONIA	CNBC	68 001	6.04	0.06	7.45
SMITH COPPER	CNBC	83 906	1.69	3.70	12.50
MT. HUNDERE (Ritco)	CNYK	2 440 000	44.90	1.10	12.60
MT. HUNDERE (Sa Dena Hess)	CNYK	2 900 000	65.00	8.40	12.90

Yukon MINFILE

MINFILE	NAMES	STATUS
105A 012	SA DENA HES, MT. HUNDERE	UNDERGROUND PAST PRODUCER
105A 013	RITCO, NORTH HILL, MT. HUNDERE, SA DENA HES	UNDERGROUND PAST PRODUCER
095E 012	HEATHER, TAM, SUD, ROD	DRILLED PROSPECT
095E 028	GRISWOLD, HEATHER, KEY, TAM, RIO	DRILLED PROSPECT
105B 013	KUBIAK, NEW, HAT	DRILLED PROSPECT
105B 026	ATOM, CRESENT LAKE	DRILLED PROSPECT
105B 027	BAR, DAN, WINDOW	DRILLED PROSPECT
105B 028	BOM, STQ, BOUND	DRILLED PROSPECT
105B 029	MUNSON, TBMB	DRILLED PROSPECT
105B 035	GODDART, DEAR, PEAK	DRILLED PROSPECT
105D 128	KREFT	DRILLED PROSPECT
105G 013	HOO	DRILLED PROSPECT
105G 125	GOON	DRILLED PROSPECT
105H 005	FLIP	DRILLED PROSPECT
105H 006	DC, DAY, EGG, TOBY, SUZANNE, LITE, TIE	DRILLED PROSPECT
105H 008	MIKO, MON, MARINA	DRILLED PROSPECT
105H 009	GLENNA, LAKE, CU, ACE, ECL, MARG, ARM	DRILLED PROSPECT
105H 011	MAX	DRILLED PROSPECT
105H 024	CANYON	DRILLED PROSPECT
105H 028	BLACK JACK	DRILLED PROSPECT
105H 029	FIR TREE	DRILLED PROSPECT
105H 050	LEE, PRIMO	DRILLED PROSPECT
105I 004	NAR	DRILLED PROSPECT
105J 009	RIDDELL, BOX, WING	DRILLED PROSPECT
105J 029	HENCH	DRILLED PROSPECT
105K 044	BLACKWOOD	DRILLED PROSPECT
105L 003	LITTLE SALMON	DRILLED PROSPECT
105L 031	CARLSON	DRILLED PROSPECT
105B 022	AURORA, TOUCHDOWN	PROSPECT
105D 140	DEB, ROSE	PROSPECT
105G 069	HARMAN, IRENE, FISH	PROSPECT
105H 018	GALE, LAN	PROSPECT
105H 031	RON	PROSPECT
105H 033	BROD	PROSPECT
105J 030	MARYLOU, BISHOP	PROSPECT
105K 013	THOMAS, LIL, MAY	PROSPECT
105L 001	LOKKEN, JACK	PROSPECT
106D 069	CLOUTIER	PROSPECT
116B 036	ROAL, MANOA, GALENA, EDITH	PROSPECT
095D 007	CHU	SHOWING
095E 050	WEST COAL RIVER	SHOWING
105B 031	MOD, BOUND	SHOWING
105B 036	SCREW	SHOWING
105B 044	IRVINE, ANGIE, COM, SOURCE	SHOWING
105B 113	STEPHENS	SHOWING
105B 120	KARTUHINI	SHOWING
105D 017	PRIMROSE	SHOWING
105D 082	FARM	SHOWING
105G 058	SPUD	SHOWING
105G 060	JAKE	SHOWING
105G 061	HOOLE	SHOWING
105G 119	SHOT	SHOWING
105H 010	STEELE, ELSA, ACE, ECL, MAR, WO, SCHEE, INN	SHOWING
105H 019	MAY, PJ, KAY, APEX, FRAN, AL, JA LO	SHOWING
105H 022	FLUKE	SHOWING
105H 037	TOY	SHOWING
105H 064	MARKHAM	SHOWING
105H 089	WO	SHOWING
105H 092	SHAN	SHOWING
105H 093	SEBASTIAN	SHOWING
105H 094	MT. BILLINGS	SHOWING
105H 096	MCPHERSON	SHOWING
105J 015	GUN	SHOWING
105J 040	NARL	SHOWING
116C 035	SUBMARINE, ROUGH NECK KID	SHOWING
105B 025	HIDDEN	ANOMALY
105K 076	HOOT	ANOMALY
105H 058	ALM	UNKNOWN



Map of Yukon showing Pb-Zn skarn occurrences and the distribution of plutonic and carbonate rocks



Map of southeast Yukon showing Pb-Zn skarn occurrences, Pb-Zn regional geochemistry and regional magnetics

W SKARNS K05

by Gerald E. Ray[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Pyrometasomatic or contact metasomatic tungsten deposits.

COMMODITIES (*BYPRODUCTS*): W (*Mo, Cu, Sn, Zn*).

EXAMPLES: **(Yukon): Bailey (105A 017), Stormy (105F 011), Risby (105F 034), Mactung (105O 002), Ray Gulch (106D 027)**; (British Columbia - *Canada/International*): Emerald Tungsten (082FSW010), Dodger (082FSW011), Feeney (082FSW247), Invincible (082FSW218), Dimac (082M123); *Fostung (Ontario, Canada), Cantung (Northwest Territories, Canada), Pine Creek and Strawberry (California, USA), Osgood Range (Nevada, USA), King Island (Tasmania, Australia), Sang Dong (South Korea).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Scheelite-dominant mineralization genetically associated with a skarn gangue.

TECTONIC SETTING: Continental margin, synorogenic plutonism intruding deeply buried sequences of eugeoclinal carbonate-shale sedimentary rocks. Can develop in tectonically thickened packages in back-arc thrust settings.

GEOLOGICAL SETTING: MacTung and CanTung in Yukon and NWT, the two largest tungsten deposits in the Northern Cordillera, are hosted by rocks of the Selwyn Basin, near the edge of the Mackenzie Platform.

AGE OF MINERALIZATION: Mainly Mesozoic, but may be any age. Over 70% of the W skarns in British Columbia are related to Cretaceous intrusions. **In Yukon, most tungsten occurrences are related to Cretaceous intrusions. Two tungsten anomalies in northern Yukon are associated with Devonian intrusive rocks, and may be related to tungsten skarns.**

HOST/ASSOCIATED ROCK TYPES: Pure and impure limestones, calcareous to carbonaceous pelites. Associated with tonalite, granodiorite, quartz monzonite and granite of both I and S-types. W skarn-related granitoids, compared to Cu skarn-related plutonic rocks, tend to be more differentiated, more contaminated with sedimentary material, and have crystallized at a deeper structural level. **Silty-banded limestone of Upper Proterozoic to Early Cambrian Yusezyu Formation and Cambro-Ordovician Rabbitkettle Formation host the most significant tungsten skarn deposits in Yukon.**

[1] British Columbia Geological Survey, Victoria, B.C., Canada

DEPOSIT FORM: Stratiform, tabular and lens-like ore bodies. Deposits can be continuous for hundreds of metres and follow intrusive contacts.

TEXTURES: Igneous textures in endoskarn. Coarse-to fine-grained, massive granoblastic to mineralogically layered textures in exoskarn. Biotite hornfelsic textures common.

ORE MINERALOGY (Principal and *subordinate*): Scheelite ± molybdenite ± chalcopyrite ± pyrrhotite ± sphalerite ± arsenopyrite ± pyrite ± powellite. May contain *trace wolframite, fluorite, cassiterite, galena, marcasite and bornite*. Reduced types are characterized by pyrrhotite, magnetite, bismuthinite, native bismuth and high pyrrhotite:pyrite ratios. Variable amounts of quartz-vein stockwork (with local molybdenite) can cut both the exo- and endoskarn. The Emerald Tungsten skarns in British Columbia include pyrrhotite-arsenopyrite veins and pods that carry up to 4 g/t Au.

ALTERATION MINERALOGY: Exoskarn alteration: Inner zone of diopside-hedenbergite (Hd_{60-90}, Jo_{5-20}) ± grossular-andradite (Ad_{10-50}, $Spess_{5-50}$) ± biotite ± vesuvianite, with outer barren wollastonite-bearing zone. An innermost zone of massive quartz may be present. Late-stage spessartine ± almandine ± biotite ± amphibole ± plagioclase ± phlogopite ± epidote ± fluorite ± sphene. Reduced types are characterized by hedenbergitic pyroxene, Fe-rich biotite, fluorite, vesuvianite, scapolite and low garnet:pyroxene ratios, whereas oxidized types are characterized by salitic pyroxene, epidote and andraditic garnet and high garnet:pyroxene ratios. Exoskarn envelope can be associated with extensive areas of biotite hornfels. Endoskarn alteration: Pyroxene ± garnet ± biotite ± epidote ± amphibole ± muscovite ± plagioclase ± pyrite ± pyrrhotite ± trace tourmaline and scapolite; local greisen developed.

ORE CONTROLS: Carbonate rocks in extensive thermal aureoles of intrusions; gently inclined bedding and intrusive contacts; structural and/or stratigraphic traps in sedimentary rocks, and irregular parts of the pluton/country rock contacts.

ASSOCIATED DEPOSIT TYPES: Sn (K06), Mo (K07) and Pb-Zn (K02) skarns. Wollastonite-rich industrial mineral skarns (K09).

COMMENTS: W skarns are separable into two types (Newberry, 1982): reduced skarns (e.g. Cantung, Mactung), formed in carbonaceous rocks and/or at greater depths, and oxidized skarns (e.g. King Island), formed in hematitic or non-carbonaceous rocks, and/or at shallower depths. Late retrograde alteration is an important factor in many W skarns because, during retrogression, the early low-grade mineralization is often scavenged and redeposited into economic high-grade ore zones (e.g. Bateman, 1945; Dick, 1976, 1980). Dolomitic rocks tend to inhibit the development of W skarns; consequently magnesian W skarns are uncommon. In British Columbia they are preferentially associated with Cretaceous intrusions and hosted by calcareous, Cambrian age cratonic, pericratonic and displaced continental margin rocks in the Cassiar, Kootenay-Barkerville, Dorsay and Ancestral North American terranes. **In Yukon and Northwest Territories, tungsten skarn deposits are preferentially associated with Cambro-Ordovician Rabbitkettle Formation silty limestone intruded by mid-Cretaceous granitic rocks.**

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: W, Cu, Mo, As, Bi and B. Less commonly Zn, Pb, Sn, Be and F geochemical anomalies.

ECONOMIC FACTORS

GRADE AND TONNAGE: Grades range between 0.4 and 2 % WO_3 (typically 0.7 %). Deposits vary from 0.1 to >30 Mt. **The MacTung deposit in Yukon contains reserves of 25.3 million tonnes grading 0.88% WO_3.**

IMPORTANCE: Skarn deposits have accounted for nearly 60 % of the western world's production, and over 80 % of British Columbia's production.

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K05 - W Skarns - BC, Yukon and NWT deposits

Deposit	Country	tonnes	WO_3
Clea	CNYT	100 000	1.50
Baker	CNNT	120 000	1.40
Bailey	CNYT	405 455	1.00
Lened	CNNT	1 000 000	1.20
Salmo District	CNBC	1 500 000	0.50
Risby	CNYT	2 700 000	0.81
Ray Gulch	CNYT	5 440 000	0.82
Cantung	CNNT	9 000 000	1.42
Fostung	CNON	16 200 000	0.23
Mac Tung	CNYT	63 000 000	0.96

Yukon MINFILE

MINFILE	NAMES	STATUS
105A 017	BAILEY, PAT	DEPOSIT
105F 011	STORMY	DEPOSIT
105F 034	RISBY	DEPOSIT
105O 002	MACTUNG	DEPOSIT
106D 027	GARNET, RAY GULCH	DEPOSIT
095E 005	ISO, BLUE, KOKO, OLLIE, CAR, JEFF, HAT, LABELLE	DRILLED PROSPECT
095E 031	IVO	DRILLED PROSPECT
105B 004	FIDDLER, BACH, TUNGSTEN, LUM, HOPE, LUCK	DRILLED PROSPECT
105B 020	BLUE HEAVEN, NIGHT, NITE	DRILLED PROSPECT
105C 036	MULLIGAN	DRILLED PROSPECT
105F 037	EVA	DRILLED PROSPECT
105F 092	AYDUCK	DRILLED PROSPECT
105G 019	BOOT	DRILLED PROSPECT
105G 104	SANDERS	DRILLED PROSPECT
105H 042	TANYA	DRILLED PROSPECT
105H 068	SUSAN	DRILLED PROSPECT
105H 070	CALI	DRILLED PROSPECT
105H 072	WOAH	DRILLED PROSPECT
105H 073	TAI	DRILLED PROSPECT
105I 006	CLEA, HI-MIN, OMO	DRILLED PROSPECT
105J 007	DRAGON, PAD	DRILLED PROSPECT
105L 040	FELIX	DRILLED PROSPECT
105L 051	DROMEDARY	DRILLED PROSPECT
105M 038	TWO BUTTES	DRILLED PROSPECT
105M 060	NEWRY, AUREX	DRILLED PROSPECT
105N 014	TONGUE	DRILLED PROSPECT
106D 084	BLUELITE	DRILLED PROSPECT
115P 012	RHOSGOBEL	DRILLED PROSPECT
095E 027	DOOSHKA, ROSE	PROSPECT
095E 032	UPPER COAL, CHARLIE	PROSPECT
095E 036	ROYALL, CREAM	PROSPECT
105B 115	STONEAXE	PROSPECT
105F 033	HAM	PROSPECT
105F 114	BIG SAM	PROSPECT
105G 071	MYDA	PROSPECT
105H 026	TERRY	PROSPECT
105H 049	NARCHILLA	PROSPECT
105H 059	BUS	PROSPECT
105J 014	PREVOST	PROSPECT
105M 040	GREAT HORN	PROSPECT
105M 051	FRIESEN	PROSPECT
115P 009	LUGDUSH, SPUD	PROSPECT
095E 021	CAESER	SHOWING
095E 039	KOMISH, TOPAZ, BING	SHOWING
105A 019	CANADA	SHOWING
105B 046	TUNG, ON, J	SHOWING
105B 089	TOOTSEE, HOT, ERIC, CARL	SHOWING
105B 097	URP	SHOWING
105B 104	TEAM	SHOWING
105B 106	URSUS	SHOWING
105B 126	ELECTRICITY, ELLE	SHOWING
105E 030	SALMON	SHOWING
105E 031	HITCHENS	SHOWING
105F 078	PIMPLE	SHOWING
105F 084	LAP	SHOWING
105F 094	OBVIOUS	SHOWING
105F 097	KIDLARK	SHOWING
105F 098	FIRST	SHOWING
105G 097	FOG	SHOWING
105G 102	HOWDEE	SHOWING
105H 025	STU	SHOWING
105H 041	BR	SHOWING
105H 043	GUY	SHOWING
105H 051	YUSEZYU	SHOWING
105H 055	ZEUS	SHOWING
105H 056	CARBIDE, AURORA	SHOWING
105H 077	ZEUT	SHOWING
105H 084	CHAP	SHOWING
105H 086	CERRO	SHOWING
105H 088	BILLINGS	SHOWING
105H 090	WE	SHOWING
105H 098	ANDERSON	SHOWING
105H 099	BROTEN	SHOWING
105H 100	MINI	SHOWING
105I 064	ROOK	SHOWING
105J 036	GULF	SHOWING
105K 111	UNION, STONE, BARB	SHOWING
105L 022	TUMMEL	SHOWING
105M 044	ROOP	SHOWING
105N 013	PLEASANT	SHOWING
105O 043	SIM	SHOWING
105O 044	NUT	SHOWING
106D 005	FLAT RIDGE	SHOWING
115G 063	ELEVEN-THIRTY	SHOWING
115G 064	KENNEDY	SHOWING
095E 034	SNEET, SNOT	ANOMALY
095E 040	VNER	ANOMALY
105B 047	CABIN, ELLE	ANOMALY
105I 059	PHEASCO	ANOMALY
115O 095	GLEESON	ANOMALY
095D 018	OUDDER	UNKNOWN
095D 022	HERPES	UNKNOWN
105B 093	RALFS, CABIN	UNKNOWN
105H 030	MONTSE	UNKNOWN
105H 032	HELEN	UNKNOWN

K05 - W Skarns - Yukon MINFILE

MINFILE	NAMES	STATUS
105A 017	BAILEY, PAT	DEPOSIT
105F 011	STORMY	DEPOSIT
105F 034	RISBY	DEPOSIT
105O 002	MACTUNG	DEPOSIT
106D 027	GARNET, RAY GULCH	DEPOSIT
095E 005	ISO, BLUE, KOKO, OLLIE, CAR, JEFF, HAT, LABELLE	DRILLED PROSPECT
095E 031	IVO	DRILLED PROSPECT
105B 004	FIDDLER, BACH, TUNGSTEN, LUM, HOPE, LUCK	DRILLED PROSPECT
105B 020	BLUE HEAVEN, NIGHT, NITE	DRILLED PROSPECT
105C 036	MULLIGAN	DRILLED PROSPECT
105F 037	EVA	DRILLED PROSPECT
105F 092	AYDUCK	DRILLED PROSPECT
105G 019	BOOT	DRILLED PROSPECT
105G 104	SANDERS	DRILLED PROSPECT
105H 042	TANYA	DRILLED PROSPECT
105H 068	SUSAN	DRILLED PROSPECT
105H 070	CALI	DRILLED PROSPECT
105H 072	WOAH	DRILLED PROSPECT
105H 073	TAI	DRILLED PROSPECT
105I 006	CLEA, HI-MIN, OMO	DRILLED PROSPECT
105J 007	DRAGON, PAD	DRILLED PROSPECT
105L 040	FELIX	DRILLED PROSPECT
105L 051	DROMEDARY	DRILLED PROSPECT
105M 038	TWO BUTTES	DRILLED PROSPECT
105M 060	NEWRY, AUREX	DRILLED PROSPECT
105N 014	TONGUE	DRILLED PROSPECT
106D 084	BLUELITE	DRILLED PROSPECT
115P 012	RHOSGOBEL	DRILLED PROSPECT
095E 027	DOOSHKA, ROSE	PROSPECT
095E 032	UPPER COAL, CHARLIE	PROSPECT
095E 036	ROYALL, CREAM	PROSPECT
105B 115	STONEAXE	PROSPECT
105F 033	HAM	PROSPECT
105F 114	BIG SAM	PROSPECT
105G 071	MYDA	PROSPECT
105H 026	TERRY	PROSPECT
105H 049	NARCHILLA	PROSPECT
105H 059	BUS	PROSPECT
105J 014	PREVOST	PROSPECT
105M 040	GREAT HORN	PROSPECT
105M 051	FRIESEN	PROSPECT
115P 009	LUGDUSH, SPUD	PROSPECT
095E 021	CAESER	SHOWING
095E 039	KOMISH, TOPAZ, BING	SHOWING
105A 019	CANADA	SHOWING
105B 046	TUNG, ON, J	SHOWING
105B 089	TOOTSEE, HOT, ERIC, CARL	SHOWING
105B 097	URP	SHOWING
105B 104	TEAM	SHOWING
105B 106	URSUS	SHOWING
105B 126	ELECTRICITY, ELLE	SHOWING
105E 030	SALMON	SHOWING
105E 031	HITCHENS	SHOWING
105F 078	PIMPLE	SHOWING
105F 084	LAP	SHOWING
105F 094	OBVIOUS	SHOWING
105F 097	KIDLARK	SHOWING
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105G 097	FOG	SHOWING
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105H 041	BR	SHOWING
105H 043	GUY	SHOWING
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105H 055	ZEUS	SHOWING
105H 056	CARBIDE, AURORA	SHOWING
105H 077	ZEUT	SHOWING
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105H 086	CERRO	SHOWING
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105H 090	WE	SHOWING
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105H 100	MINI	SHOWING
105I 064	ROOK	SHOWING
105J 036	GULF	SHOWING
105K 111	UNION, STONE, BARB	SHOWING
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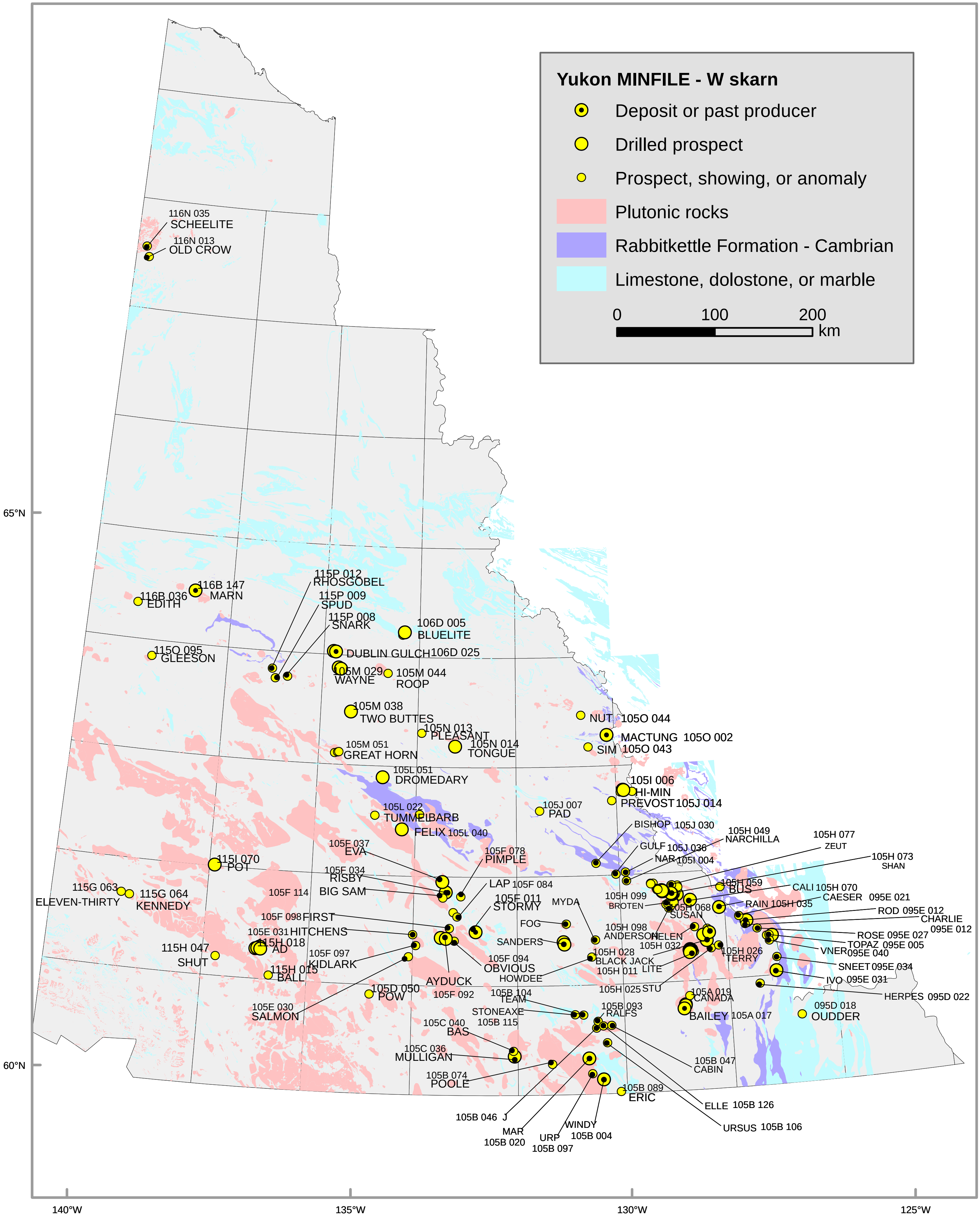
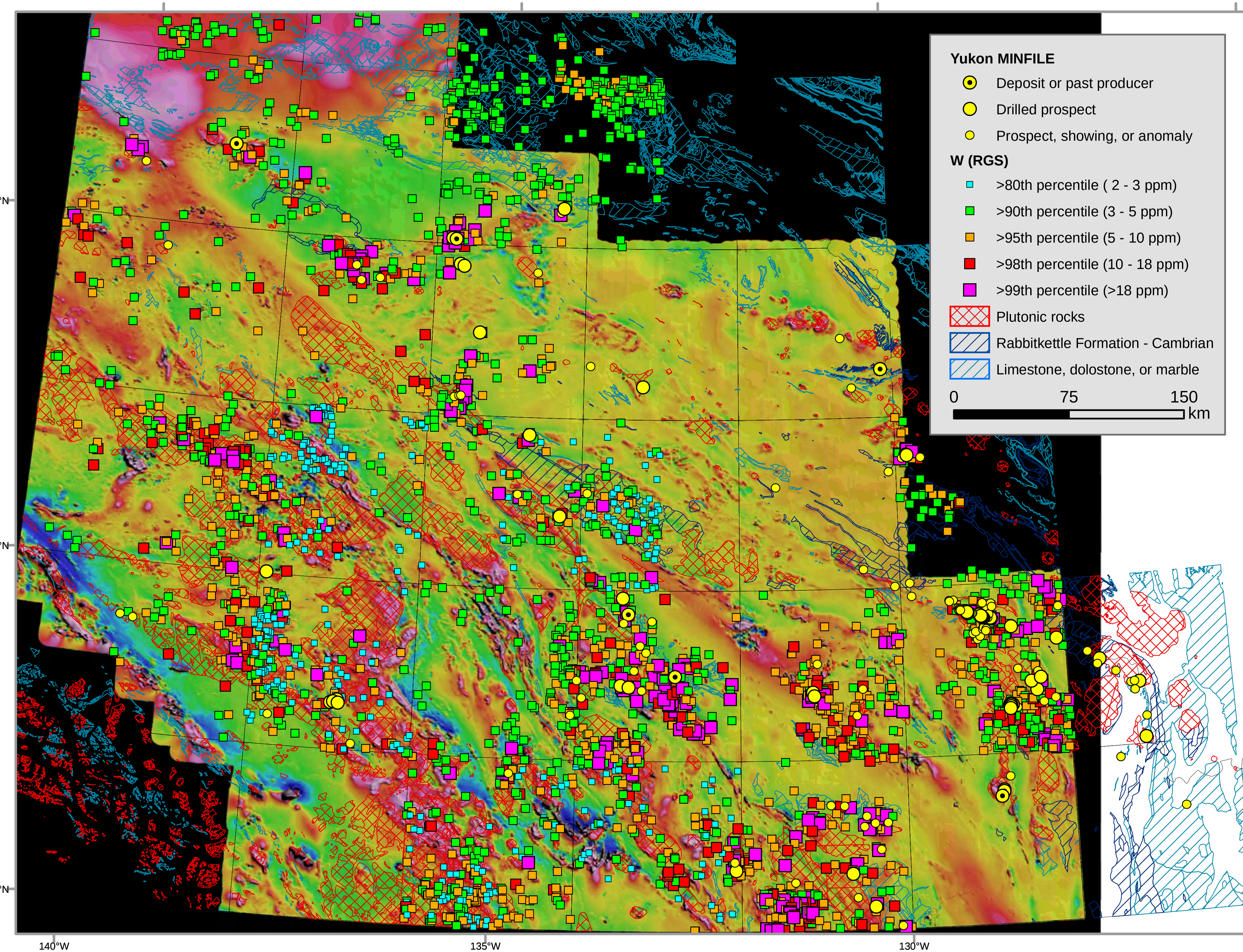
095E 040	VNER	ANOMALY
105B 047	CABIN, ELLE	ANOMALY
105I 059	PHEASCO	ANOMALY
115O 095	GLEESON	ANOMALY
095D 018	OUDDER	UNKNOWN
095D 022	HERPES	UNKNOWN
105B 093	RALFS, CABIN	UNKNOWN
105H 030	MONTSE	UNKNOWN
105H 032	HELEN	UNKNOWN



Map of Yukon showing W-skarn occurrences and the distribution of plutonic rocks, carbonate rocks and the Rabbitkettle Formation



Map of Yukon showing W skarn occurrences, W geochemistry, regional magnetics and the distribution of plutonic rocks, carbonate rocks and the Rabbitkettle Formation

Sn SKARNS K06

by Gerald E. Ray[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Pyrometasomatic or contact metasomatic tin deposits.

COMMODITIES (*BYPRODUCTS*): Sn (*W, Zn, magnetite*).

EXAMPLES: **(Yukon): JC (105B 040)**;
(British Columbia - *Canada/International*): Only three in British Columbia - Silver Diamond, Atlin Magnetite, and Daybreak (104N069, 126 and 134 respectively); *JC (Yukon, Canada), Moina, Mount Lindsay, Hole 16 and Mt. Garnet (Tasmania, Australia), Lost River (Alaska, USA).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Cassiterite-dominant mineralization genetically associated with a skarn gangue (includes calcic and magnesian Sn skarns).

TECTONIC SETTINGS: Late to post orogenic granites emplaced into thick and deeply buried continental margin sedimentary sequences, or sequences in rifted or stable cratonic environments.

AGE OF MINERALIZATION: Most economic deposits are Mesozoic or Paleozoic, but occurrences may be any age (the occurrences in British Columbia are Late Cretaceous). **The JC deposit and other Sn prospects in southern Yukon are mid-Cretaceous, and associated with the Seagull Batholith.**

HOST/ASSOCIATED ROCK TYPES: Carbonates and calcareous sedimentary sequences. Associated with differentiated (low Ca, high Si and K) ilmenite-series granite, adamellite and quartz monzonitic stocks and batholiths (of both I and S-type) intruding carbonate and calcareous clastic rocks. Sn skarns tend to develop in reduced and deep-level environments and may be associated with greisen alteration.

DEPOSIT FORM: Variable; can occur as either stratiform, stockwork, pipe-like or irregular vein-like orebodies.

TEXTURES: Igneous textures in endoskarn. Coarse-to fine-grained, massive granoblastic to mineralogically layered textures in exoskarn; wrigglite skarns contain thin rhythmic and alternating layers rich in either magnetite, fluorite, vesuvianite or tourmaline. Some hornfelsic textures.

ORE MINERALOGY: Cassiterite ± scheelite ± arsenopyrite ± pyrrhotite ± chalcopyrite ± stannite ± magnetite ± bismuthinite ± sphalerite ± pyrite ± ilmenite.

ALTERATION MINERALOGY: Exoskarn alteration: grandite garnet (Ad_{15-75}, $Pyralsp_{5-30}$) (locally Sn, F, and Be enriched), hedenbergitic pyroxene (Hd_{40-95}) ± vesuvianite (sometimes Sn and F-enriched)

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[1] British Columbia Geological Survey, Victoria, B.C., Canada

± malayaite ± Fe and/or F-rich biotite ± stanniferous sphene ± gahnite ± rutile ± Sn-rich ilvaite ± wollastonite ± adularia. Late minerals include muscovite, Fe-rich biotite, chlorite, tourmaline, fluorite, sellaite, stilpnomelane, epidote and amphibole (latter two minerals can be Sn rich). Associated greisens include quartz and muscovite ± tourmaline ± topaz ± fluorite ± cassiterite ± sulphide minerals. Magnesian Sn skarns can also contain olivine, serpentine, spinel, ludwigite, talc and brucite.

ORE CONTROLS: Differentiated plutons intruding carbonate rocks; fractures, lithological or structural contacts. Deposits may develop some distance (up to 500 m) from the source intrusions.

ASSOCIATED DEPOSIT TYPES: W skarns (K05), Sn ± Be greisens (I13), Sn-bearing quartz-sulphide veins and mantos (J02). In British Columbia, some of the Sn and W skarn-related intrusions (e.g. Cassiar batholith, Mount Haskin stock) are associated with small Pb-Zn skarn occurrences (K02).

COMMENTS: Sn skarns generally form at deep structural levels and in reduced oxidation states. However, wrigglite Sn skarns tend to develop in relatively near-surface conditions, such as over the cupolas of high-level granites. The three Sn skarn occurrences in British Columbia are all associated with an S-type, fluorine-rich accretionary granite, the Surprise Lake Batholith. However, they are unusual in being hosted in allochthonous oceanic rocks of the Cache Creek Terrane. **The most significant Sn skarn occurrences in Yukon are associated with the mid-Cretaceous Seagull Batholith.**

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Sn, W, F, Be, Bi, Mo, As, Zn, Cu, Rb, Li, Cs and Re geochemical anomalies. Borate-bearing magnesian Sn skarns may exhibit B enrichment.

GEOPHYSICAL SIGNATURE: Magnetic, induced polarization and possible radiometric anomalies.

ECONOMIC FACTORS

GRADE AND TONNAGE: Deposits can grade up to 1 % Sn, but much of the metal occurring in malayaite, garnet, amphibole and epidote is not economically recoverable. Worldwide, deposits reach 30 Mt, but most range between 0.1 and 3 Mt.

IMPORTANCE: Worldwide, Sn skarns represent a major reserve of tin. However, current production from skarn is relatively minor compared to that from placer Sn deposits and Sn-rich greisens and mantos. British Columbia has had no Sn production from skarns.

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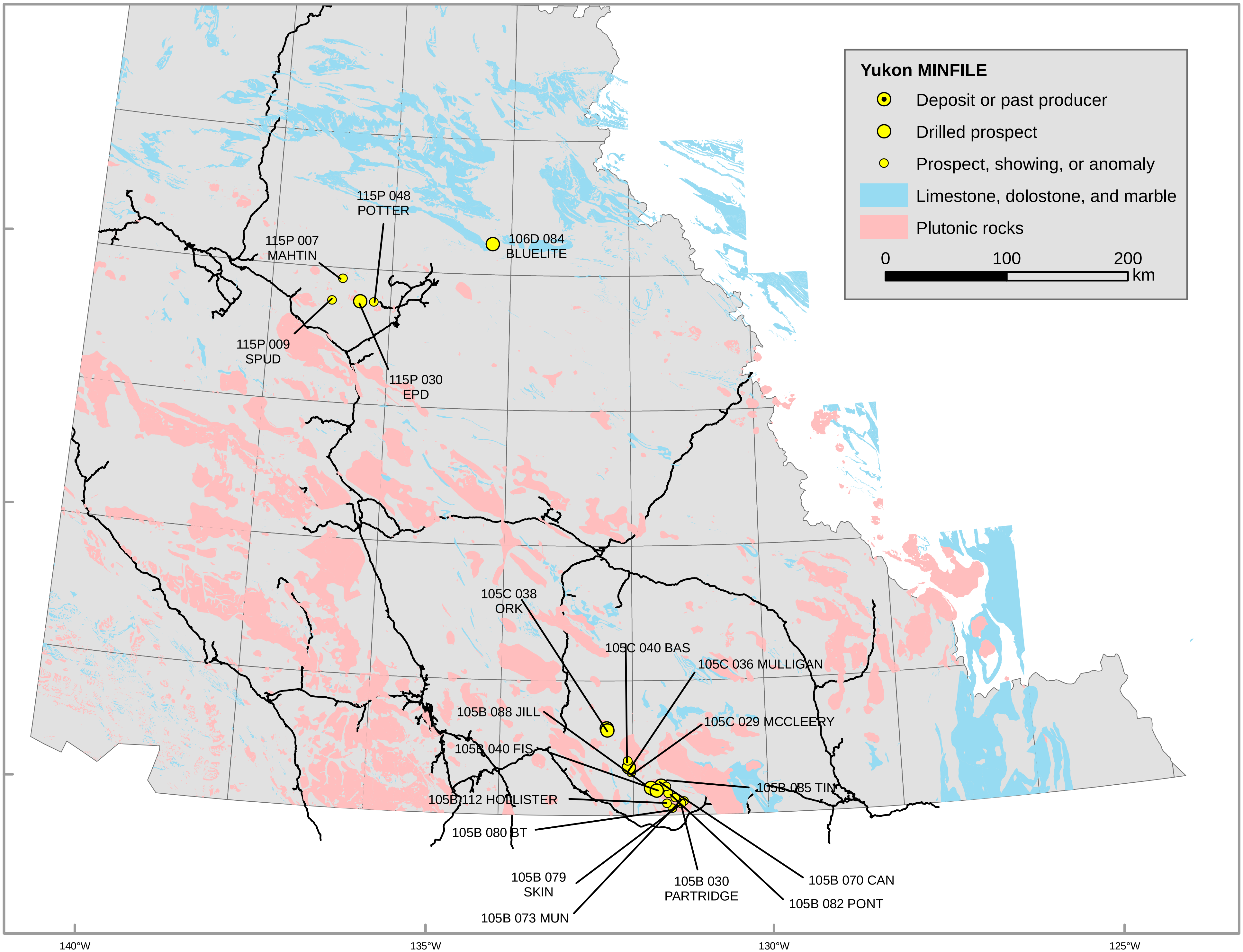
K06 - Sn Skarns - World deposits

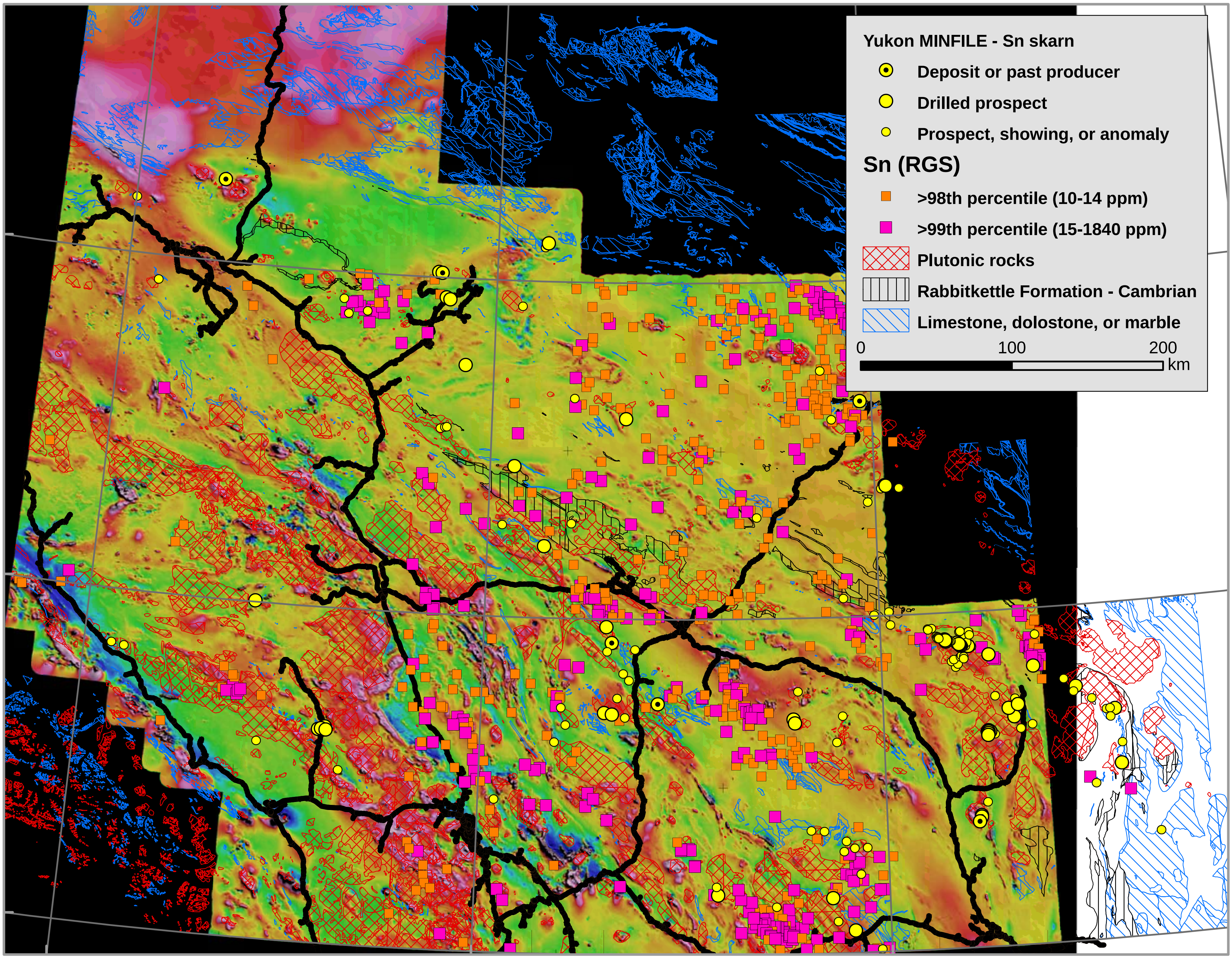
Deposit	Country	tonnes	Sn (%)
JC	CNYT	1 250 000	0.54
Gilliam	AUQS	2 000 000	0.80
Pinnacles	AUQS	4 000 000	0.30
Moina	AUTS	27 000 000	0.15
Lost River	USAK	36 400 000	0.27

Yukon MINFILE

MINFILE	NAMES	STATUS
105B 040	JC, VIOLA, FXE, FIS, FUR	DRILLED PROSPECT
105B 070	CAN	DRILLED PROSPECT
105B 088	SMITH, MC, SWIFT, JILL, SLIDE, SLIP	DRILLED PROSPECT
105C 038	MINDY	DRILLED PROSPECT
115P 030	OLIVER, EPD	DRILLED PROSPECT
105B 030	PARTRIDGE, VAL	PROSPECT
105B 073	CURRENT, MUN	PROSPECT
115P 048	POTTER, BOULDER CREEK, SCHEELITE DOME PROJECT	PROSPECT
105B 080	SLOUCE, BT	SHOWING
105B 085	TIN, CAN	SHOWING
105B 082	PONT	ANOMALY
105B 112	HOLLISTER, VH	ANOMALY
105C 040	BAS	ANOMALY



Map of Yukon showing Sn skarn occurrences and the distribution of plutonic and carbonate rocks



Map of Yukon showing Sn skarn occurrences, Sn geochemistry, regional magnetics, plutonic rocks, carbonate rocks and the Rabbitkettle Formation

PLUTONIC-RELATED AU QUARTZ VEINS & VEINLETS L02

by David V. Lefebure[1] and Craig Hart[2]

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYMS: Intrusion-related gold systems, gold porphyries, plutonic-related gold quartz veins. Plutonic-related gold, Au-lithophile element deposits, Fort Knox-type Au, high arsenic and/or bismuth plutonic-related mesothermal gold deposits, intrusion-hosted gold vein and brittle shear zone deposits.

COMMODITIES (BYPRODUCTS): Au (Ag, W).

EXAMPLES: **(Yukon): Dublin Gulch (106D 025), Clear Creek (115P 014), Scheelite Dome (115P 003), Brewery Creek (116B 160);**
(British Columbia - *Canada/International*): Cam Gloria? (082M266), Ridge Zone, Rozan Property (082FSW179); *Fort Knox, Cleary Hill (Alaska, USA), Mokrsko (Czech Republic), Timbarra (New South Wales, Australia).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Gold mineralization hosted by millimetre to metre-wide quartz veins hosted by equigranular to porphyritic granitic intrusions and adjacent hornfelsed country rock. The veins form parallel arrays (sheeted) and less typically, weakly developed stockworks; the density of the veins and veinlets is a critical element for defining ore. Native gold occurs associated with minor pyrite, arsenopyrite, pyrrhotite, scheelite and bismuth and telluride minerals.

TECTONIC SETTINGS: Most commonly found in continental margin sedimentary assemblages where intruded by plutons behind continental margin arcs. Typically developed late in orogeny or post-collisional settings.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Veins form in tensional fractures and shears within, and near, the apices of small (<3 km^2) granitoid intrusions at depths of 3-8 kilometres.

AGE OF MINERALIZATION: Any age, although they are best known (preserved?) in Paleozoic to Mesozoic rocks. Cenozoic deposits generally not yet exposed by erosion. Deposits in Alaska and the Yukon are Cretaceous age. Central Asian and European deposits are Carboniferous.

HOST/ASSOCIATED ROCK TYPES: The host rocks are granitic intrusions and variably metamorphosed sedimentary rocks. Associated volcanic rocks are rare. The granitoid rocks are lithologically variable, but typically granodiorite, quartz monzonite to granite. Most intrusions have some degree of lithological variation that appear as multiple phases that can include monzonite, monzogranite, albite granites, alkali syenite and syenite. The more differentiated phases commonly contain feldspar and quartz and less than

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5% mafic minerals. Some deposits have abundant associated dykes, including lamprophyres, pegmatites, aplites and phases that have been fractionated from the main intrusion. Medium-to coarse-grained intrusions are commonly equigranular, but can contain megacrysts of potassium feldspar or porphyritic phenocrysts of quartz, , plagioclase, or biotite. Biotite is common, hornblende is only locally observed, pyroxene is rare, and muscovite and tourmaline is common in more highly fractionated phases, aplites or pegmatites. The intrusions have a reduced primary oxidation state. Evidence of fluid saturation, such as miarolitic cavities, locally up to several centimetres, can be common; some intrusions exhibit much larger ones. Many of the granitoid intrusions have contact metamorphic aureoles that extend up to several km from the intrusion and can be much larger than the surface exposure of the intrusion. The stocks generally intrude variably metamorphosed sedimentary rocks (sandstone, shale, carbonate), however, some cut sequences which include metavolcanic rocks. In some cases the deposits are hosted by relatively high-grade metamorphic rocks including orthogneiss that may reflect the emplacement of the intrusions and veins at greater depths.

DEPOSIT FORM: Mineralization can be divided into intrusion-related, epizonal and shear-veins. Intrusion-related mineralization typically occurs widespread sheeted vein arrays. The arrays typically consist of numerous sheeted, or less commonly stockwork, veinlets and veins that form zones that are 10’s of metres wide, and continuous for several 10’s of metres. The veins are commonly hairline to centimetres wide, while some veins may be up to tens of metres thick. Epizonal mineralization is typically less focused, and may be disseminated, or occur as replacements. The thicker shear-veins veins are typically in fault zones outside of the pluton. The sheeted and stockwork zones extend up to a kilometre in the greatest dimension, while individual veins can be traced for more than a kilometre in exceptional cases.

TEXTURE/STRUCTURE: The sheeted veins are planar and often parallel to regional structures. The veins are generally extensional with no offset of walls, although some vein systems may also include shear-hosted veins. The veins may have minor vugs and drusy quartz. While most veins and structures are steeply dipping, shallowly dipping pegmatite and quartz bodies occur in some deposits, particularly those in the plutonic apices.

ORE MINERALOGY [Principal and *subordinate*]: Sulphide minerals are generally less than 3% and can be less than 1%. A number of deposits/intrusions have late and/or peripheral arsenopyrite, stibnite or galena veins. Native gold, sometimes visible, occurs with associated minor pyrite, arsenopyrite, loellingite, pyrrhotite, variable amounts of scheelite or more rarely wolframite, and sometimes *molybdenite, bismuthinite, native bismuth, maldonite, tellurobismuthinite, bismite, telleurides, tetradymite, galena and chalcopyrite*. Epizonal veins are arsenopyrite-pyrite rich and lack associated Bi, Te and W minerals. The thicker, solitary veins typically contain higher percentages (<20%) of sulphide minerals. Generally, sulphide mineral content is higher in veins hosted in the country-rocks.

GANGUE MINERALOGY [Principal and *subordinate*]: Quartz is the dominant gangue mineral with associated minor *sericite, alkali feldspar, biotite, calcite and tourmaline*. In some deposits the quartz veins grade into pegmatite dykes along strike - a relationship that has been referred to as vein-dykes or pegmatite veins. The pegmatites in some deposits can carry significant amounts of gold or scheelite, although they do not usually constitute ore. Many “veins” may lack gangue and are simply sulphide mineral coatings on fracture surfaces.

ALTERATION MINERALOGY: These deposits are characterized by relatively restricted alteration zones which are most obvious as narrow alteration selvages along the veins. The alteration generally consists of the same non-sulphide minerals as occur in the veins, typically albite, potassium feldspar, biotite, sericite, carbonate (dolomite) and minor pyrite. Pervasive alteration, dominated by sericite, only occurs in association with the best ore zones. The wall rocks surrounding the granitoid intrusions are typically hornfelsed and if carbonaceous, contain disseminated pyrrhotite. Alteration appears to be more extensive with shallow depths of emplacement or greater distances from the intrusion. Epizonal deposits may have clay alteration minerals.

WEATHERING: The quartz veins resist weathering and can form linear knobs. Since alteration zones are frequently weak and the veins often contain only minor sulphide minerals, associated gossans or colour anomalies are rare. However, oxidized sulphide-rich epizonal mineralization may yield gossans.

GENETIC MODELS: The veins are genetically related to proximal granitoid intrusions, which explains their association with tungsten, bismuth and other lithophile elements, and the transitional relationships with pegmatites seen in some deposits. Mineralization likely formed from late stage fluids that accumulated in late-stage melts of differentiating granitic intrusions at depths of 2 to 8 km below the surface. These fluids typically contain elevated PCO_2 and have lower salinities which enable them to transport gold and/or tungsten and only limited amounts of base metals. At some point following sufficient differentiation to concentrate anomalous concentrations of elements, such as Au and W, the fluids are released along fractures that developed in response to regional stresses and faults that accommodated pluton emplacement. Locally fluids infiltrate permeable or reactive rock units to form replacement mineralization or skarns. Stockwork mineralization is not common, but may have higher grades due to increased vein density. The deeper vein systems had little or no meteoric water input. In most deposits there are several other styles of mineralization, such as skarns and distal sulphide-rich veins that can be related to the same granitic intrusions but have different metallogenic signatures as they formed from rapidly evolving fluids. These characteristics are typical of an intrusion-centred mineralizing system, but are not characteristic of the shear-veins that do not show any metallogenic zonation or associated deposit types. The epizonal deposits may have evidence vectoring towards a higher-temperature zone, but typically form outside of the steep thermal gradients that are proximal to a cooling pluton.

ORE CONTROLS: The mineralization is strongly structurally controlled and spatially related to highly differentiated granitoid intrusion. Mineralization is commonly hosted by, or close to, the most evolved phase of the intrusion (differentiation index greater than 80).

ASSOCIATED DEPOSIT TYPES: W and Au skarns (K05, K04), W veins (I12), stibnite-gold veins (I09), Au-quartz veins (I01), disseminated gold sediment-hosted deposits (E03) and possibly polymetallic veins (I05). The veins commonly erode to produce nearby placer deposits (C01, C02).

COMMENTS: Differentiated reduced granites also host Sn greisens, but these may indicate too much fractionation to be a good gold mineralizer. Porphyry deposits, which may have associated tungsten mineralization and stibnite-base metal-gold veins are typically associated with oxidized magmas. Epizonal deposits, such as the Donlin Creek and Brewery Creek deposits have characteristics that include high sulphidation epithermal deposits. These granites are emplaced at relatively shallow depths (less than 2 kilometres) and can occur in the same regions as W-Au veins.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Placer gold in creeks draining plutons or hornfels is the best geochemical indicator. Analysis of heavy mineral or silt samples for W, Au, As and Bi is particularly effective. Elevated values of Au-W-Bi-As ± (Sn-Sb-Ag-Mo-Cu-Pb-Te-Zn) can be found in stream sediments, soils and rocks. Distal Sb and proximal Bi is a common association in the Yukon deposits.

GEOPHYSICAL SIGNATURE: Aeromagnetic data may be entirely flat as reduced granites have no magnetic signature. If the country rocks are reducing (e.g. carbonaceous), aeromagnetic signatures may produce “donut” anomalies with high magnetic values associated with pyrrhotite in the contact metamorphic zone fringing a non- magnetic intrusion.

OTHER EXPLORATION GUIDES: The number of deposits correlates inversely with the surface exposure of the related granitoid intrusion because stocks and batholiths with considerable erosion are generally less prospective. Evidence of highly differentiated granites and fluid-phase separation, such as pegmatites, aplites, unidirectional solidification textures (USTs) and leucocratic phases, indicates prospective settings. Lamprophyres indicate regions of high extension and potentially good structural sites for mineralization.

Gold, wolframite, and scheelite in stream gravels and placer deposits are excellent guides. The associated deposit types (e.g. skarns) can also assist in identifying prospective areas.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: The bulk mineable, intrusion-hosted low grade sheeted vein deposits contain tens to hundreds of million tonnes of ~ 0.8 to 1.4 g/t Au. The epizonal deposits have slightly higher grades, 2-5 g/t Au and the shear veins have form high grade deposits contain hundreds of thousands to millions of tonnes grading ~10 to 35 g/t Au. Gold to silver ratios are typically less than 1. Some gold-producing veins have produced W when it was deemed a strategic metal or it reached unusually high commodity prices.

Intrusion-related
Fort Knox, Alaska - 143.5 M tonnes grading 0.82 g/t Au (cutoff of 0.39 g/t)
Dublin Gulch (Eagle Zone), Yukon - 100 Mt grading 1.2 g/t Au
Epizonal
Brewery Creek, Yukon - 13 Mt of 1.44 g/t Au
Donlin Creek, Alaska
Shear-veins
Pogo, Alaska - 9.05 Mt grading 17.83 g/t Au (cutoff of 3.43 g/t)
Ryan Lode, Alaska
Cleery Hill - ~1.36 Mt grading better than 34 g/t Au

ECONOMIC LIMITATIONS: The Fort Knox deposit has a low strip ratio and the ore is oxidized to the depths of drilling (greater than 300 m). A carbon-in-leach gold absorption with conventional carbon stripping process is used to recover the gold. The refractory nature of the arsenic-rich mineralization below the oxidation zone could render an otherwise attractive deposit sub-economic. Intrusion-hosted deposits may have a high work index.

IMPORTANCE: These deposits represent a potentially important gold resource which is found in regions that have seen limited gold exploration in recent years. A number of deposits are now known that contain more than a 100 tonnes of gold. In virtually all regions the production of gold from placers related to these deposits has far exceeded the lode gold production.

ACKNOWLEDGEMENTS: This deposit profile draws heavily from presentations and related articles by Jim Lang, John Thompson, Jim Mortensen and Tim Baker summarizing research completed by the Mineral Deposits Research Unit of the University of British Columbia, Dan McCoy of Placer Dome and Moira Smith of Teck Exploration. Mike Cathro kindly reviewed the profile and provided constructive comments.

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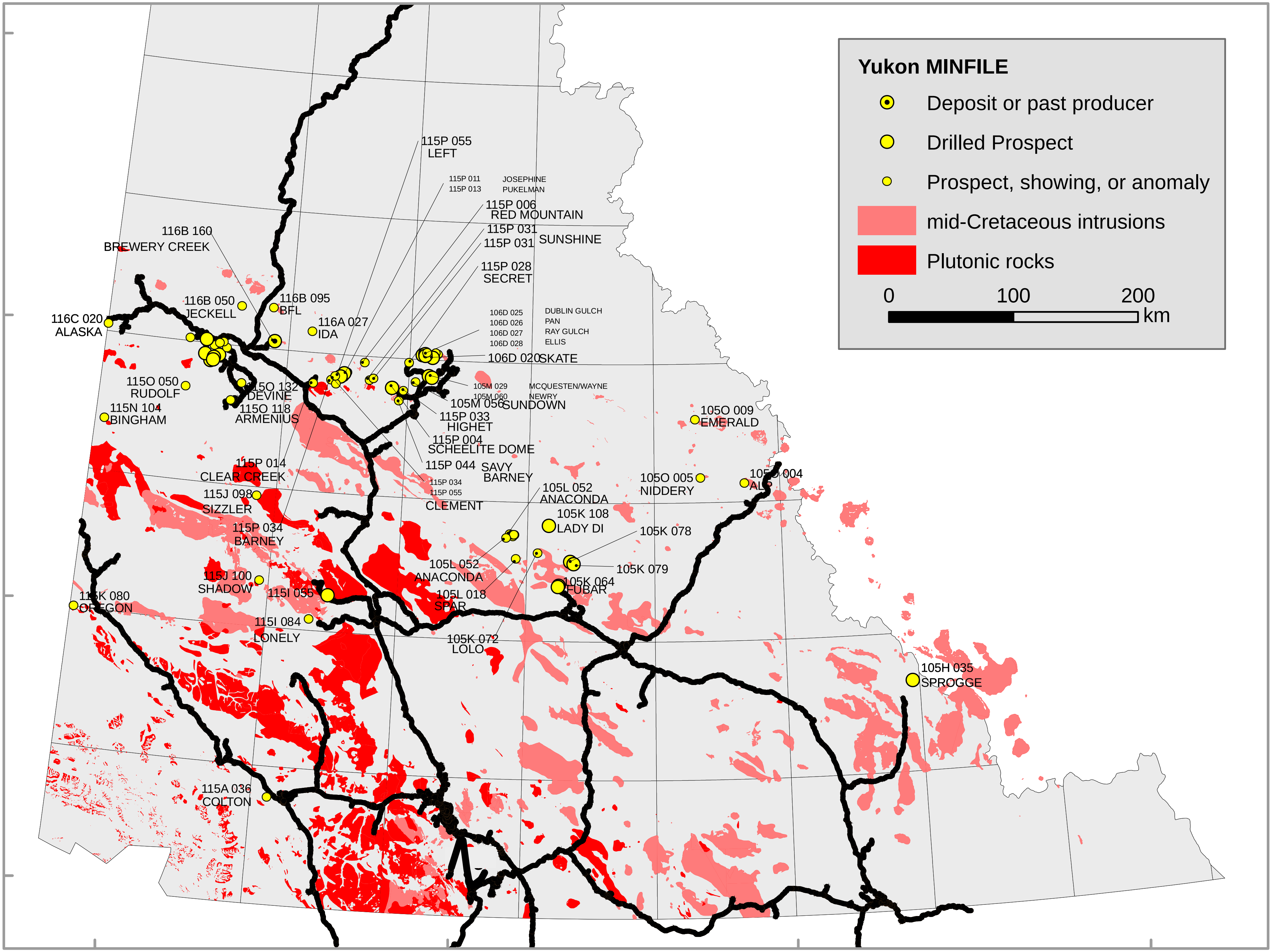
L02 - Plutonic-related Au quartz veins and veinlets - Yukon and Alaska deposits

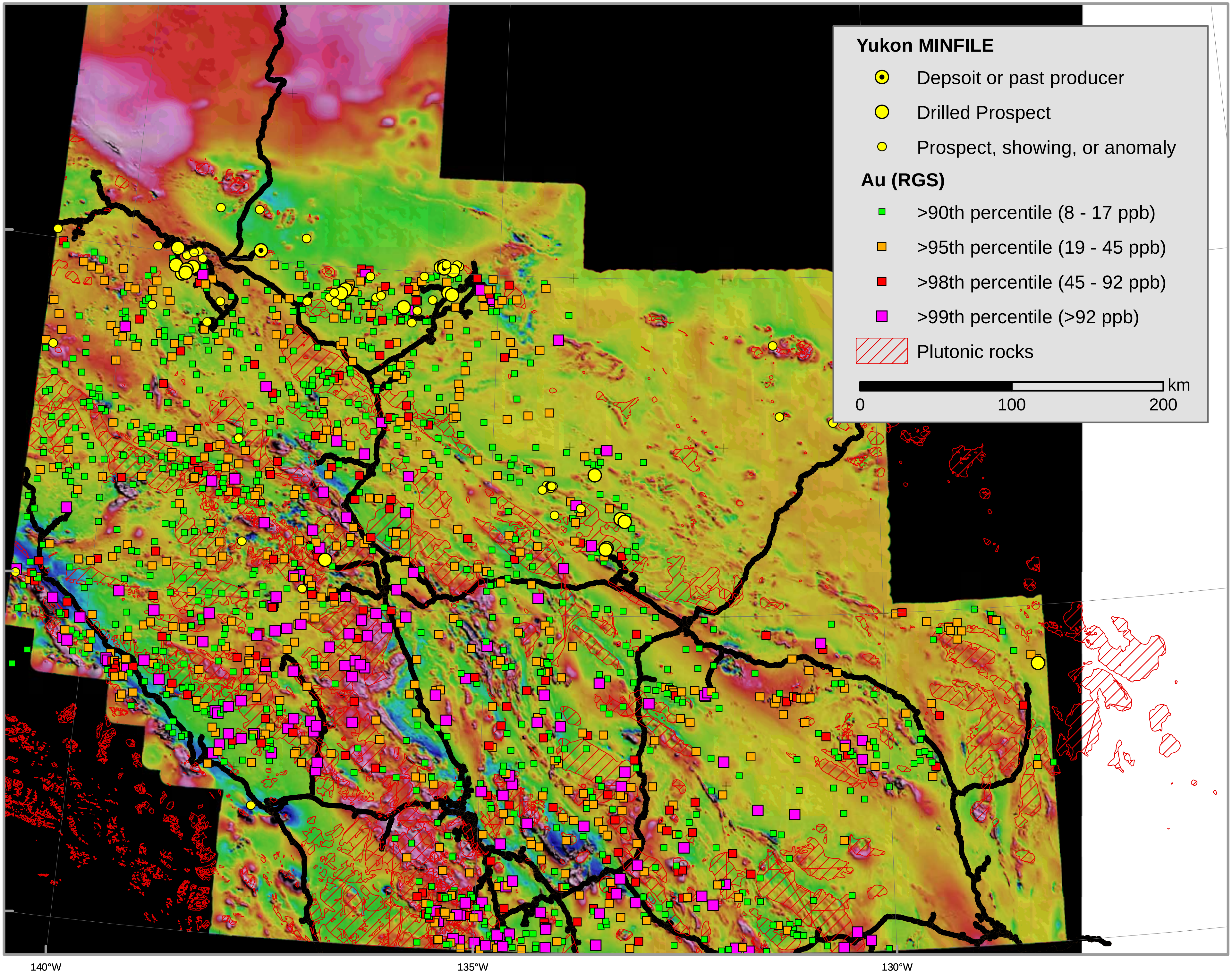
Deposit	country	tonnes	Au (g/t)	cutoff (g/t)
Ryan Lode	USAK	4 390 300	3	
Pogo	USAK	9 050 000	17.8	
Gil	USAK	9 700 000	1.37	
Brewery Creek	CNYT	13 300 000	1.44	
True North	USAK	16 500 000	2.46	
Shotgun	USAK	55 000 000	3.05	0.55
Dublin Gulch	CNYT	99 000 000	1.2	
Donlin Creek	USAK	110 700 000	2.91	1.5
Fort Knox	USAK	169 000 000	0.93	

Yukon MINFILE

MINFILE	NAMES	STATUS
115O 072	LONE STAR	UNDERGROUND PAST PRODUCER
105M 029	MCQUESTEN, WAYNE	OPEN PIT PAST PRODUCER
116B 160	BREWERY CREEK	OPEN PIT PAST PRODUCER
106D 025	DUBLIN GULCH	DEPOSIT
105H 035	RAIN	DRILLED PROSPECT
105K 064	JACOLA	DRILLED PROSPECT
105K 078	KEGLOVIC, MARK, DANA, HAL, HALO	DRILLED PROSPECT
105K 079	IVAN, DANA, TER, IRMA, HALL	DRILLED PROSPECT
105K 108	LADY DI	DRILLED PROSPECT
105O 058	LM	DRILLED PROSPECT
106D 020	SKATE, LYNX, LEN, JAY	DRILLED PROSPECT
115O 087	CARMACKS	DRILLED PROSPECT
115O 146	VICTORIA, LONE STAR	DRILLED PROSPECT
115P 006	HOBO, RED MOUNTAIN	DRILLED PROSPECT
115P 013	PUKELMAN	DRILLED PROSPECT
115P 023	LEWIS, SLEET, BEAR PAW	DRILLED PROSPECT
115P 033	HIGHET, SCHEELITE DOME PROJECT	DRILLED PROSPECT
116B 095	TK, SANDOW	DRILLED PROSPECT
116B 126	QUIGLEY, GC	DRILLED PROSPECT
105O 005	NIDDERY	PROSPECT
115P 031	BIX, SUNSHINE, SP, A	PROSPECT
116B 006	UNEXPECTED, SURPRISE CLAIMS	PROSPECT
105M 056	SUNDOWN	SHOWING
106D 018	ERIN	SHOWING
115O 088	TRILBY	SHOWING
115P 011	JOSEPHINE	SHOWING
115P 034	BARNEY	SHOWING
115P 061	BIG	SHOWING
116A 037	HEIDI	SHOWING
095E 052	ELF	ANOMALY
105K 072	PAIGE, ALTA, LOLO	ANOMALY
105L 018	SPAR	ANOMALY
115P 028	SECRET	ANOMALY
115P 055	LEFT, BARNEY	ANOMALY
116B 050	JECKELL, IRON KING	ANOMALY
116B 159	STUTTER, SPEC, JOE, ALPHA	ANOMALY
116C 020	ALASKA	ANOMALY
115K 080	CALIFORNIA, OREGON, LUCKY STRIKE	UNKNOWN
115N 104	BINGHAM	UNKNOWN
115O 050	RUDOLF	UNKNOWN
115P 044	SAVY	UNKNOWN



Mapof Yukon showing plutonic related Au occurrences, distribution of all plutonic rocks, and the distribution of mid-Cretaceous intrusions



Map of Yukon showing plutonic related Au occurrences, Au geochemistry, regional magnetics and the distribution of plutonic rocks

PORPHYRY Cu-Au: ALKALIC L03

by Andre Panteleyev[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Porphyry copper, porphyry Cu-Au, diorite porphyry copper.

COMMODITIES (*BYPRODUCTS*): Cu, Au (*Ag*).

EXAMPLES: **(Yukon): Minto (115I 021), Def (115I 022), Williams Creek? (115I 008);** (British Columbia - *Canada/International*): Iron Mask batholith deposits - Afton (092INE023), Ajax (092INE012, 013), Mt. Polley (Cariboo Bell, 093A008), Mt. Milligan (093N196, 194), Copper Mt./Ingerbelle (092HSE001, 004), Galore Creek (104G090), Lorraine? (093N002); *Ok Tedi (Papua New Guinea); Tai Parit and Marian? (Philippines).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Stockworks, veinlets and disseminations of pyrite, chalcopyrite, bornite and magnetite occur in large zones of economically bulk-mineable mineralization in or adjoining porphyritic intrusions of diorite to syenite composition. The mineralization is spatially, temporally and genetically associated with hydrothermal alteration of the intrusive bodies and hostrocks.

TECTONIC SETTING(S): In orogenic belts at convergent plate boundaries, commonly oceanic volcanic island arcs overlying oceanic crust. Chemically distinct magmatism with alkalic intrusions varying in composition from gabbro, diorite and monzonite to nepheline syenite intrusions and coeval shoshonitic volcanic rocks, takes place at certain times in segments of some island arcs. The magmas are introduced along the axis of the arc or in cross-arc structures that coincide with deep-seated faults. The alkalic magmas appear to form where there is slow subduction in steeply dipping, tectonically thickened lithospheric slabs, possibly when polarity reversals (or `flips') take place in the subduction zones. In British Columbia all known deposits are found in Quesnellia and Stikinia terranes.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: High level (epizonal) stock emplacement levels in magmatic arcs, commonly oceanic volcanic island arcs with alkalic (shoshonitic) basic flows to intermediate and felsic pyroclastic rocks. Commonly the high-level stocks and related dykes intrude their coeval and cogenetic volcanic piles.

[1] British Columbia Geological Survey, Victoria, B.C., Canada

AGE OF MINERALIZATION: Deposits in the Canadian Cordillera are restricted to the Late Triassic/Early Jurassic (215-180 Ma) with seemingly two clusters around 205-200 and ~ 185 Ma. In southwest Pacific island arcs, deposits are Tertiary to Quaternary in age. **Jurassic intrusive rocks host the Minto and Def deposits in Yukon.**

HOST/ASSOCIATED ROCK TYPES: Intrusions range from fine-through coarse-grained, equigranular to coarsely porphyritic and, locally, pegmatitic high-level stocks and dyke complexes. Commonly there is multiple emplacement of successive intrusive phases and a wide variety of breccias. Compositions range from (alkalic) gabbro to syenite. The syenitic rocks vary from silica-undersaturated to saturated compositions. The most undersaturated nepheline normative rocks contain modal nepheline and, more commonly, pseudoleucite. The silica-undersaturated suites are referred to as nepheline alkalic whereas rocks with silica near-saturation, or slight silica over saturation, are termed quartz alkalic (Lang *et al*., 1993). Coeval volcanic rocks are basic to intermediate alkalic varieties of the high-K basalt and shoshonite series and rarely phonolites.

DEPOSIT FORM: Stockworks and veinlets, minor disseminations and replacements throughout large areas of hydrothermally altered rock, commonly coincident wholly or in part with hydrothermal or intrusion breccias. Deposit boundaries are determined by economic factors that outline ore zones within larger areas of low-grade, laterally zoned mineralization.

TEXTURE/STRUCTURE: Veinlets and stockworks; breccia, sulphide and magnetite grains in fractures and along fracture selvages; disseminated sulphides as interstitial or grain and lithic clast replacements. Hydrothermally altered rocks can contain coarse-grained assemblages including feldspathic and calcsilicate replacements ('porphyroid' textures) and open space filling with fine to coarse, granular and rarely pegmatitic textures.

ORE MINERALOGY [Principal and *subordinate*]: Chalcopyrite, pyrite and magnetite; bornite, chalcocite and *rare galena, sphalerite, tellurides, tetrahderite, gold and silver*. Pyrite is less abundant than chalcopyrite in ore zones.

GANGUE MINERALOGY: Biotite, K-feldspar and sericite; garnet, clinopyroxene (diopsidic) and anhydrite. Quartz veins are absent but hydrothermal magnetite veinlets are abundant.

ALTERATION MINERALOGY: Biotite, K-feldspar, sericite, anhydrite/gypsum, magnetite, hematite, actinolite, chlorite, epidote and carbonate. Some alkalic systems contain abundant garnet including the Ti-rich andradite variety - melanite, diopside, plagioclase, scapolite, prehnite, pseudoleucite and apatite; rare barite, fluorite, sodalite, rutile and late-stage quartz. Central and early formed potassic zones, with K-feldspar and generally abundant secondary biotite and anhydrite, commonly coincide with ore. These rocks can contain zones with relatively high-temperature calcsilicate minerals diopside and garnet. Outward there can be flanking zones in basic volcanic rocks with abundant biotite that grades into extensive, marginal propylitic zones. The older alteration assemblages can be overprinted by phyllic sericite-pyrite and, less commonly, sericite-clay-carbonate-pyrite alteration. In some deposits, generally at depth in silica-saturated types, there can be either extensive or local central zones of sodic alteration containing characteristic albite with epidote, pyrite, diopside, actinolite and rarer scapolite and prehnite.

ORE CONTROLS: Igneous contacts, both internal between intrusive phases and external with wallrocks; cupolas and the uppermost, bifurcating parts of stocks, dyke swarms and volcanic vents. Breccias, mainly early formed intrusive and hydrothermal types. Zones of most intensely developed fracturing give rise to ore-grade vein stockworks.

ASSOCIATED DEPOSIT TYPES: Skarn copper (K01); Au-Ag and base metal bearing mantos (M01, M04), replacements and breccias in carbonate and non-carbonate rocks; magnetite-apatite breccias (D07); epithermal Au-Ag : both high and low sulphidation types (H04, H05) and alkalic, Te and

F-rich epithermal deposits (H08); auriferous and polymetallic base metal quartz and quartz-carbonate veins (I01, I05); placer Au (C01, C02).

COMMENTS: Subdivision of porphyry deposits is made on the basis of metal content, mainly ratios between Cu, Au and Mo. This is a purely arbitrary, economically based criterion; there are few differences in the style of mineralization between the deposits. Differences in composition between the hostrock alkalic and calcalkalic intrusions and subtle, but significant, differences in alteration mineralogy and zoning patterns provide fundamental geologically based contrasts between deposit model types. Porphyry copper deposits associated with calcalkaline hostrocks are described in mineral deposit profile L04.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Alkalic cupriferous systems do not contain economically recoverable Mo (< 100 ppm) but do contain elevated Au (> 0.3 g/t) and Ag (>2 g/t). Cu grades vary widely but commonly exceed 0.5 % and rarely 1 %. Many contain elevated Ti, V, P, F, Ba, Sr, Rb, Nb, Te, Pb, Zn, PGE and have high CO_2 content. Leaching and supergene enrichment effects are generally slight and surface outcroppings normally have little of the copper remobilized. Where present, secondary minerals are malachite, azurite, lesser copper oxide and rare sulphate minerals; in some deposits native copper is economically significant (e.g. Afton, Kemess).

GEOPHYSICAL SIGNATURE: Ore zones, particularly those with high Au content, are frequently found in association with magnetite-rich rocks and can be located by magnetic surveys. Pyritic haloes surrounding cupriferous rocks respond well to induced polarization surveys. The more intensely hydrothermally altered rocks produce resistivity lows.

OTHER EXPLORATION GUIDES: Porphyry deposits are marked by large-scale, markedly zoned metal and alteration assemblages. Central parts of mineralized zones appear to have higher Au/Cu ratios than the margins. The alkalic porphyry Cu deposits are found exclusively in Later Triassic and Early Jurassic volcanic arc terranes in which emergent subaerial rocks are present. The presence of hydrothermally altered clasts in coarse pyroclastic deposits can be used to locate mineralized intrusive centres.

ECONOMIC FACTORS

GRADE AND TONNAGE:

- Worldwide according to Cox and Singer (U.S. Geological Survey Open File Report 88-46, 1988) 20 typical porphyry Cu-Au deposits, including both calcalkaline and some alkalic types, contain on average: 160 Mt with 0.55 % Cu, 0.003 % Mo, 0.38 g/t Au and 1.7 g/t Ag.
- British Columbia alkalic porphyry deposits range from <10 to >300 Mt and contain from 0.2 to 1.5 % Cu, 0.2 to 0.6 g/t Au and >2 g/t Ag; Mo contents are negligible. Median values for 22 British Columbia deposits with reported reserves (with a heavy weighting from a number of small deposits in the Iron Mask batholith) are 15.5 Mt with 0.58 % Cu, 0.3 g/t Au and >2 g/t Ag.

END USES: Production of chalcopyrite or chalcopyrite-bornite concentrates with significant Au credits.

IMPORTANCE: Porphyry deposits contain the largest reserves of Cu and close to 50 % of Au reserves in British Columbia; alkalic porphyry systems contain elevated Au values.

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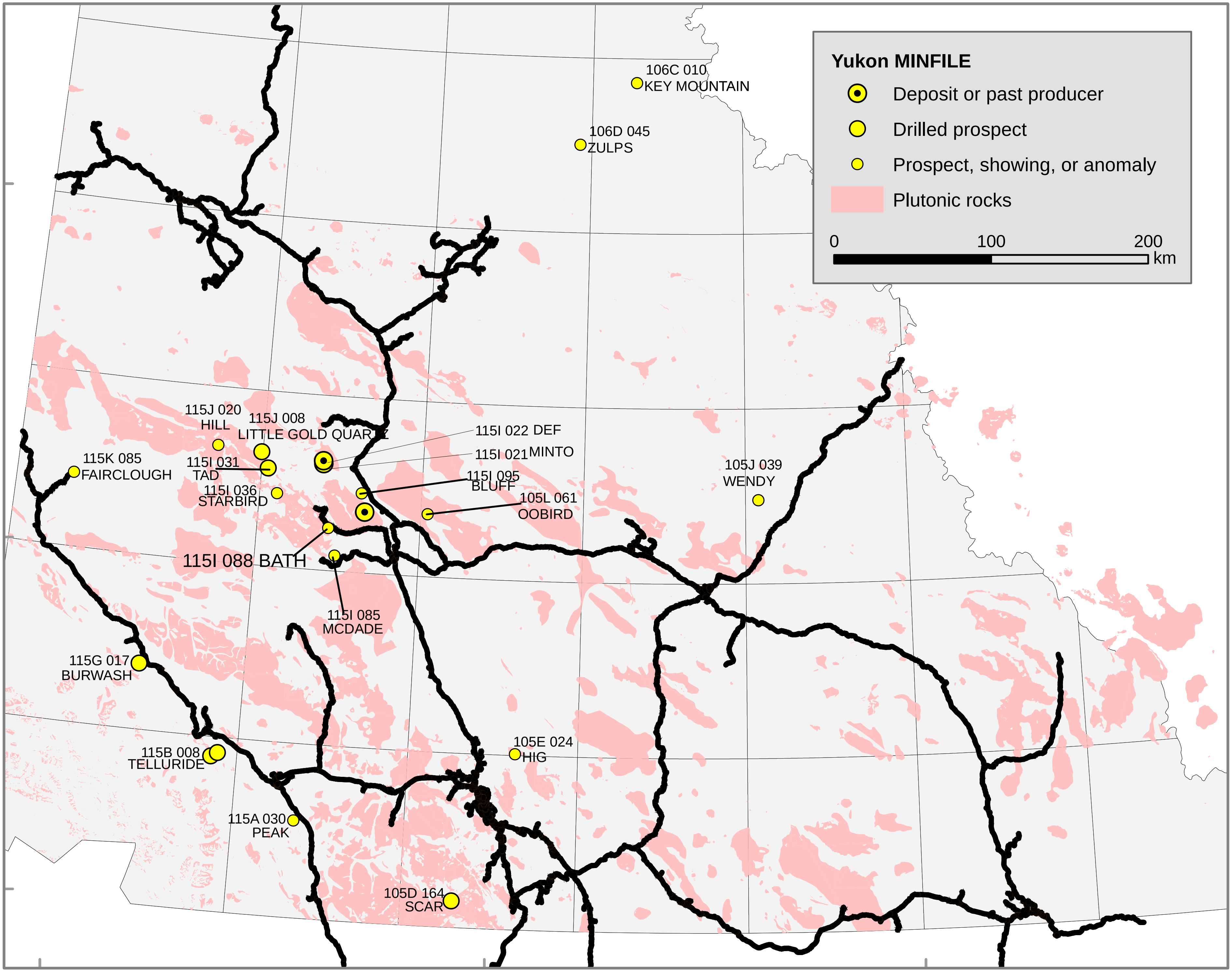
L03 - Alkalic porphyry Cu-Au - BC and Yukon deposits

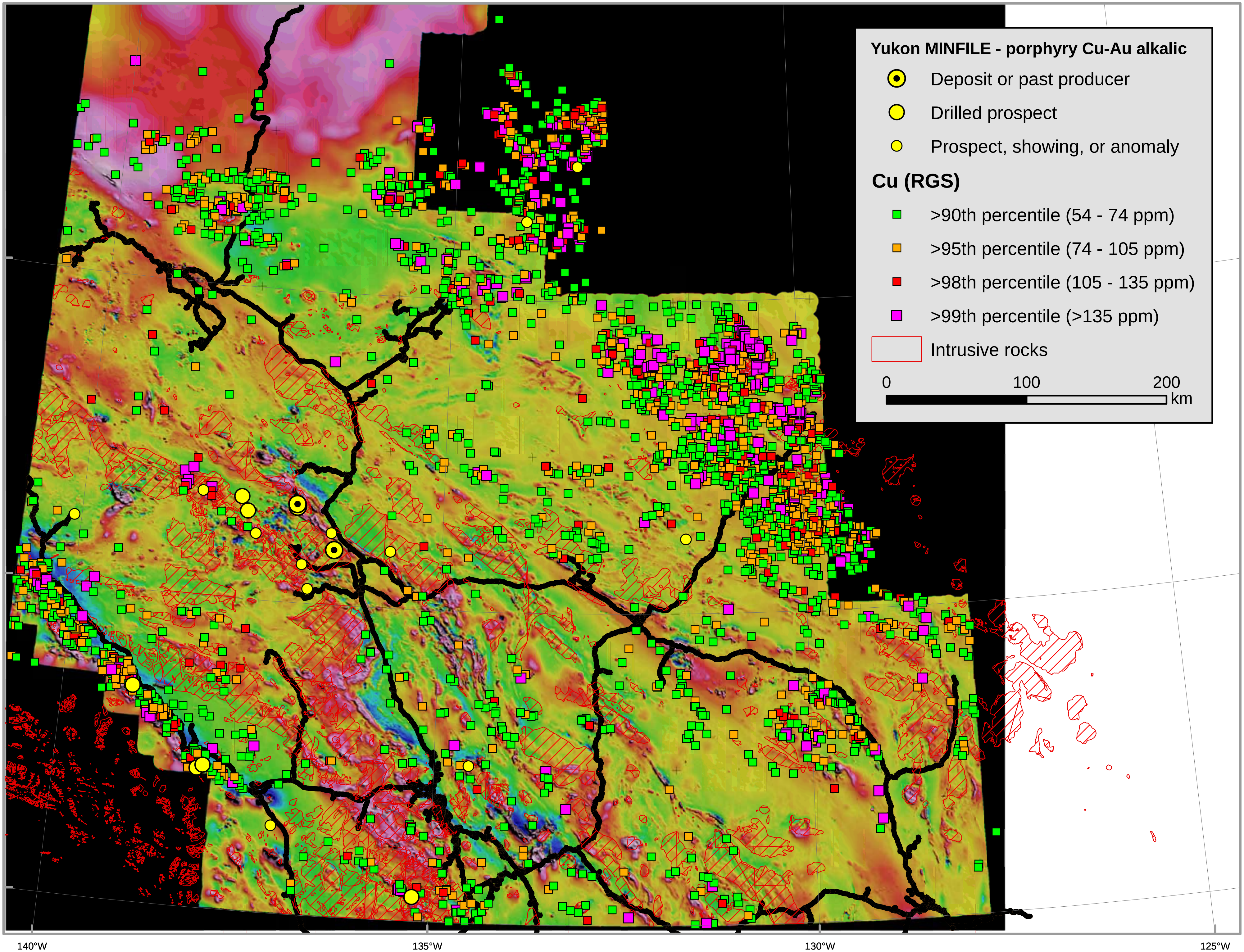
Deposit	Country	tonnes	Au (g/t)	Ag (g/t)	Cu (%)
IRON MASK	CNBC	165 555	0.71	2.79	1.48
VOIGT	CNBC	220 394	1.79		0.50
COL	CNBC	2 032 000			0.60
MISTY	CNBC	3 000 000			0.60
GALAXY	CNBC	3 174 898	0.21		0.65
RAINBOW	CNBC	4 467 000		4.00	0.66
VIRGINIA	CNBC	6 260 000	0.17		0.36
TAM	CNBC	7 000 000			0.60
MINTO	CNYK	7 980 000	0.62	9.30	2.13
RONDA	CNBC	9 072 000			0.70
ALABAMA	CNBC	9 200 000	0.20		0.32
LORRAINE	CNBC	10 000 000	0.21		0.67
PRIMER	CNBC	20 900 000			0.20
COPPER MOUNTAIN	CNBC	32 400 000	1.17	17.00	0.75
INGER BELLE	CNBC	42 625 840	0.17	0.70	0.37
CHUCHUA	CNBC	50 000 000	0.25		0.22
AXECHI	CNBC	57 500 000			0.50
AFTON	CNBC	68 735 660	0.47	2.10	0.63
MOUNT POLLEY	CNBC	77 594 000	0.45		0.33
GALORE CREEK	CNBC	125 000 000	0.40	7.70	1.06
MOUNT MILLIGAN	CNBC	329 000 000	0.45		0.22

Yukon MINFILE

MINFILE	NAMES	STATUS
115I 008	WILLIAMS CREEK, BOY	DEPOSIT
115I 021	MINTO	DEPOSIT
115I 022	DEF, MINTO	DEPOSIT
115J 008	HAYES, SONORA GULCH	DRILLED PROSPECT
105O 051	BURMEISTER, LUCKY JOE	DRILLED PROSPECT
105E 024	HIG	DRILLED PROSPECT
105L 061	OOBIRD	SHOWING
115P 062	COBBLE	SHOWING
115I 088	BATH	ANOMALY



Map of Yukon showing alkalic porphyry Cu-Au occurrences and the distribution of plutonic rocks



Map of Yukon showing alkalic Cu-Au porphyry occurrences, Cu regional geochemistry, regional magnetics and the distribution of plutonic rocks

PORPHYRY Cu ± Mo ± Au L04

by Andre Panteleyev[1]

Modified for Yukon by A. Fonseca

Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYM: Calcalkaline porphyry Cu, Cu-Mo, Cu-Au.

COMMODITIES (*BYPRODUCTS*): Cu. Mo and Au are generally present but quantities range from insufficient for economic recovery to major ore constituents. *Minor Ag in most deposits; rare recovery of Re from Island Copper mine.*

EXAMPLES **(Yukon): Casino (115J 028), Revenue (115J 042), Nucleus (115I 107), Cash (115I 103), Stu (115I 011);**

(British Columbia - *Canada/International*):

- Volcanic type deposits (Cu + Au ± Mo) - Fish Lake (092O041), Kemess (094E021,094), Hushamu (EXPO, 092L240), Red Dog (092L200), Poison Mountain (092O046), Bell (093M001), Morrison (093M007), Island Copper (092L158); *Dos Pobres (USA); Far Southeast (Lepanto/Mankayan), Dizon, Guianaong, Taysan and Santo Thomas II (Philippines), Frieda River and Panguna (Papua New Guinea).*
- Classic deposits (Cu + Mo ± Au) - Brenda (092HNE047), Berg (093E046), Huckleberrry (093E037), Schaft Creek (104G015); ***Casino (Yukon, Canada)****, Inspiration, Morenci, Ray, Sierrita-Experanza, Twin Buttes, Kalamazoo and Santa Rita (Arizona, USA), Bingham (Utah, USA),El Salvador, (Chile), Bajo de la Alumbrera (Argentina).*
- Plutonic deposits (Cu ± Mo) - Highland Valley Copper (092ISE001, 011, 012, 045), Gibraltar (093B012,007), Catface (092F120); *Chuquicamata, La Escondida and Quebrada Blanca (Chile).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Stockwork of quartz veinlets, quartz veins, closely spaced fractures and breccias containing pyrite and chalcopyrite with lesser molybdenite, bornite and magnetite occur in large zones of economically bulk-mineable mineralization in or adjoining porphyritic intrusions and related breccia bodies. Disseminated sulphide minerals are present, generally in subordinate amounts. The mineralization is spatially, temporally and genetically associated with hydrothermal alteration of the hostrock intrusions and wallrocks.

TECTONIC SETTINGS: In orogenic belts at convergent plate boundaries, commonly linked to subduction-related magmatism. Also in association with emplacement of high-level stocks during

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[1] British Columbia Geological Survey, Victoria, B.C., Canada

extensional tectonism related to strike-slip faulting and back-arc spreading following continent margin accretion.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: High-level (epizonal) stock emplacement levels in volcano-plutonic arcs, commonly oceanic volcanic island and continent-margin arcs. Virtually any type of country rock can be mineralized, but commonly the high-level stocks and related dykes intrude their coeval and cogenetic volcanic piles.

AGE OF MINERALIZATION: Two main periods in the Canadian Cordillera: the Triassic/Jurassic (210-180 Ma) and Cretaceous/Tertiary (85-45 Ma). Elsewhere deposits are mainly Tertiary, but range from Archean to Quaternary.

HOST/ASSOCIATED ROCK TYPES: Intrusions range from coarse-grained phaneritic to porphyritic stocks, batholiths and dyke swarms; rarely pegmatitic. Compositions range from calcalkaline quartz diorite to granodiorite and quartz monzonite. Commonly there is multiple emplacement of successive intrusive phases and a wide variety of breccias. Alkalic porphyry Cu-Au deposits are associated with syenitic and other alkalic rocks and are considered to be a distinct deposit type (see model L03). **Jurassic intrusions host the majority of porphyry prospects in Yukon. The Casino and Cash deposits, however, are hosted in Upper Cretaceous intrusive rocks; the Revenue deposit is hosted in mid-Cretaceous intrusive rocks; and the Stu deposit is hosted in Triassic intrusive rocks.**

DEPOSIT FORM: Large zones of hydrothermally altered rock contain quartz veins and stockworks, sulphide-bearing veinlets; fractures and lesser disseminations in areas up to 10 km^2 in size, commonly coincident wholly or in part with hydrothermal or intrusion breccias and dyke swarms. Deposit boundaries are determined by economic factors that outline ore zones within larger areas of low-grade, concentrically zoned mineralization. Cordilleran deposits are commonly subdivided according to their morphology into three classes - classic, volcanic and plutonic (see Sutherland Brown, 1976; McMillan and Panteleyev, 1988):

- <u>Volcanic type deposits</u> (e.g. Island Copper) are associated with multiple intrusions in subvolcanic settings of small stocks, sills, dykes and diverse types of intrusive breccias. Reconstruction of volcanic landforms, structures, vent-proximal extrusive deposits and subvolcanic intrusive centres is possible in many cases, or can be inferred. Mineralization at depths of 1 km, or less, is mainly associated with breccia development or as lithologically controlled preferential replacement in hostrocks with high primary permeability. Propylitic alteration is widespread and generally flanks early, centrally located potassic alteration; the latter is commonly well mineralized. Younger mineralized phyllic alteration commonly overprints the early mineralization. Barren advanced argillic alteration is rarely present as a late, high-level hydrothermal carapace.
- <u>Classic deposits</u> (e.g., Berg, **Casino**) are stock related with multiple emplacements at shallow depth (1 to 2 km) of generally equant, cylindrical porphyritic intrusions. Numerous dykes and breccias of pre, intra, and post-mineralization age modify the stock geometry. Ore bodies occur along margins and adjacent to intrusions as annular ore shells. Lateral outward zoning of alteration and sulphide minerals from a weakly mineralized potassic/propylitic core is usual. Surrounding ore zones with potassic (commonly biotite-rich) or phyllic alteration contain molybdenite ± chalcopyrite, then chalcopyrite and a generally widespread propylitic, barren pyritic aureole or 'halo'.
- <u>Plutonic deposits</u> (e.g., the Highland Valley deposits) are found in large plutonic to batholithic intrusions immobilized at relatively deep levels, say 2 to 4 km. Related dykes and intrusive breccia bodies can be emplaced at shallower levels. Hostrocks are phaneritic coarse grained to porphyritic. The intrusions can display internal compositional differences as a result of differentiation with gradational to sharp boundaries between the different phases of magma emplacement. Local swarms of dykes, many with associated breccias, and fault zones are sites of mineralization. Ore bodies around silicified alteration zones tend to occur as diffuse vein

stockworks carrying chalcopyrite, bornite and minor pyrite in intensely fractured rocks but, overall, sulphide minerals are sparse. Much of the early potassic and phyllic alteration in central parts of ore bodies is restricted to the margins of mineralized fractures as selvages. Later phyllic-argillic alteration forms envelopes on the veins and fractures and is more pervasive and widespread. Propylitic alteration is widespread but unobtrusive and is indicated by the presence of rare pyrite with chloritized mafic minerals, saussuritized plagioclase and small amounts of epidote.

TEXTURE/STRUCTURE: Quartz, quartz-sulphide and sulphide veinlets and stockworks; sulphide grains in fractures and fracture selvages. Minor disseminated sulphide minerals commonly replacing primary mafic minerals. Quartz phenocrysts can be partially resorbed and overgrown by silica.

ORE MINERALOGY (Principal and *subordinate*): Pyrite is the predominant sulphide mineral; in some deposits the Fe oxide minerals magnetite, and rarely hematite, are abundant. Ore minerals are chalcopyrite; molybdenite, lesser bornite and rare (primary) chalcocite. Subordinate minerals are *tetrahedrite/tennantite, enargite and minor gold, electrum and arsenopyrite*. In many deposits late veins commonly contain galena and sphalerite in a gangue of quartz, calcite and barite.

GANGUE MINERALOGY (Principal and *subordinate*): Gangue minerals in mineralized veins are mainly quartz with lesser *biotite, sericite, K-feldspar, magnetite, chlorite, calcite, epidote, anhydrite and tourmaline*. Many of these minerals are also pervasive alteration products of primary igneous mineral grains.

ALTERATION MINERALOGY: Quartz, sericite, biotite, K-feldspar, albite, anhydrite/gypsum, magnetite, actinolite, chlorite, epidote, calcite, clay minerals, tourmaline. Early formed alteration can be overprinted by younger assemblages. Central and early formed potassic zones (K-feldspar and biotite) commonly coincide with ore. This alteration can be flanked in volcanic hostrocks by biotite-rich rocks that grade outward into propylitic rocks. The biotite is a fine-grained, 'shreddy' looking secondary mineral that is commonly referred to as an early developed biotite (EDB) or a 'biotite hornfels'. These older alteration assemblages in cupriferous zones can be partially to completely overprinted by later biotite and K-feldspar and then phyllic (quartz-sericite-pyrite) alteration, less commonly argillic, and rarely, in the uppermost parts of some ore deposits, advanced argillic alteration (kaolinite-pyrophyllite) .

WEATHERING: Secondary (supergene) zones carry chalcocite, covellite and other Cu_2S minerals (digenite, djurleite, etc.), chrysocolla, native copper and copper oxide, carbonate and sulphate minerals. Oxidized and leached zones at surface are marked by ferruginous 'cappings' with supergene clay minerals, limonite (goethite, hematite and jarosite) and residual quartz.

ORE CONTROLS: Igneous contacts, both internal between intrusive phases and external with wallrocks; cupolas and the uppermost, bifurcating parts of stocks, dyke swarms. Breccias, mainly early formed intrusive and hydrothermal types. Zones of most intensely developed fracturing give rise to ore-grade vein stockworks, notably where there are coincident or intersecting multiple mineralized fracture sets.

ASSOCIATED DEPOSIT TYPES: Skarn Cu (K01), porphyry Au (K02), epithermal Au-Ag in low sulphidation type (H05) or epithermal Cu-Au-Ag as high-sulphidation type enargite-bearing veins (L01), replacements and stockworks; auriferous and polymetallic base metal quartz and quartz-carbonate veins (I01, I05), Au-Ag and base metal sulphide mantos and replacements in carbonate and non-carbonate rocks (M01, M04), placer Au (C01, C02).

COMMENTS: Subdivision of porphyry copper deposits can be made on the basis of metal content, mainly ratios between Cu, Mo and Au. This is a purely arbitrary, economically based criterion, an artifact of mainly metal prices and metallurgy. There are few differences in the style of mineralization between deposits although the morphology of calcalkaline deposits does provide a basis for subdivision into three distinct subtypes - the 'volcanic, classic, and plutonic' types. A fundamental contrast can be made on the compositional differences between calcalkaline quartz-bearing porphyry copper deposits and the alkalic (silica undersaturated) class. The alkalic porphyry copper deposits are described in a separate model - L03.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Calcalkalic systems can be zoned with a cupriferous (± Mo) ore zone having a ‘barren’, low-grade pyritic core and surrounded by a pyritic halo with peripheral base and precious metal-bearing veins. Central zones with Cu commonly have coincident Mo, Au and Ag with possibly Bi, W, B and Sr. Peripheral enrichment in Pb, Zn, Mn, V, Sb, As, Se, Te, Co, Ba, Rb and possibly Hg is documented. Overall the deposits are large-scale repositories of sulphur, mainly in the form of metal sulphide minerals, chiefly pyrite.

GEOPHYSICAL SIGNATURE: Ore zones, particularly those with higher Au content, can be associated with magnetite-rich rocks and are indicated by magnetic surveys. Alternatively the more intensely hydrothermally altered rocks, particularly those with quartz-pyrite-sericite (phyllic) alteration produce magnetic and resistivity lows. Pyritic haloes surrounding cupriferous rocks respond well to induced polarization (I.P.) surveys but in sulphide-poor systems the ore itself provides the only significant IP response.

OTHER EXPLORATION GUIDES: Porphyry deposits are marked by large-scale, zoned metal and alteration assemblages. Ore zones can form within certain intrusive phases and breccias or are present as vertical 'shells' or mineralized cupolas around particular intrusive bodies. Weathering can produce a pronounced vertical zonation with an oxidized, limonitic leached zone at surface (leached capping), an underlying zone with copper enrichment (supergene zone with secondary copper minerals) and at depth a zone of primary mineralization (the hypogene zone).

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE:

Worldwide according Cox and Singer (1988) based on their subdivision of 55 deposits into subtypes according to metal ratios, typical porphyry Cu deposits contain (median values):

Porphyry Cu-Au:	160 Mt with 0.55 % Cu, 0.003 % Mo, 0.38 g/t Au and 1.7 g/t Ag.
Porphyry Cu-Au-Mo:	390 Mt with 0.48 % Cu, 0.015 % Mo, 0.15 g/t Au and 1.6 g/t Ag.
Porphyry Cu-Mo:	500 Mt with 0.41 % Cu, 0.016 % Mo, 0.012 g/t Au and 1.22 g/t Ag.

A similar subdivision by Cox (1986) using a larger data base results in:

Porphyry Cu:	140 Mt with 0.54 %Cu, <0.002 % Mo, <0.02g/t Au and <1 g/t Ag.
Porphyry Cu-Au:	100 Mt with 0.5 %Cu, <0.002 % Mo, 0.38g/t Au and 1g/t Ag. (This includes deposits from the British Columbia alkalic porphyry class, B.C. model L03.)
Porphyry Cu-Mo:	500 Mt with 0.42 % Cu, 0.016 % Mo, 0.012 g/t Au and 1.2 g/t Ag.

British Columbia porphyry Cu ± Mo ± Au deposits range from <50 to >900 Mt with commonly 0.2 to 0.5 % Cu, <0.1 to 0.6 g/t Au, and 1 to 3 g/t Ag. Mo contents are variable from negligible to 0.04 % Mo. Median values for 40 B.C. deposits with reported reserves are: 115 Mt with 0.37 % Cu, ~0.01 % Mo, 0.3g /t Au and 1.3 g/t Ag.

ECONOMIC LIMITATIONS: Mine production in British Columbia is from primary (hypogene) ores. Rare exceptions are Afton mine where native copper was recovered from an oxide zone, and

Gibraltar and Bell mines where incipient supergene enrichment has provided some economic benefits.

END USES: Porphyry copper deposits produce Cu and Mo concentrates, mainly for international export.

IMPORTANCE: Porphyry deposits contain the largest reserves of Cu, significant Mo resources and close to 50 % of Au reserves in British Columbia.

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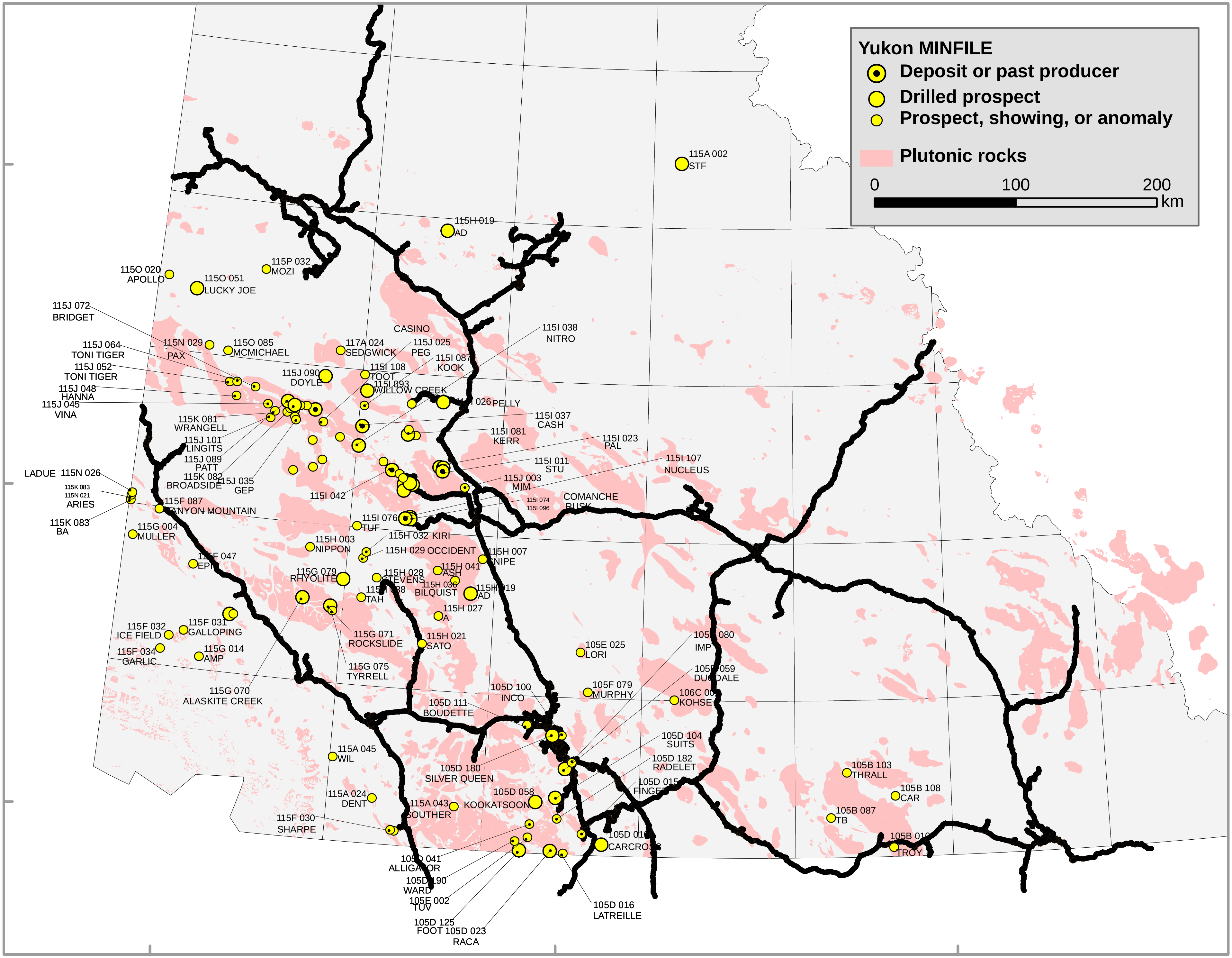
L04 - Porphyry Cu-Mo-Au - BC and Yukon deposits

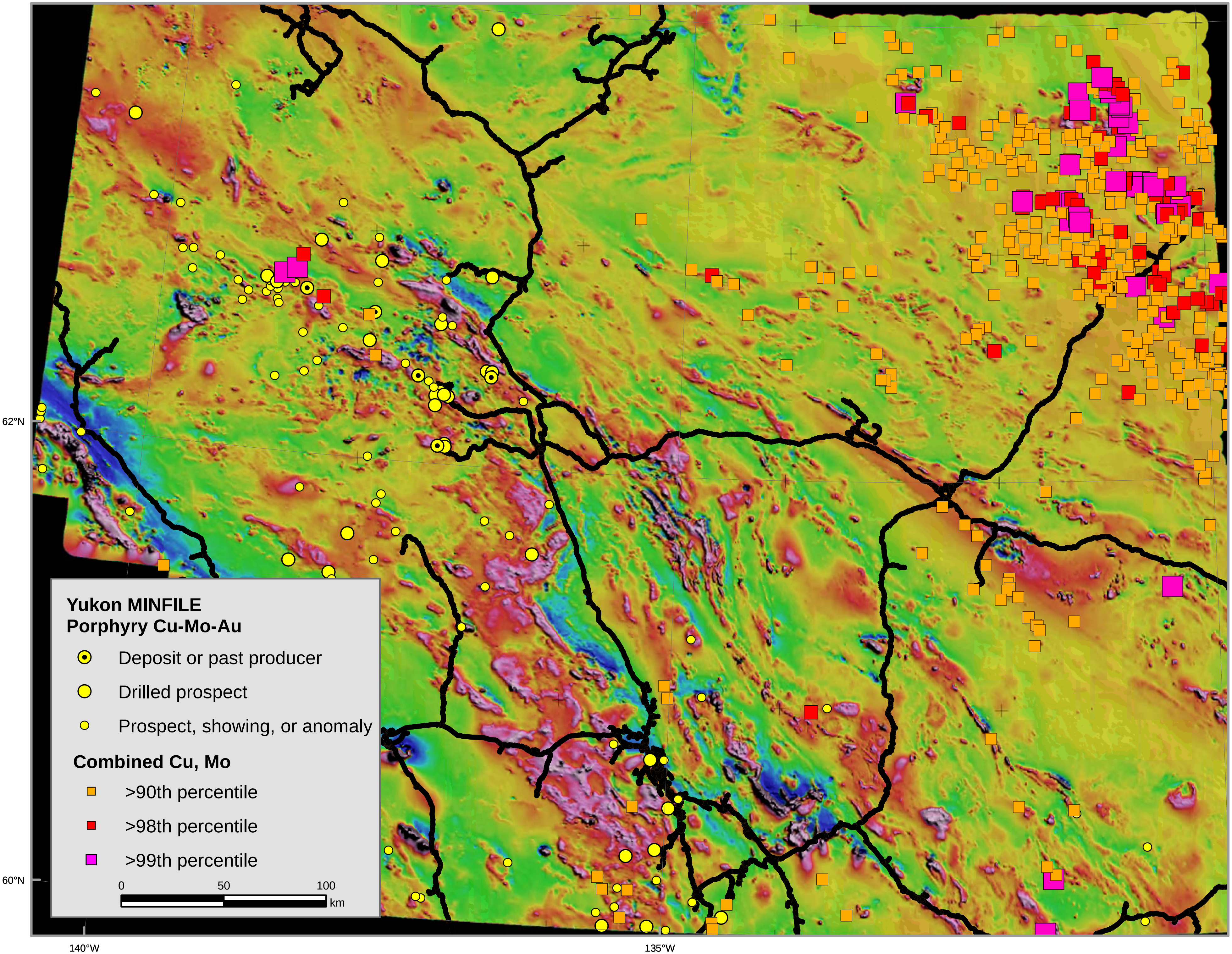
Deposit	country	tonnes	Cu (%)	Mo (%)	Au(g/t)	Ag(g/t)
NUCLEUS	CNYK	211 900			3.160	
TASEKO	CNBC	9 501 800	0.580	0.000	0.750	17.000
KRAIN	CNBC	14 000 000	0.560	0.010	0.000	0.000
OX LAKE	CNBC	17 000 000	0.330	0.040	0.000	0.000
BIG	CNBC	18 000 000	0.360	0.000	0.000	0.000
NANIKA	CNBC	18 144 000	0.440	0.009	0.210	0.380
WILLIAMS CREEK	CNYK	20 000 000	1.060		0.450	
REY	CNBC	21 488 290	0.230	0.020	0.000	0.000
RED DOG	CNBC	25 000 000	0.350	0.000	0.440	0.000
EAGLE	CNBC	30 000 000	0.410	0.010	0.200	2.710
GNAT	CNBC	30 000 000	0.390	0.000	0.000	0.000
SWAN	CNBC	36 000 000	0.200	0.000	0.000	0.000
CASH	CNYK	36 300 000	0.170	0.018	0.200	0.400
DOROTHY	CNBC	40 800 000	0.250	0.010	0.000	0.000
ANNOTH	CNBC	43 381 160	0.270	0.000	0.000	0.000
LOUISE	CNBC	50 000 000	0.300	0.020	0.300	0.000
KERR	CNBC	60 000 000	0.860	0.000	0.340	2.000
GRANISLE	CNBC	66 434 150	0.420	0.000	0.130	1.330
HI-MAR	CNBC	82 000 000	0.300	0.000	0.300	0.000
MORRISON	CNBC	86 000 000	0.420	0.000	0.340	3.400
HUCKLEBERRY	CNBC	100 000 000	0.560	0.017	0.000	0.000
GAMBIE	CNBC	114 000 000	0.290	0.010	0.000	1.000
WHITIN	CNBC	124 000 000	0.060	0.030	0.000	0.000
HIGHMONT	CNBC	125 000 000	0.220	0.020	0.000	0.000
BETHLEHEM	CNBC	134 000 000	0.440	0.000	0.010	0.740
CATFACE	CNBC	138 000 000	0.460	0.000	0.050	0.000
BELL	CNBC	143 000 000	0.420	0.000	0.200	0.480
POPLAR	CNBC	144 000 000	0.370	0.020	0.000	0.000
O.K.	CNBC	155 000 000	0.390	0.020	0.000	0.000
POISON MOUNTAIN	CNBC	159 000 000	0.330	0.010	0.310	0.000
HUSHAMO	CNBC	173 000 000	0.270	0.010	0.340	0.000
CASINO	CNYK	178 200 000	0.303	0.028	0.376	
MAGGIE	CNBC	181 000 000	0.280	0.030	0.000	0.000
BRENDA	CNBC	183 000 000	0.250	0.040	0.010	1.060
KEMESS	CNBC	230 000 000	0.230	0.000	0.650	0.000
BERG	CNBC	238 000 000	0.390	0.030	0.050	2.840
JAR	CNBC	260 000 000	0.430	0.020	0.000	0.000
ISLAND COPPER	CNBC	373 000 000	0.370	0.017	0.110	0.940
GIBRALTAR	CNBC	965 000 000	0.320	0.010	0.070	0.150
FISH LAKE	CNBC	976 000 000	0.250	0.000	0.480	0.000
SCHAFT CREEK	CNBC	1 000 000 000	0.300	0.020	0.140	1.200
HIGHLAND VALLEY COPPER	CNBC	1 200 000 000	0.372	0.010	0.005	1.730

L04 - Porphyry Cu-Mo-Au - Yukon MINFILE

MINFILE	NAMES	STATUS
105C 009	RED MOUNTAIN, FOX, BOSWELL RIVER	DEPOSIT
115I 037	CASH	DEPOSIT
115I 107	NUCLEUS, GOLDEN REVENUE	DEPOSIT
115J 028	CASINO	DEPOSIT
105D 010	CARCROSS	DRILLED PROSPECT
105D 023	FAWLEY, RACA	DRILLED PROSPECT
105D 058	KOOKATSOON	DRILLED PROSPECT
105D 059	DUGDALE, COWLEY PARK	DRILLED PROSPECT
105D 104	SUITS, KING LAKE	DRILLED PROSPECT
105D 180	SILVER QUEEN	DRILLED PROSPECT
115A 002	DALTON, STF	DRILLED PROSPECT
115G 015	CORK	DRILLED PROSPECT
115G 070	RAFT, ALASKITE CREEK	DRILLED PROSPECT
115G 071	ROCKSLIDE	DRILLED PROSPECT
115G 079	RHYOLITE	DRILLED PROSPECT
115I 023	PAL	DRILLED PROSPECT
115I 026	PELLY	DRILLED PROSPECT
115I 038	KLAZAN, NITRO	DRILLED PROSPECT
115I 042	REVENUE, GOLDEN REVENUE	DRILLED PROSPECT
115I 050	GRANGER, RAG	DRILLED PROSPECT
115I 066	CYPRUS, MT. NANSEN	DRILLED PROSPECT
115I 070	MALONEY, POT	DRILLED PROSPECT
115I 074	COMANCHE	DRILLED PROSPECT
115I 081	KERR	DRILLED PROSPECT
115I 093	GOULTER, WILLOW CREEK, ELIZA, DISCOVERY CREEK	DRILLED PROSPECT
115I 094	GIANT	DRILLED PROSPECT
115J 036	ZAPPA, MOTHERS, KOFFEE	DRILLED PROSPECT
115J 089	PATTISON, PATT, ROSS	DRILLED PROSPECT
115J 090	INDIANA, DOYLE	DRILLED PROSPECT
115J 101	ANA, AZTEC	DRILLED PROSPECT
115K 082	TRUDI, BROADSIDE, SNOW, BA	DRILLED PROSPECT
105B 087	MCPRES, I, TB	PROSPECT
105E 002	TUV, MARS	PROSPECT
106C 001	KOHSE	PROSPECT
115A 012	CAVE, SANDY, MUSH, MOLLY, ROCKY	PROSPECT
115F 034	GARLIC	PROSPECT
115I 032	PHELPS	PROSPECT
105B 103	THRALL	SHOWING
105D 015	FINGER	SHOWING
105D 016	LATREILLE	SHOWING
105D 041	ALLIGATOR	SHOWING
105D 100	INCO, RED RIDGE, RED TOP	SHOWING
105D 190	WARD	SHOWING
105F 079	MURPHY	SHOWING
115A 024	DEVILHOLE, GREEN EAGLE, JOY, DENT	SHOWING
115A 043	SOUTHER	SHOWING
115A 045	TATSHENSHINI, WALL, SKY, TUF, WIL	SHOWING
115F 030	SHARPE	SHOWING
115F 031	GALLOPING	SHOWING
115F 047	EPIC	SHOWING
115F 087	CANYON MOUNTAIN	SHOWING
115G 069	TALBOT	SHOWING
115H 003	NIPPON, AH, RAZ	SHOWING
115H 007	SNIPE	SHOWING
115H 021	SATO, MAK, KL	SHOWING
115H 038	TAHTE, TAH	SHOWING
115H 041	ITTLEMIT, ASH	SHOWING
115I 045	NEWKIRK	SHOWING
115I 076	TUF	SHOWING
115I 108	TOOT	SHOWING
115J 002	KLOT, CHRIS, K, BGD	SHOWING
115J 003	MIM	SHOWING
115J 017	COCKFIELD, RAY, CO, DR, COFIELD, KOKUP, OKE, ITEN	SHOWING
115J 040	BOREAL, DUCHESS, PRINCESS	SHOWING
115J 044	BID	SHOWING
115J 045	VINA	SHOWING
115J 052	TONI TIGER, W, CAFFEINE	SHOWING
115J 072	SCROGGIE, C, SC, BRIDGET	SHOWING
115J 091	AMOCO, CC	SHOWING
115N 021	ARIES	SHOWING
115N 026	LADUE	SHOWING
115O 085	MCMICHAEL	SHOWING
105B 010	TROY	ANOMALY
105B 108	REGIONAL, CARIBOU, CAR	ANOMALY
105D 080	IMP	ANOMALY
115G 004	MULLER	ANOMALY
115G 014	AMP	ANOMALY
115G 075	TYRRELL	ANOMALY
115H 027	POPLAR, A	ANOMALY
115H 028	STEVENS, JON	ANOMALY
115H 029	OCCIDENT, STEVE	ANOMALY
115H 032	KIRI	ANOMALY
115I 029	DELTA	ANOMALY
115I 039	COM	ANOMALY
115I 048	EDGAR	ANOMALY
115I 087	KOOK	ANOMALY
115I 102	LUMBY	ANOMALY
115J 025	PEG, GAP	ANOMALY
115J 029	HOLE	ANOMALY
115J 031	CLEVELAND, CUB	ANOMALY
115J 032	RONGE, CASH, GUN, BARB, GUY	ANOMALY
115J 034	GEP	ANOMALY
115J 035	AZTEC	ANOMALY
115J 048	HANNA, FBH, EX	ANOMALY
115J 064	LYON, HOLE	ANOMALY
115K 081	WRANGELL	ANOMALY
115N 029	PAX	ANOMALY
115O 020	APOLLO	ANOMALY
115P 032	MOZI	ANOMALY
115H 036	BILQUIST, ZN, YAM	UNKNOWN
115J 015	CROCK, ELW	UNKNOWN



Map of Yukon showing porphyry Cu-Mo-Au occurrences and the distribution of plutonic rocks



Map of Yukon showing Cu-Mo-Au porphyry occurrences, regional magnetics and Cu-Mo regional geochemistry

PORPHYRY Mo (LOW-F-TYPE) L05

by W. David Sinclair[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Calc-alkaline Mo stockwork; Granite-related Mo; Quartz-monzonite Mo.

COMMODITIES (*BYPRODUCTS*): Mo (*Cu, W*)

EXAMPLES **(Yukon): Red Mountain (105C 009), Logtung (105B 039);**
(British Columbia - *Canada/International*): Endako (093K006), Boss Mountain (093A001), Kitsault (103P120), Adanac (104N052), Carmi (082ESW029), Bell Moly (103P234), Red Bird (093E026), Storie Moly (104P069), Trout Lake (082KNW087); ***Red Mountain (Yukon, Canada)****, Quartz Hill (Alaska, USA), Cannivan (Montana, USA), Thompson Creek (Idaho, USA), Compaccha (Peru), East Kounrad (Russia), Jinduicheng (China).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Stockwork of molybdenite-bearing quartz veinlets and fractures in intermediate to felsic intrusive rocks and associated country rocks. Deposits are low grade but large and amenable to bulk mining methods.

TECTONIC SETTING(S): Subduction zones related to arc-continent or continent-continent collision.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: High-level to subvolcanic felsic intrusive centres; multiple stages of intrusion are common.

AGE OF MINERALIZATION: Archean (e.g. Setting Net Lake, Ontario) to Tertiary; Mesozoic and Tertiary examples are more common. **A Late Cretaceous stock hosts the Red Mountain deposit in Yukon.**

HOST/ASSOCIATED ROCK TYPES: All kinds of rocks may be hostrocks. Tuffs or other extrusive volcanic rocks may be associated with deposits related to subvolcanic intrusive rocks. Genetically related intrusive rocks range from granodiorite to granite and their fine-grained equivalents, with quartz monzonite most common: they are commonly porphyritic. The intrusive rocks are characterized by low F contents (generally <0.1 % F) compared to intrusive rocks associated with Climax-type porphyry Mo deposits. **Quartz-monzonite porphyry, quartz-eye porphyry, and granodiorite porphyry host molybdenite mineralization at the Red Mountain deposit in south-central Yukon.**

DEPOSIT FORM: Deposits vary in shape from an inverted cup, to roughly cylindrical, to highly irregular. They are typically hundreds of metres across and range from tens to hundreds of metres in vertical extent.

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[1] Geological Survey of Canada, Ottawa, Ontario, Canada

TEXTURE/STRUCTURE: Ore is predominantly structurally controlled; mainly stockworks of crosscutting fractures and quartz veinlets, also veins, vein sets and breccias.

ORE MINERALOGY (Principal and *subordinate*): Molybdenite is the principal ore mineral*; chalcopyrite, scheelite, and galena are generally subordinate*.

GANGUE MINERALOGY: Quartz, pyrite, K-feldspar, biotite, sericite, clays, calcite and anhydrite.

ALTERATION MINERALOGY: Alteration mineralogy is similar to that of porphyry Cu deposits. A core zone of potassic and silicic alteration is characterized by hydrothermal K-feldspar, biotite, quartz and, in some cases, anhydrite. K-feldspar and biotite commonly occur as alteration selvages on mineralized quartz veinlets and fractures but may be pervasive in areas of intense fracturing and mineralization. Phyllic alteration typically surrounds and may be superimposed to various degrees on the potassic-silicic core; it consists mainly of quartz, sericite and carbonate. Phyllic alteration is commonly pervasive and may be extensive. Propylitic alteration consisting mainly of chlorite and epidote may extend for hundreds of metres beyond the zones of potassic-silicic and phyllic alteration. Zones of argillic alteration, where present, are characterized by clay minerals such as kaolinite and are typically overprinted on the other types of alteration; distribution of argillic alteration is typically irregular.

WEATHERING: Oxidation of pyrite produces limonitic gossans; oxidation of molybdenite produces yellow ferrimolybdenite.

ORE CONTROLS: Quartz veinlet and fracture stockwork zones superimposed on intermediate to felsic intrusive rocks and surrounding country rocks; multiple stages of mineralization commonly present.

GENETIC MODEL: Magmatic-hydrothermal. Large volumes of magmatic, highly saline aqueous fluids under pressure strip Mo and other ore metals from temporally and genetically related magma. Multiple stages of brecciation related to explosive fluid pressure release from the upper parts of small intrusions result in deposition of ore and gangue minerals in crosscutting fractures, veinlets and breccias in the outer carapace of the intrusions and in associated country rocks. Incursion of meteoric water during waning stages of the magmatic-hydrothermal system may result in late alteration of the hostrocks, but does not play a significant role in the ore-forming process.

ASSOCIATED DEPOSIT TYPES: Ag-Pb-Zn veins (I05), Mo-bearing skarns (K07) may be present.

COMMENTS: Fluorite has not been observed in the Red Mountain deposit, in Yukon, but the deposit area is defined by F, W, Pb, Ag, Cu, and Zn soil geochemical anomalies peripheral to Mo.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Mo, Cu, W and F may be anomalously high in hostrocks close to and overlying mineralized zones; anomalously high levels of Pb, Zn and Ag occur in peripheral zones as much as several kilometres distant. Mo, W, F, Cu, Pb, Zn and Ag may be anomalously high in stream sediments. Mo, W and Pb may be present in heavy mineral concentrates.

GEOPHYSICAL SIGNATURE: Magnetic anomalies may reflect presence of pyrrhotite or magnetite in hornfels zones. Radiometric surveys may be used to outline anomalous K in altered and mineralized zones. Induced polarization and resistivity surveys may be used to outline high-pyrite alteration zones.

OTHER EXPLORATION GUIDES: Limonitic alteration of pyrite can result in widespread gossan zones. Yellow ferrimolybdite may be present in oxidized zones. Ag-Pb-Zn veins may be present in peripheral zones.

ECONOMIC FACTORS

GRADE AND TONNAGE: Typical size is 100 Mt at 0.1 to 0.2 % Mo. The following figures are for production plus reserves:

Endako (B.C.): 336 Mt at 0.087 % Mo; Boss Mountain (B.C.): 63 Mt. at 0.074 % Mo;

Kitsault (B.C.): 108 Mt at 0.115 % Mo; Lucky Ship (B.C.): 14 Mt at 0.090 % Mo;
Adanac (B.C.): 94 Mt at 0.094 % Mo; Carmi (B.C.): 34 Mt at 0.091 % Mo;
Mount Haskin (B.C.): 12 Mt at 0.090 % Mo; Bell Moly (B.C.): 32 Mt at 0.066 % Mo;
Red Bird (B.C.): 34 Mt at 0.108 % Mo; Storie Moly (B.C.): 101 Mt at 0.078 % Mo;
Trout Lake (B.C.): 50 Mt at 0.138 % Mo; Glacier Gulch (B.C.): 125 Mt at 0.151 % Mo;
Red Mountain (Yukon): 187 Mt at 0.100 % Mo; Quartz Hill (Alaska): 793 Mt at 0.091 % Mo;
Thompson Creek (Idaho): 181 Mt at 0.110 % Mo; Compaccha (Peru): 100 Mt at 0.072 % Mo;
East Kounrad (Russia): 30 Mt at 0.150 % Mo;
Logtung (Yukon): 162 Mt @ 0.05% MoS_2 and 0.13% WO_3

IMPORTANCE: Porphyry Mo deposits associated with low-F felsic intrusive rocks have been an important source of world molybdenum production. Virtually all of Canada's Mo production comes from these deposits and from porphyry Cu-Mo deposits.

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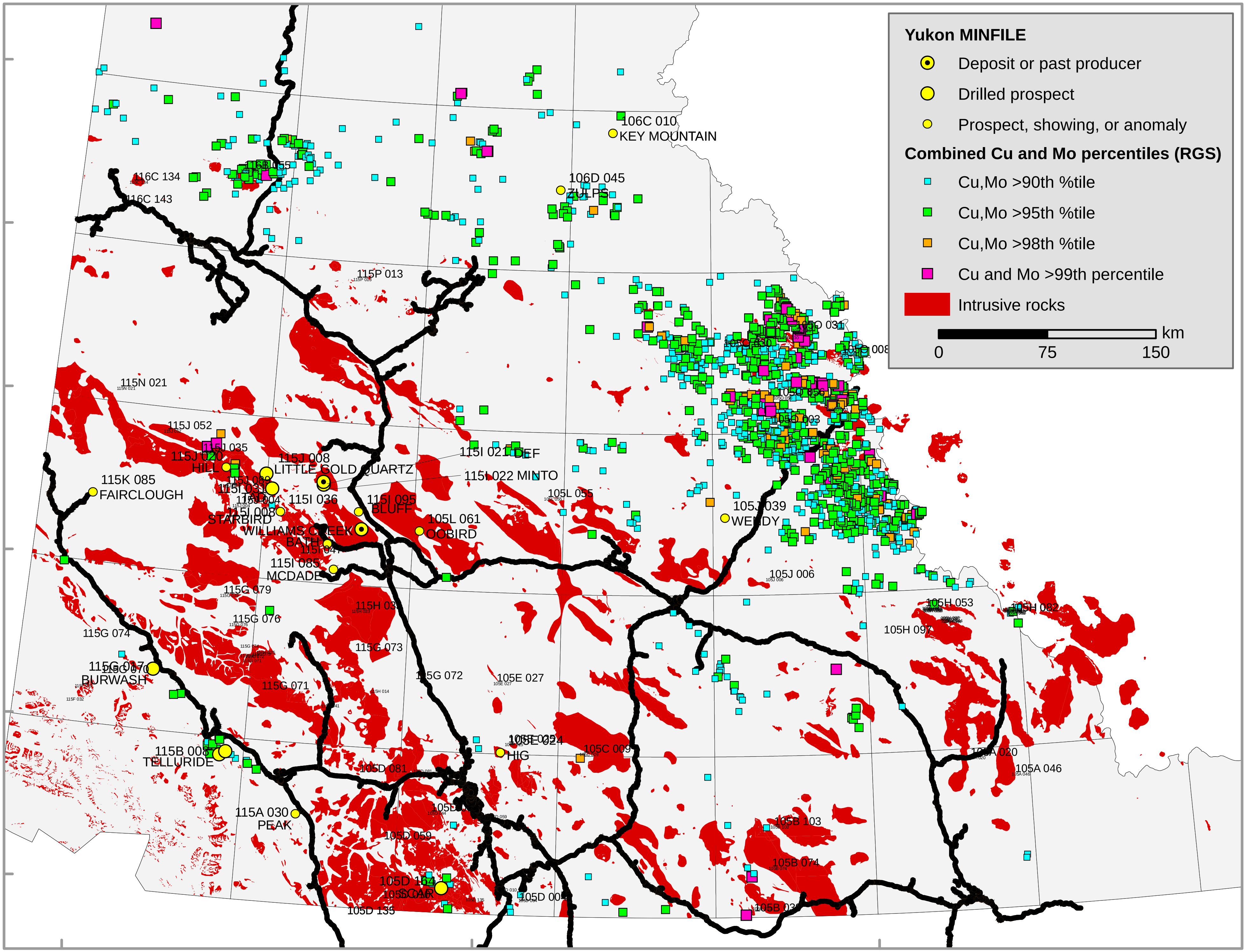
L05 - Porphyry Mo - BC, Alaska and Yukon deposits

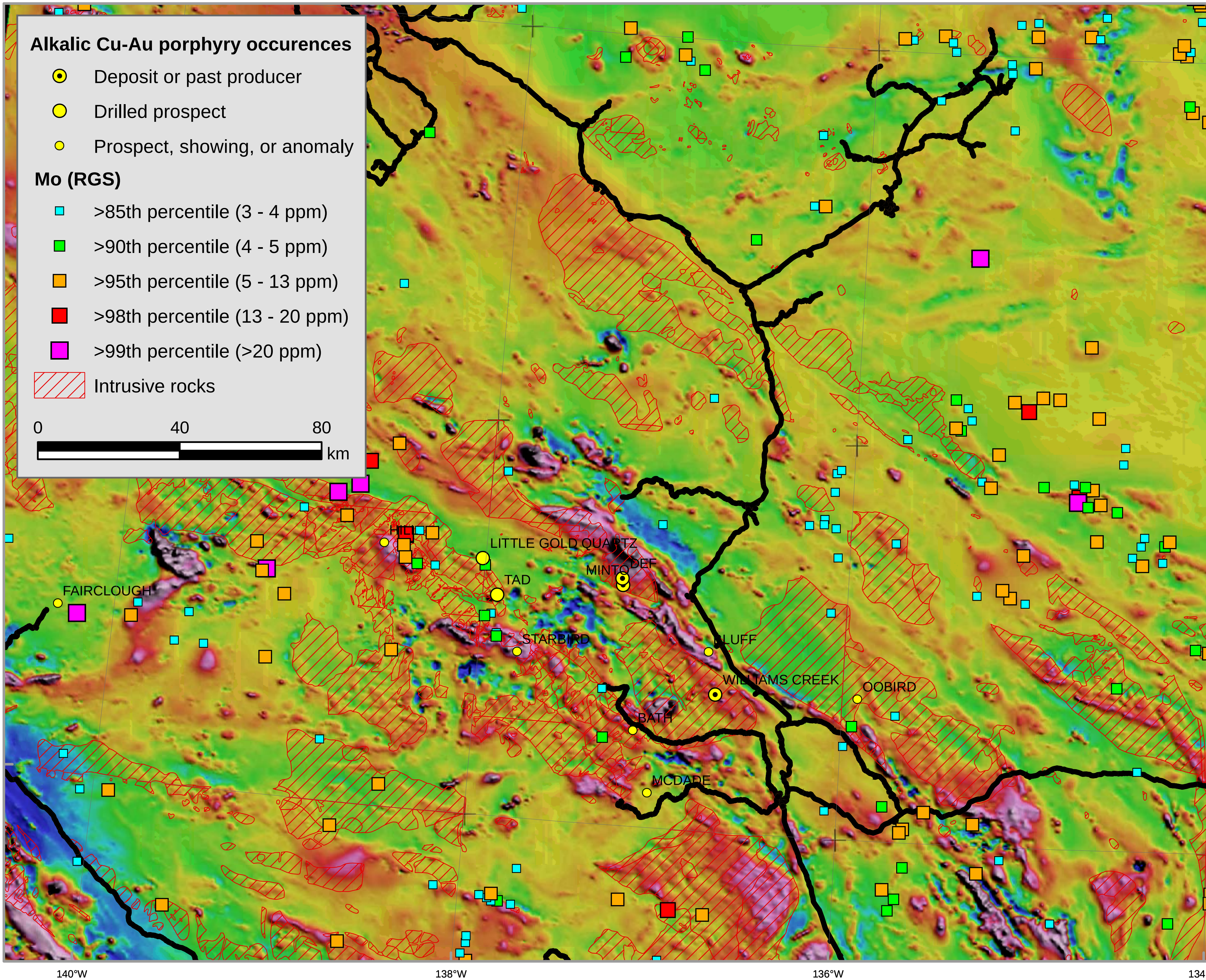
Deposit	country	tonnes	Mo
STEWART	CNBC	204,000	0.220
ROUNDY CREEK	CNBC	8,385,000	0.090
TIDEWATER	CNBC	9,000,347	0.060
BOSS MOUNTAIN	CNBC	11,352,650	0.180
MOUNT HASKIN	CNBC	12,000,000	0.090
JOE MT	CNBC	12,200,000	0.090
LUCKY SHIP	CNBC	18,000,000	0.100
GEM	CNBC	22,670,000	0.100
CARMI MOLY	CNBC	39,000,000	0.100
MOUNT THOM	CNBC	40,820,000	0.070
SERB CREEK	CNBC	41,150,000	0.050
TROUT LAKE	CNBC	50,000,000	0.140
REDBIRD	CNBC	63,500,000	0.100
GLACIER GULCH	CNBC	90,000,000	0.170
BELL MOLY	CNBC	96,160,000	0.050
KLIYU	CNBC	100,000,000	0.060
STORIE	CNBC	101,000,000	0.080
KITSAUL	CNBC	113,000,000	0.100
ADANAC	CNBC	152,000,000	0.060
AJAX	CNBC	179,000,000	0.070
RED MOUNTAIN	CNYK	187,000,000	0.100
MT. OGDEN	CNBC	220,000,000	0.180
ENDAKO	CNBC	339,000,000	0.070
QUARTZ HILL	USAK	793,000,000	0.091

Yukon MINFILE

MINFILE	NAMES	STATUS
105D 004	LIME	DRILLED PROSPECT
116C 134	PLUTO	DRILLED PROSPECT
105A 020	MURRAY	SHOWING
105D 044	ARK	SHOWING
105E 025	LORI	SHOWING
105E 027	BACON, JAVA	SHOWING
105H 044	RENA	SHOWING
105H 053	TILLEI	SHOWING
105H 082	TUNA	SHOWING
105H 097	TUS	SHOWING
105L 055	HODDER	SHOWING
105O 008	KEELE	SHOWING
105O 030	GRIZZ	SHOWING
105O 031	VAN ANGEREN	SHOWING
115G 076	DWARF	SHOWING
115H 033	BUFF	SHOWING
105A 046	TAFFIE	ANOMALY
105D 135	WEST ARM	ANOMALY
105J 006	TAC	ANOMALY
115F 032	ICE FIELD	ANOMALY
115G 073	BED	ANOMALY
115G 074	ALASKITE	ANOMALY
115I 047	TRITOP	ANOMALY
115J 004	SOMME, TOM	ANOMALY
116B 055	FIREWEED	ANOMALY
105O 003	JEFF	UNKNOWN
105O 056	GOLD	UNKNOWN
115G 072	NORTH STAR	UNKNOWN
115H 025	KATHY	UNKNOWN
116C 143	SWEDE	UNKNOWN



Map of Yukon showing porphyry Mo occurrences, Cu-Mo geochemistry and the distribution of intrusive rocks



Map of central Yukon showing alkalic Cu-Au porphyry occurrences, regional magnetics and Mo regional geochemistry

PORPHYRY Sn L06

by W. David Sinclair[1]
modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYM: Subvolcanic Sn

COMMODITIES (*BYPRODUCTS*): Sn (*Ag, W*)

EXAMPLES: (British Columbia - *Canada/International*): *Mount Pleasant (New Brunswick, Canada), East Kemptville (Nova Scotia, Canada), Catavi, Chorolque and Cerro Rico stock (Bolivia), Ardlethan and Taronga (Australia), Kingan (Russia), Yinyan (China), Altenberg (Germany).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Fine-grained cassiterite in veinlet and fracture stockwork zones, breccia zones, and disseminated in porphyritic felsic intrusive rocks and associated country rocks.

TECTONIC SETTING: Zones of weak to moderate extension in cratons, particularly post orogenic zones underlain by thick crust, possibly cut by shallow-dipping subduction zones.

GEOLOGICAL SETTING: High-level to subvolcanic felsic intrusive centres in cratons; multiple stages of intrusion may be present. **In Yukon, prospective porphyry stocks and dykes of the Ross Assemblage were emplaced along the crustal-scale Tintina Fault.**

AGE OF MINERALIZATION: Paleozoic to Tertiary. **Porphyry Sn prospects in Yukon are related to the mid-Cretaceous Selwyn Plutonic Suite, particularly the Seagull Batholith, and to porphyry stocks in the lower Tertiary Ross assemblage.**

HOST/ASSOCIATED ROCK TYPES: Predominantly genetically related intrusive rocks and associated breccias, but may also include related or unrelated sedimentary, volcanic, igneous and metamorphic rocks. Genetically related felsic intrusive rocks are F and/or B enriched and are commonly porphyritic. Tuffs or other extrusive volcanic rocks may be associated with deposits related to subvolcanic intrusions.

DEPOSIT FORM: Deposits vary in shape from inverted cone, to roughly cylindrical, to highly irregular. They are typically large, generally hundreds of metres across and ranging from tens to hundreds of metres in vertical extent.

TEXTURE/STRUCTURE: Ore is predominantly structurally controlled in stockworks of crosscutting fractures and quartz veinlets, or disseminated in hydrothermal breccia zones. Veins, vein sets, replacement zones may also be present.

[1] Geological Survey of Canada, Ottawa

ORE MINERALOGY (Principal and subordinate): Cassiterite, *stannite, chalcopyrite, sphalerite and galena. Complex tin- and silver-bearing sulphosalts occur in late veins and replacement zones.*

GANGUE MINERALOGY: Pyrite, arsenopyrite, löllingite, topaz, fluorite, tourmaline, muscovite, zinnwaldite and lepidolite.

ALTERATION MINERALOGY: In the Bolivian porphyry Sn deposits, sericite + pyrite ± tourmaline alteration is pervasive; in some deposits it surrounds a central zone of quartz + tourmaline. Sericitic alteration is typically bordered by weak propylitic alteration. In other deposits (*e.g.*, Ardlethan, Yinyan), central zones are characterized by greisen alteration consisting of quartz + topaz + sericite; these zones grade outward to quartz + sericite + chlorite alteration.

WEATHERING: Oxidation of pyrite produces limonitic gossans. Deep weathering and erosion can result in residual concentrations of cassiterite in situ or in placer deposits down slope or downstream.

ORE CONTROLS: Ore minerals occur in fracture stockworks, hydrothermal breccias and replacement zones centred on 1-2 km^2, genetically related felsic intrusions.

GENETIC MODEL: Magmatic-hydrothermal. Large volumes of magmatic, highly saline aqueous fluids under pressure strip Sn and other ore metals from temporally and genetically related magma. Multiple stages of brecciation related to explosive fluid pressure release from the upper parts of small intrusions result in deposition of ore and gangue minerals in crosscutting fractures, veinlets and breccias in the outer carapace of the intrusions and associated country rocks. Mixing of magmatic with meteoric water during waning stages of the magmatic-hydrothermal system may result in deposition of some Sn and other metals, particularly in late-stage veins.

ASSOCIATED DEPOSIT TYPES: Sn veins (I13), Sn-polymetallic veins (H07).

COMMENTS: Some of the deposits listed (*e.g* , Taronga, East Kemptville) are not "subvolcanic" but they are similar to some porphyry Cu deposits with regard to their large size, low grade, relationship to felsic intrusive rocks and dominant structural control (ie., mineralized veins, fractures and breccias).

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Sn, Ag, W, Cu, Zn, As, Pb, Rb, Li, F, B may be anomalously high in host rocks close to mineralized zones and in secondary dispersion halos in overburden. Anomalously high contents of Sn, W, F, Cu, Pb and Zn may occur in stream sediments and Sn, W, F (topaz) and B (tourmaline) may be present in heavy mineral concentrates.

GEOPHYSICAL SIGNATURE: Genetically related intrusions may be magnetic lows (ilmenite- rather than magnetite-dominant); contact aureole may be magnetic high if pyrrhotite or magnetite are present in associated skarn or hornfels zones. Radiometric surveys may be used to outline anomalous U, Th or K in genetically related intrusive rocks or in associated altered and mineralized zones.

OTHER EXPLORATION GUIDES: Sn (-Ag) deposits may be zoned relative to base metals at both regional (district) and local (deposit) scales.

ECONOMIC FACTORS

GRADE AND TONNAGE: Tens of millions of tonnes at grades of 0.2 to 0.5% Sn.
Mount Pleasant (New Brunswick): 5.1 Mt @ 0.79% Sn; East Kemptville (Nova Scotia): 56 Mt @ 0.165% Sn; Catavi (Bolivia): 80 Mt @ 0.3% Sn; Cerro Rico stock, Bolivia: averages 0.3% Sn; Ardlethan (Australia): 9 Mt @ 0.5% Sn; Taronga (Australia): 46.8 Mt @ 0.145% Sn; Altenberg, (Germany): 60 Mt @ 0.3% Sn; Yinyan (China): "large" (50 - 100 Mt?) @ 0.46% Sn

ECONOMIC LIMITATIONS: Low grades require high volumes of production which may not be justified by demand.

IMPORTANCE: A minor source of tin on a world scale; when it was in production, East Kemptville was the major producer of tin in North America.

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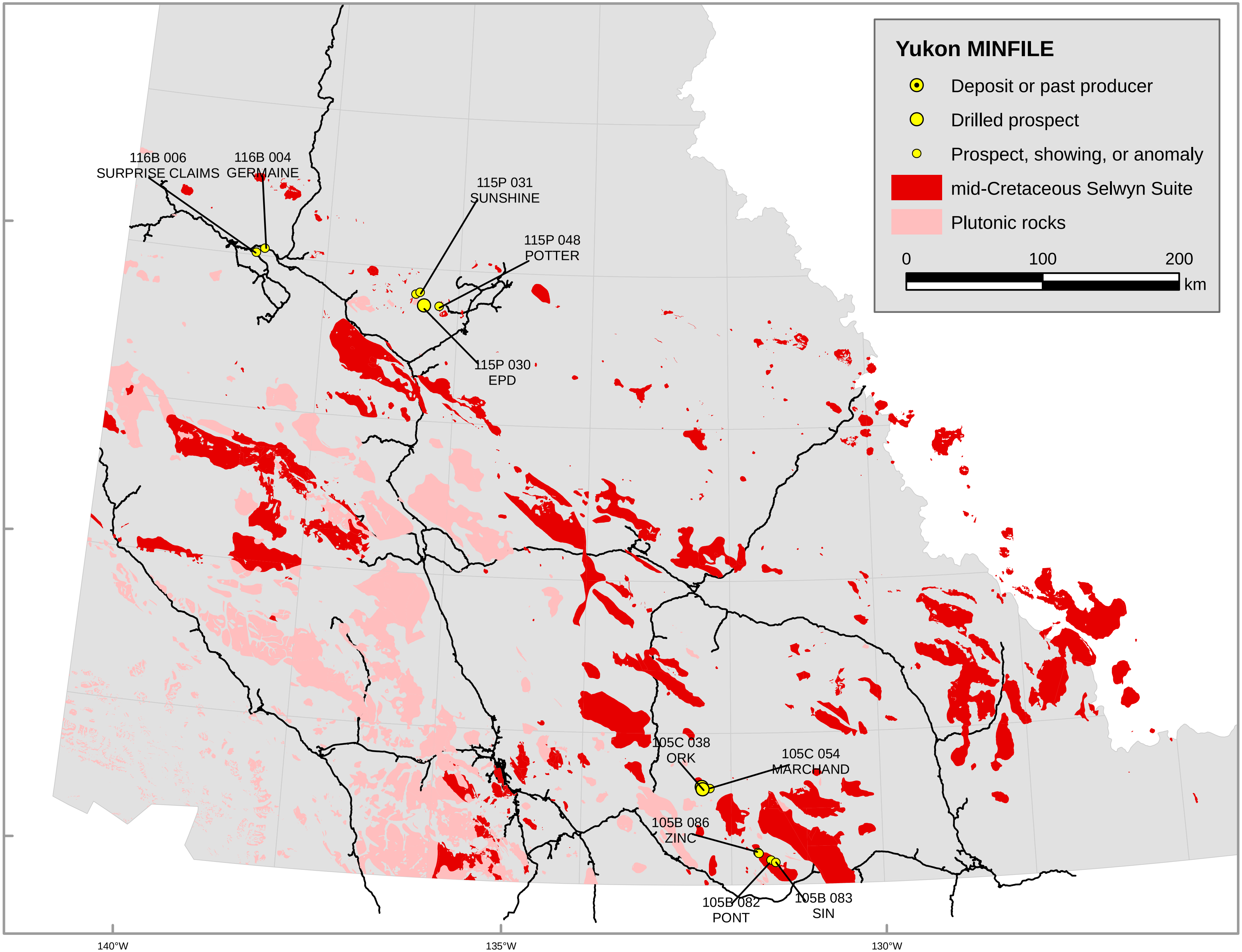
L06 - Porphyry Sn - World Deposits

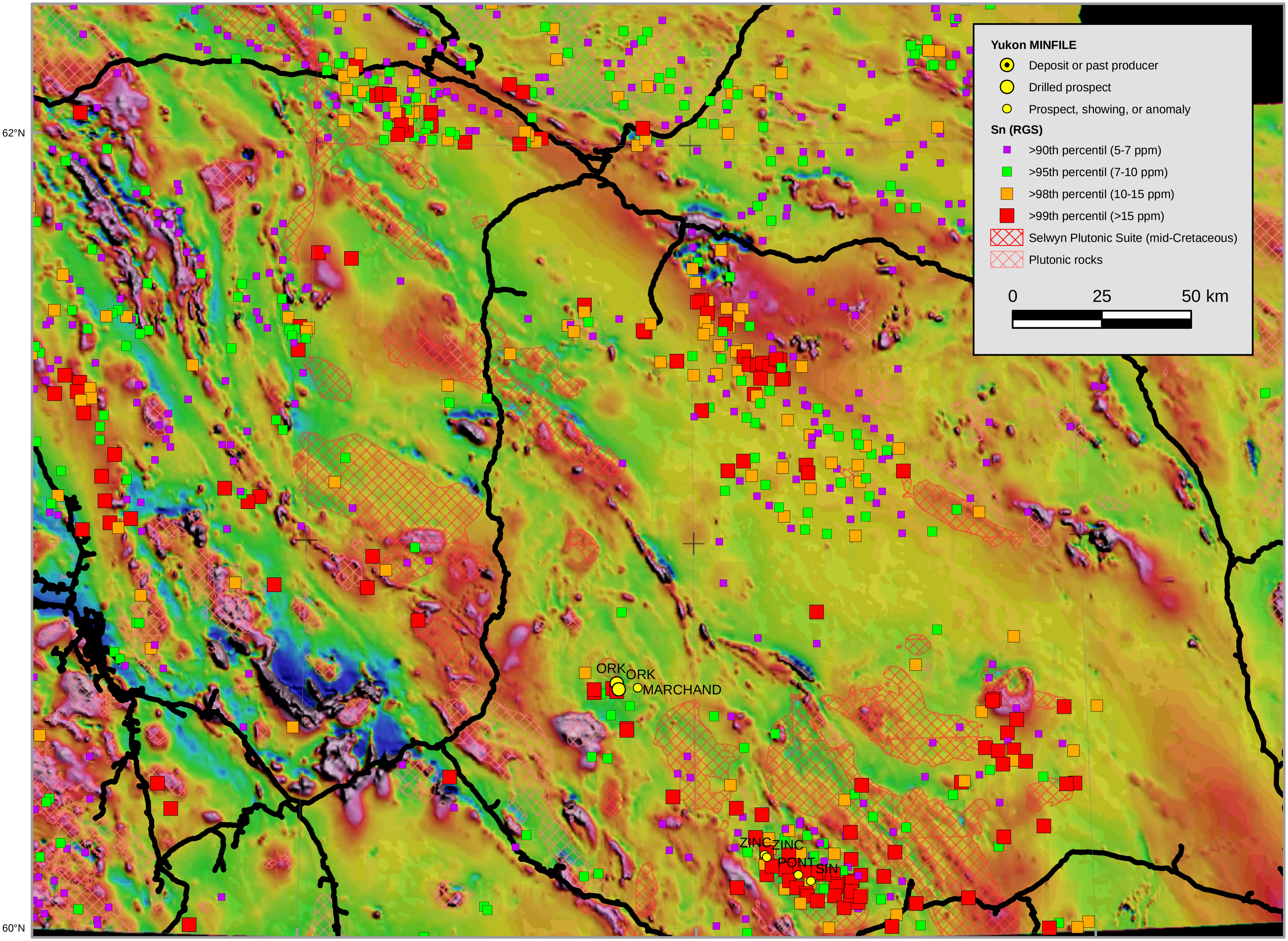
deposit	country	tonnes	Sn %
Mount Pleasant	CNNB	5 100 000	0.79
Ardlethan	AUST	9 000 000	0.5
Taronga	AUST	46 800 000	0.145
Yinyan	CHNA	50 000 000	0.46
East Kemptville	CNNS	56 000 000	0.165
Altenberg	GERM	60 000 000	0.3
Catavi	BOLI	80 000 000	0.3

Yukon MINFILE

MINFILE	NAMES	STATUS
116B 004	GERMAINE	DRILLED PROSPECT
105B 083	SIN	SHOWING



Map of Yukon showing porphyry Sn occurrences, the distribution of all plutonic rocks and the distribution of Selwyn suite plutonic rocks



Map of south central Yukon showing porphyry Sn occurrences, regional magnetics and Sn regional geochemistry

PORPHYRY W L07

by W. David Sinclair[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYM: Stockwork W-Mo

COMMODITIES (*BYPRODUCTS*): W (*Mo, Sn, Ag*).

EXAMPLES: **(Yukon): Logtung (105B 039)**;
(British Columbia - *Canada/International*): Boya; *Mount Pleasant (New Brunswick, Canada),* ***Logtung (Yukon, Canada)****, Xingluokeng, Lianhuashan and Yanchuling (China).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Stockworks of W-bearing quartz veinlets and fractures in felsic intrusive rocks and associated country rocks. Deposits are low grade but large and amenable to bulk mining methods.

TECTONIC SETTING: Zones of weak to moderate extension in cratons, particularly post-collisional zones in areas of tectonically thickened crust.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: High-level to subvolcanic felsic intrusive centres; multiple stages of intrusion are common.

AGE OF MINERALIZATION: Paleozoic to Tertiary, but Mesozoic and Tertiary examples are more common. **At the Logtung deposit, mineralization is associated with undeformed intrusive rocks dated at 118 Ma that are interpreted to be part of the mid-Cretaceous Cassiar Suite.**

HOST/ASSOCIATED ROCK TYPES: Highly variable; mineralized rocks may be predominantly genetically related intrusive rocks, but may also be related or unrelated sedimentary, volcanic, igneous and metamorphic rocks. Genetically related felsic intrusive rocks are commonly F-rich (fluorite and/or topaz bearing) and porphyritic; unidirectional solidification features, particularly comb quartz layers, may also be present. Tuffs or other extrusive volcanic rocks may be associated with deposits related to subvolcanic intrusions.

DEPOSIT FORM: Deposits vary in shape from inverted cup-shaped, to roughly cylindrical, to highly irregular. They are typically large, generally hundreds of metres across and ranging from tens to hundreds of metres in vertical extent.

TEXTURE/STRUCTURE: Ore minerals is structurally controlled; mainly stockworks of crosscutting fractures and quartz veinlets, also veins, vein sets, breccias, disseminations and replacements.

[1] Geological Survey of Canada, Ottawa, Ontario, Canada

ORE MINERALOGY (Principal and *subordinate*): Main ore mineral is generally either scheelite or wolframite, although in some deposits both are present. *Subordinate ore minerals include molybdenite, bismuth, bismuthinite and cassiterite.*

GANGUE MINERALOGY: Pyrite, pyrrhotite, magnetite, arsenopyrite, löllingite, quartz, K-feldspar, biotite, muscovite, fluorite, topaz.

ALTERATION MINERALOGY: Hydrothermal alteration is pervasive to fracture controlled and, at deposit scale, is concentrically zoned. It is commonly characterized by the presence of greisen alteration minerals, including topaz, fluorite and Li- and F-rich micas. At Mount Pleasant, for example, pervasive greisen alteration consisting of quartz + topaz ± sericite ± chlorite associated with high-grade W zones and grades laterally into fracture-controlled quartz-biotite-chlorite-topaz alteration associated with lower grade W zones. Propylitic alteration, mainly chlorite and sericite, extends as far as 1500 m beyond the mineralized zones. Potassic alteration, dominated by K-feldspar, occurs locally within the central areas of pervasive greisen alteration. Other deposits such as Xingluokeng (China) are characterized more by central zones of silicic and potassic alteration (K-feldspar and biotite); zones of weak greisen alteration consisting of muscovite and fluorite may be present. Sericitic alteration forms a broad aureole around the central potassic zone; irregular zones of argillic alteration may be superimposed on both the potassic and sericitic zones. In detail, alteration patterns may be complex; at Logtung, for example, different stages of mineralized veins and fractures are characterized by different assemblages of ore and alteration minerals.

WEATHERING: Oxidation of pyrite produces limonitic gossans; oxidation of molybdenite, if present, may produce yellow ferrimolybdenite.

ORE CONTROLS: Quartz veinlet and fracture stockwork zones surround or are draped over and are superimposed to varying degrees on small stocks (<1 km^2); multiple stages of mineralization commonly present; felsic intrusions associated with the deposits are typically F-rich.

GENETIC MODEL: Magmatic-hydrothermal. Large volumes of magmatic, highly saline aqueous fluids under pressure strip W, Mo and other ore metals from temporally and genetically related magma. Multiple stages of brecciation related to explosive fluid pressure release from the upper parts of small intrusions result in deposition of ore and gangue minerals in crosscutting fractures, veinlets and breccias in the outer carapace of the intrusions and associated country rocks. Incursion of meteoric water during waning stages of the magmatic-hydrothermal system may result in late alteration of the hostrocks, but does not play a significant role in the ore forming process.

ASSOCIATED DEPOSIT TYPES: Porphyry W deposits may be part of a spectrum of deposits that include Climax-type Mo deposits (L08) as one end-member and porphyry Sn deposits as the other (L06). Vein/replacement W, Sn, Ag deposits may be associated (I05, H07), *e.g.* Logjam Ag-Pb-Zn veins peripheral to the Logtung W-Mo deposit. Skarn (contact metamorphic) zones associated with genetically related felsic intrusions may be mineralized, but are not typical skarn W (i.e. contact metasomatic) deposits.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: W, Mo and Sn are anomalous in hostrocks close to mineralized zones; anomalously high contents of F, Zn, Pb and Cu occur in wallrocks up to several kilometres from mineralized zones. W, Sn, Mo, F, Cu, Pb and Zn may be anomalously high in stream sediments and W, Sn and F (topaz) may be present in heavy mineral concentrates.

GEOPHYSICAL SIGNATURE: Genetically related intrusions may be magnetic lows (ilmenite rather than magnetite dominant); contact aureole may be magnetic high if pyrrhotite or magnetite are present in associated skarn or hornfels zones. Radiometric surveys may be used to outline anomalous U, Th or K in genetically related intrusive rocks or in associated altered and mineralized zones.

OTHER EXPLORATION GUIDES: The presence of scheelite can be detected with an ultraviolet lamp.

ECONOMIC FACTORS

GRADE AND TONNAGE: Tens to more than 100 Mt at grades of 0.2 to 0.3 % W (Lianhushan is exceptional at 0.8 % W). Boya (British Columbia): limited size due to thrust fault truncation, no published resource data. Mount Pleasant (New Brunswick): Fire Tower zone: 22.5 Mt @ 0.21 % W, 0.10 % Mo, 0.08 % Bi, (includes 9.4 Mt @ 0.31 % W, and 0.12 % Mo), North zone: 11 Mt @ 0.2 % W, 0.1 % Mo. Logtung (Yukon): 162 Mt @ 0.10 % W, 0.03 % Mo. Xingluokeng (China): 78 Mt @ 0.18 % W. Lianhuashan (China): ~40 Mt @ 0.8 % W. **Geological resource estimates of the Logtung deposit are 230 Mt @ 0.104% W, 0.05% Mo, including a higher grade core consisting of 55 Mt @ 0.16% W, 0.062% Mo.**

ECONOMIC LIMITATIONS: Low grades require high production volumes which may not be justified by current demand for tungsten.

IMPORTANCE: Not currently an important source of world W production; some W may be recovered from deposits in China (*e.g.,* Lianhuashan), but none is recovered at present (1994) from deposits outside China. Mount Pleasant Tungsten in New Brunswick produced slightly more than 2000 t of concentrate grading 70 % WO_3 from 1 Mt of ore mined from 1983 to 1985.

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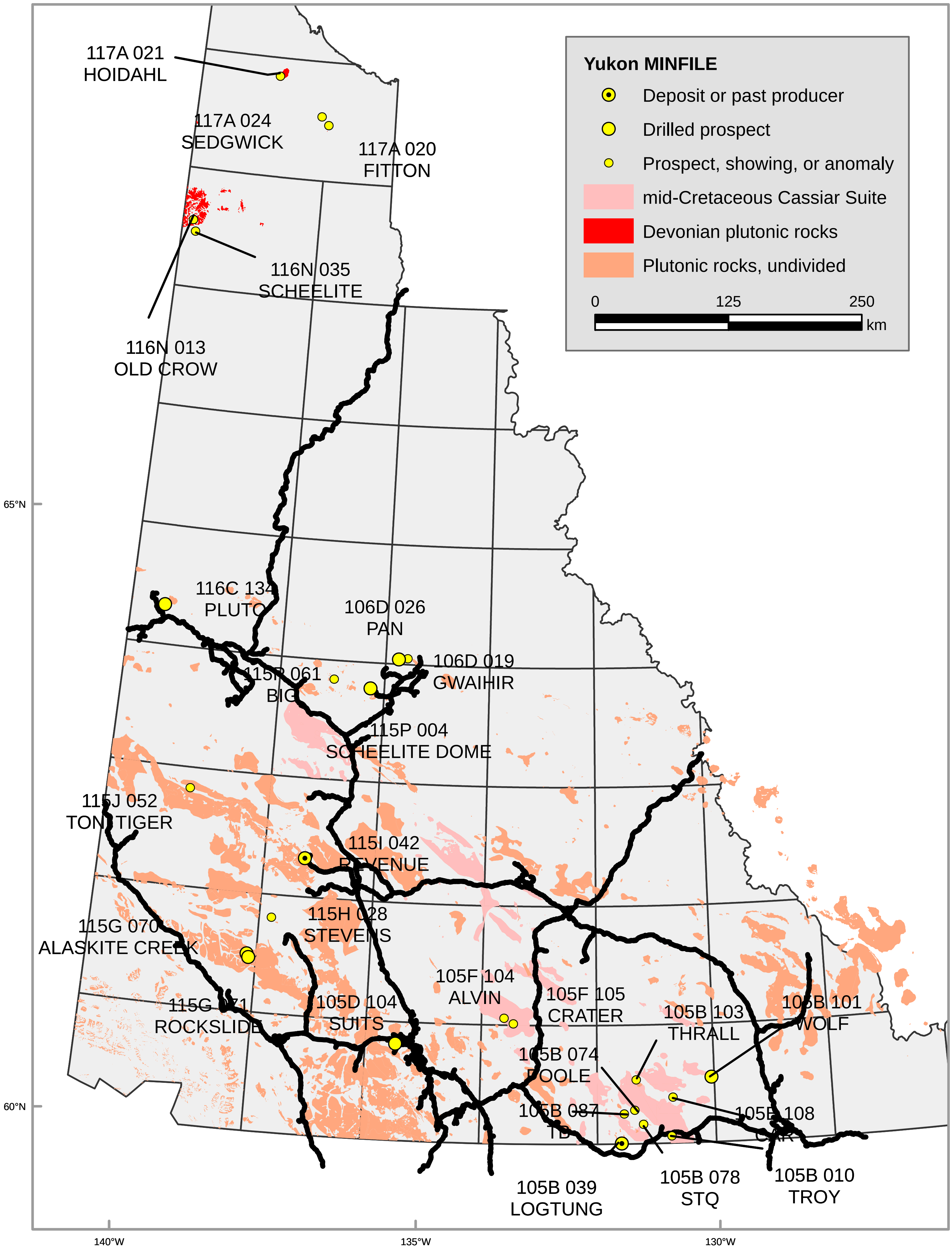
L07 - Porphyry W - World Deposits

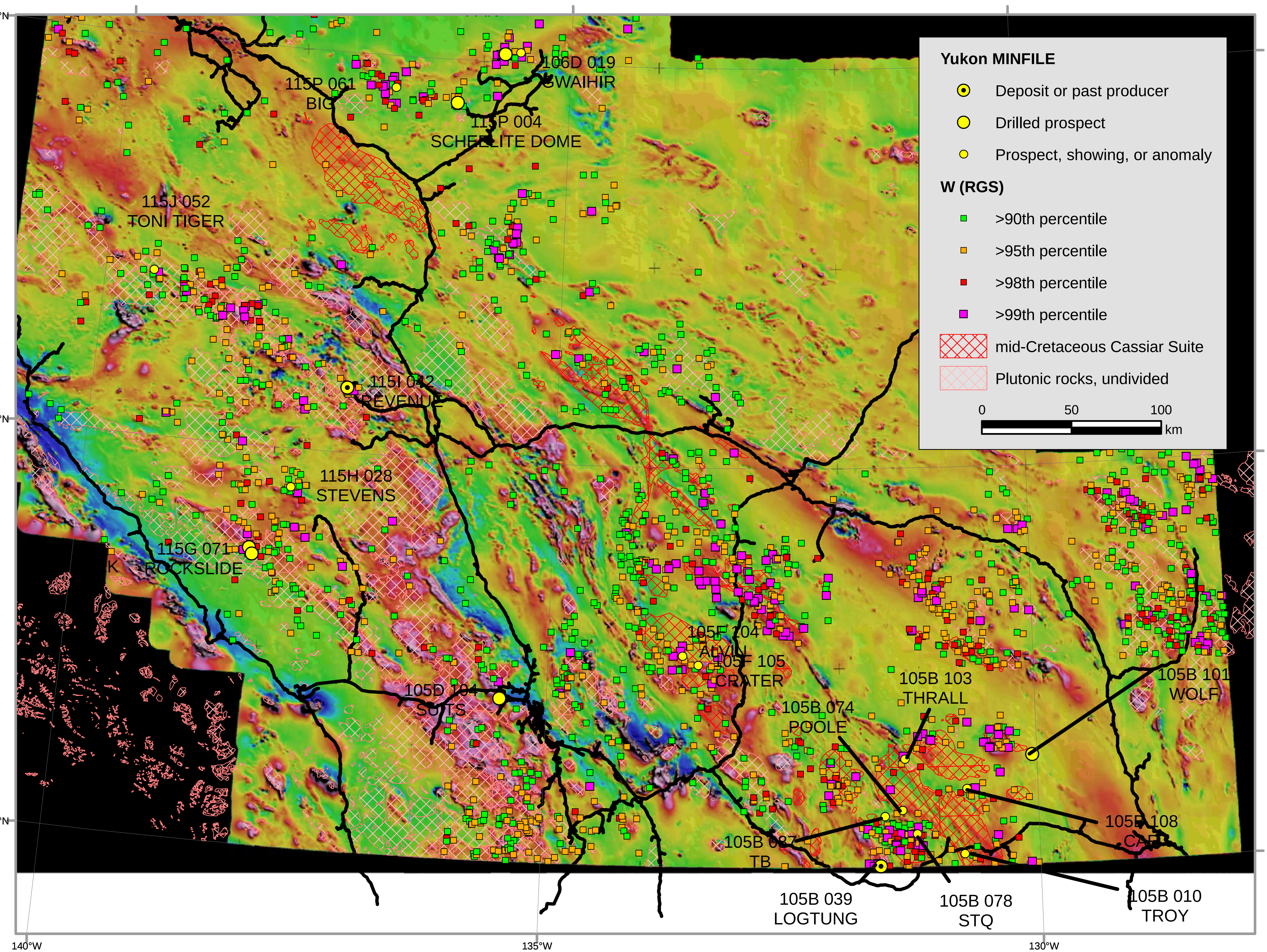
Deposit	Country	tonnes	WO_3	Mo	Bi
Logtung	CNYK	162 000 000	0.13	0.03	
Mount Pleasant Fire Tower	CNNB	22 500 000	0.21	0.1	0.08
Mount Pleasant North Zone	CNNB	11 000 000	0.2	0.1	
Xingluokeng	CHINA	78 000 000	0.18		
Lianhuashan	CHINA	40 000 000	0.8		

Yukon MINFILE

MINFILE	NAMES	STATUS
105B 039	LOGTUNG	DEPOSIT
105B 101	CORDILLERAN, WOLF, END ZONE	DRILLED PROSPECT
106D 026	POTATO HILLS, PAN	DRILLED PROSPECT
115P 004	SCHEELITE DOME, SCHEELITE DOME PROJECT	DRILLED PROSPECT
106D 019	GWAIHIR	PROSPECT
105B 074	POOLE, HL, ICE	SHOWING
105B 078	VERLEY	SHOWING
105F 104	ALVIN, TIM	SHOWING
105F 105	CRATER	SHOWING
117A 024	SEDGWICK	SHOWING
116N 013	OLD CROW	ANOMALY
116N 035	SCHEELITE	ANOMALY



Map of Yukon showing W-porphyry occurrences and the distribution of plutonic rocks



Map of southern Yukon showing W porphyry occurrences, W geochemistry, regional magnetics, Cassiar Suite plutonic rocks, and other plutonic rocks

PODIFORM CHROMITE M03

by Chris Ash[1]
Modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
May 30, 2005.

IDENTIFICATION

SYNONYMS: Alpine type; ophiolite hosted chromite.

COMMODITIES (*BYPRODUCTS*): Chromite (may contain platinum group elements Os, Ir and Ru).

EXAMPLES: (British Columbia - *Canada/International*): Castle Mountain Nickel (082ESE091) and Scottie Creek (092INW001); *Guleman ore field (Turkey); Kalimash - Kukes-Tropoje district, Bulquize and Todo Manco - Bater-Martanesh district (Mirdita ophiolite, Albania); Tiébaghi ophiolite and Massif du Sud (New Caledonia), Acoje and Masinloc-Coto (Zambales range/ophiolite, Luzon, Phillipines); Batamshinsk, Stepninsk, Tagashaisai and Main SE ore fields (Kempirsai massif, Southern Urals, Russia); Xeraivado and Skoumtsa mines (Vourinos ophiolite, Greece); Semail ophiolite (Oman); Luobusa, Donqiao, Sartohay, Yushi, Solun, Wudu and Hegenshan deposits (China) all > 1.5 Mt.*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Deposits of massive chromite occur as pods, lenses or layers within ophiolitic ultramafic rocks.

TECTONIC SETTING: Obducted fragments of oceanic, lower crustal and upper mantle ultramafic rocks within accreted oceanic terranes.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Formed as a primary magmatic differentiate during early olivine and chrome-spinel crystal fractionation of basaltic liquid at an oceanic spreading centre; (1) as massive to disseminated pods and lenses of chrome-spinel surrounded by a dunite envelope within depleted mantle harzburgite; or (2) as massive to disseminated cumulate layers in dunite at the base of the crustal plutonic section.

AGE OF MINERALIZATION: Mesozoic and younger.

HOST/ASSOCIATED ROCK TYPES: Variably serpentinized peridotite; residual mantle harzburgite; cumulate dunite.

DEPOSIT FORM: Podiform, tabular lenses, irregular masses, cumulate layers. Pods and lenses typically occur in clusters of variable size.

TEXTURE/STRUCTURE: Massive to disseminated, nodular (*syn*. leopard, grape, bean or shot ore), chromite net, occluded silicate, orbicular.

ORE MINERALOGY: Chromite.

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GANGUE MINERALOGY [Principal and *subordinate*]: Variably serpentinized olivine and orthopyroxene, magnetite, *iddingsite*.

WEATHERING: Black, no noticeable affects resulting from surface oxidation.

ORE CONTROLS: Proximity to the crust-mantle transition zone. Restricted to dunite bodies in tectonized harzburgite below this transition, or lower dunitic portions of ultramafic cumulate section above it.

GENETIC MODEL: Early fractional crystallization of chromite from a basaltic liquid either (1) just below the crust-mantle transition (syn. petrological MOHO) in small magma pockets or possibly conduits within the residual mantle harzburgite; or (2) immediately above the crust-mantle transition as cumulate layers within dunite at the base of the axial magma chamber. Pods and lenses in harzburgite obtain their diagonistic shape as a result subsolidus to hypersolidus ductile deformation due to mantle convection.

COMMENTS: Ophiolites of suprasubduction zone affinity with harzburgite mantle sections appear to be the only ophiolite type to host economic deposits of podiform chromite. A lack of any sizable chromite occurrence in British Columbia may reflect the fact that most ophiolitic complexes in the province are of mid-ocean ridge affinity. Occurrences of podiform chromite are found in ophiolitic ultramafic rocks in the Slide Mountain, Cache Creek and Bridge River terranes. Most of these known occurrences have been reviewed by Hancock (1990). **Yukon has no podiform chromite deposits. Prospects are located in Yukon-Tanana, Slide Mountain, Cache Creek, and Windy-McKinley terranes.**

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Cr

GEOPHYSICAL SIGNATURE: Gravity anomaly.

OTHER EXPLORATION GUIDES: Found in rocks formed near or within the ophiolitic crust-mantle transition zone.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: Grades range from 20 to 60% Cr_2O_3 and are a function of the texture of the chromite; *i.e.* amount of chromite relative to gangue serpentinite. Tonnages are variable, ranging from several thousand tonnes to several million tonnes.

ECONOMIC LIMITATIONS: The complex structure and irregular distribution make exploration and development difficult.

END USES: Chromium has a wide range of uses in the iron and steel industry which accounts for over 75% of its use. Chromite is also used in making refractory bricks for furnace linings.

IMPORTANCE: An important source of metallurgical-type chromite ores (45-60% Cr_2O_3: Cr/Fe = 2.8-4.3). Podiform chromite is the only source of refractory-type ore (min. 25% Al_2O_3: min. 60% Cr_2O_3 + Al_2O_3: max. 15% FeO). Historically podiform-type ore fields account for 57% of all chromite produced.

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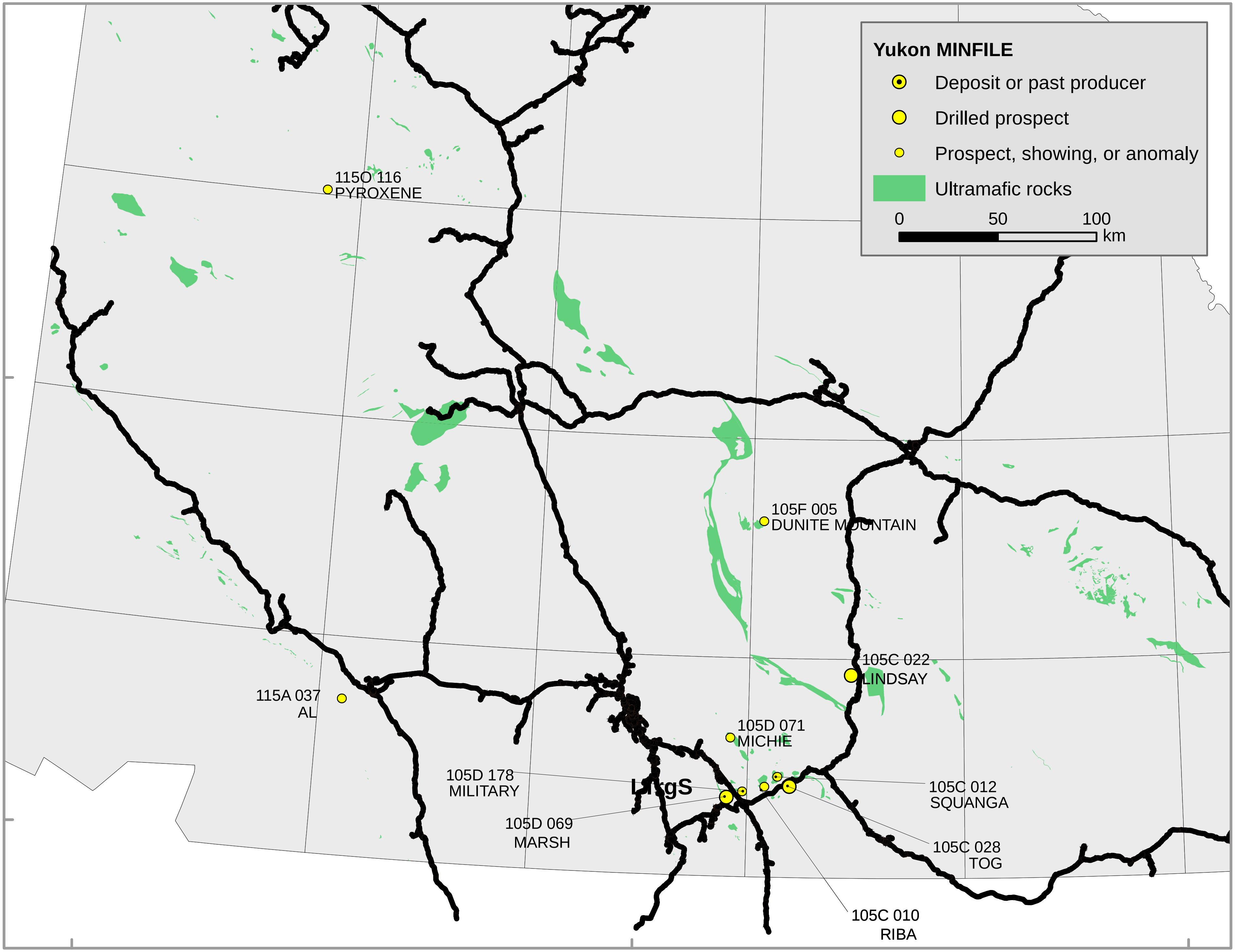
M03 - Podiform chromite - World deposits

Minor podiform chromite deposits

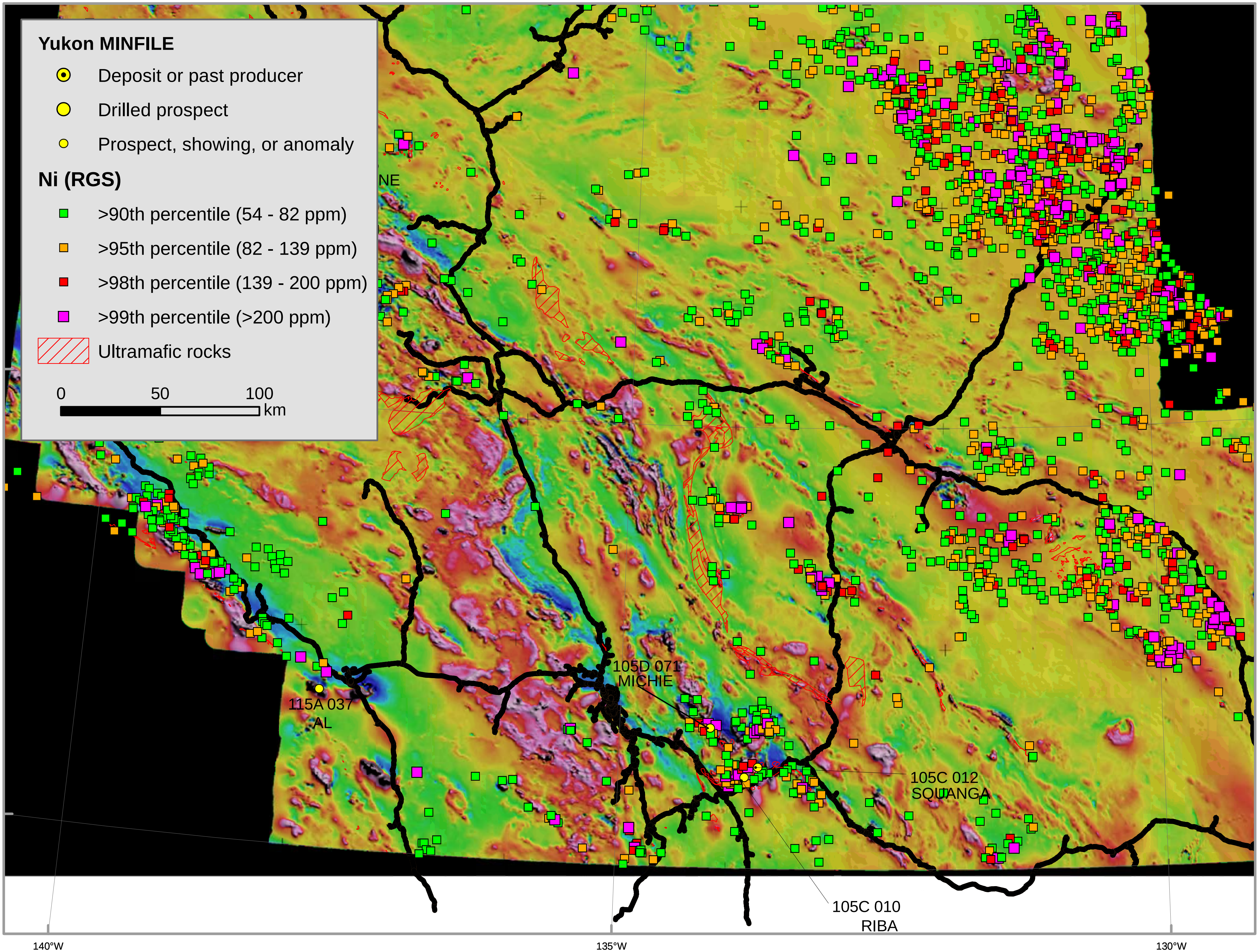
Deposit	country	tonnes	Cr %
Altindag	TRKY	560	46.60
Akarca	TRKY	750	28.00
Yayca Boyna	TRKY	800	39.00
Cenger-Adatepe	TRKY	1,000	43.00
Dogu Kef	TRKY	1,000	41.00
Akkoya	TRKY	1,200	34.70
Tilkim-Karanlik	TRKY	1,300	42.00
Karani	TRKY	1,800	47.00
Jose	CUBA	2,000	31.00
Sekioren	TRKY	2,000	47.00
Toparlar-Alacik	TRKY	2,000	39.00
Eldirek	TRKY	2,452	41.50
Dagkuplu	TRKY	2,500	41.10
Koycegiz-Orta	TRKY	2,700	42.00
Findikli #301	TRKY	2,750	48.00
Kagit Octu	TRKY	2,800	48.00
Guillermina	CUBA	3,000	25.00
Catolsinir II	TRKY	3,000	48.00
Kuzkavak	TRKY	3,000	50.00
Musa Danisman	TRKY	3,000	55.20
Terlik	TRKY	3,000	48.90
Karaculha	TRKY	4,000	31.00
Yurtlak	TRKY	4,000	46.30
Tekneli	TRKY	4,100	47.00
Danacik	TRKY	4,200	46.80
Kuldoden	TRKY	4,300	45.70
Catak-Koraalan	TRKY	4,500	47.40
Yanikara	TRKY	4,560	47.00
Consolation	NCAL	4,920	49.00
Gunlik Basi	TRKY	5,000	27.00
Karatas-Kumocak	TRKY	5,000	42.20
Kartalkoyu	TRKY	5,000	48.85
Kemikli Inbasi	TRKY	5,000	41.00
Kurudere Basi	TRKY	5,000	35.00
Dcev 7	NCAL	5,067	57.00
Kavakdere	TRKY	5,700	44.00
Karaninar	TRKY	5,750	42.00
Child Harold	NCAL	5,812	50.00
El Cid	CUBA	6,000	34.00
Bagirsakdire	TRKY	6,000	51.00
Sarikaya	TRKY	6,000	49.50
Kavakcali	TRKY	6,150	41.70
Balcicakiri	TRKY	6,500	48.60
Yukari Zorkum	TRKY	6,500	38.00
La Victoria	CUBA	7,000	25.00
Suluiyeh	IRAN	7,000	56.00
Stephane	NCAL	7,350	47.00
Bugugan	TRKY	8,000	38.70
Igdeli Payas	TRKY	8,200	44.70
Bellevue	NCAL	8,428	49.50
Ikisulu-Gercek	TRKY	8,558	49.00
P. B.	NCAL	8,878	52.00
Ofelia	CUBA	9,000	35.50
Domuzburnu II	TRKY	9,500	36.40
Morrachini	NCAL	9,700	53.00
Dovis	IRAN	10,000	50.00
Bereket	TRKY	10,000	56.10
Mirandag Koru	TRKY	10,000	57.36
Mirandag Mevki	TRKY	10,000	37.40
Yilmaz Ocagi	TRKY	10,000	50.90
Bozkonus	TRKY	10,200	47.00
Gorunur	TRKY	10,700	47.20
Yaprakli	TRKY	10,700	47.20
Findikli	TRKY	11,000	47.00
Sofulu	TRKY	11,000	50.00
Asagi Zorkum	TRKY	12,000	40.00
Findikli #326	TRKY	12,000	50.00
Bonsecours	NCAL	12,257	53.00
Karageban	TRKY	13,000	39.50
Catak	TRKY	14,000	41.00
Salur-Karacam	TRKY	15,000	49.00
Tuzlakaya	TRKY	15,000	35.00
Sutpinar	TRKY	17,400	47.00

Yukon MINFILE

MINFILE	NAMES	STATUS
105C 012	SQUANGA	SHOWING
105D 071	MICHIE	SHOWING
115A 037	STRIDE, CHROMITE, MINK	SHOWING
106D 004	WHITTING, BAG	SHOWING
115O 116	PYROXENE	ANOMALY



Map of Yukon showing podiform chromite occurrences and the distribution of ultramafic rocks



Map of Yukon showing podiform chromite occurrences, Ni regional geochemistry, regional magnetics and the distribution of ultramafic rocks

SCHIST-HOSTED EMERALDS Q07

G.J. Simandl[1], S. Paradis[2] and T.Birkett[3]
Modified for Yukon by A. Fonseca and G. Bradshaw
Refer to preface for general references and formatting significance.
May 30, 2005

IDENTIFICATION

SYNONYMS: Emerald deposits commonly described as "suture zone-related", "pegmatite-related schist-hosted" or "exometamorphic", "exometasomatic", "biotite schist-type", "desilicated pegmatite related" and "glimerite-hosted" are covered by this model.

COMMODITIES (BYPRODUCTS): Emerald (industrial grade beryl, other gemstones, such as aquamarine, chrysoberyl, phenakite, tourmaline).

EXAMPLES **(Yukon): Tsa da Glisza (Regal Ridge) (105G 123)**;
(British Columbia - *Canada/International*): *Socoto and Carnaiba deposits (Brazil), Habachtal (Austria), Perwomaisky, Mariinsky, Aulsky, Krupsky, Chitny and Tsheremshansky deposits (Russia), Franqueira (Spain), Gravelotte mine (South Africa), Mingora Mines (Pakistan).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Emerald deposits principally related to mafic and ultramafic schists or unmetamorphosed ultramafic rocks in contact with felsic rocks, either pegmatoid dykes, granitic rocks, paragneisses or orthogneisses. Such contacts may be either intrusive or tectonic.

TECTONIC SETTINGS: Found in cratonic areas as well as in mobile belts. In many cases related to major Phanerozoic or Proterozoic suture zones that may involve island arc-continent or continent-continent collision zones. The lithological assemblages related to suture zones commonly form a "tectonic mélange" and in some areas are described as "ophiolitic melange".

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Mainly in greenstone belts, but also in other areas where Cr-bearing rocks may be adjacent to pegmatites, aplites, granites and other felsic rocks rich in beryllium. Metamorphic grade is variable; however, it typically reaches green-schist to amphibolite facies. **In Yukon, Tsa da Glisza emeralds are associated with mafic volcanic rocks of Yukon-Tanana Terrane intruded by mid-Cretaceous plutonic rocks of Anvil-Cassiar Suite.**

AGE OF MINERALIZATION: The deposits are hosted by Archean age rocks or younger. The age of mineralization is typically linked to either a period of tectonic activity or a time of pegmatoid emplacement. **Tsa da Glisza emeralds are related to mid-Cretaceous intrusive rocks.**

HOST/ASSOCIATED ROCK TYPES: Biotite schists ("biotites", "phlogopitites" and "glimerites") are a particularly favourable host. Other favourable hosts are metamorphosed mafic volcanic rocks, such as epidote-chlorite-actinolite-bearing rock, chlorite and chlorite-talc schists, talc and talc-carbonate schists, white mica schists, mafic schists and gneisses and amphibolites. Less

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commonly emeralds occur in unmetamorphosed mafic or ultramafic rocks and possibly listwaenites. Pegmatites or quartz veins in the contact zone between granitic rocks and mafic rocks may in some cases host emeralds. A wide variety of rocks can be associated with schist-hosted emerald deposits, including granite, syenite, tonalite, granodiorite, a variety of orthogneisses, marbles, black phyllites, white mica schists, mylonites, cataclasites and other metasedimentary rocks.

DEPOSIT FORM: Most of the mineralization is hosted by tabular or lenticular mafic schists or “blackwall zones”. Favourable zones are a few metres to tens of metres wide and follow the contacts between felsic and mafic/ultramafic lithologies for distances of tens to hundreds of metres, but economically mineable portions are typically much smaller. For example, mineable bodies in the Urals average 1 metre in thickness and 25 to 50 metres in length. Pegmatoides, where present, may form horizontal to steeply dipping pods, lens-shaped or tabular bodies or anastamosing dykes which may be zoned.

TEXTURE/STRUCTURE: In blackwall or schists, lepidoblastic texture predominates. The individual, discrete emerald-bearing mafic layers within the favourable zones may be complexly folded, especially where the mineralization is not spatially associated with pegmatites. Emeralds are commonly zoned. They may form porphyroblasts, with sigmoidal orientation of the inclusion trails; beryl may form the rims separating phenakite form the surrounding biotite schist; or emerald crystals may be embedded in quartz lenses within the biotite schist. Chrysoberyl may appear as subhedral porphyroblasts or skeletal intergrowths with emerald, phenakite or apatite. Where disseminated beryl crystals also occur within pegmatites, they are short, commonly fractured, prismatic to tabular with poor terminations; but may be up to 2 metres in length and 1 metre in cross section. Long, prismatic, unfractured crystals occur mainly in miarolitic cavities.

ORE MINERALOGY [Principal and *subordinate*]: Emerald and *other beryls (in some cases aquamarine or morganite), ± chrysoberyl and industrial grade beryl. Spodumene gems (in some cases kunzite) may be found in related pegmatites.*

GANGUE MINERALOGY [Principal and *subordinate*]: In the schist: biotite and/or phlogopite, talc, actinolite, plagioclase, serpentine, ± fuchsite, ± quartz, ± carbonates, ± chlorite, ± muscovite, ± pyrite, *epidote, ± phenakite, ± milarite and other beryllium species, ± molybdenite, ± apatite, ± garnet, ± magnetite, ± ilmenite, ± chromite, ± tourmaline, ± cassiterite.*
In the pegmatoids: feldspars (commonly albite), quartz, micas; ± *topaz*, ± *phenakite* , ± *molybdenite*, ± *Sn and W-bearing minerals*, ± *bazzite*, ± *xenotime*, ± *allanite*, ± *monazite*, ± *phosphates*, ± *pollucite*, ± *columbite-tantalite*, ± *kyanite*, *zircon*, ± *beryllonite*, ± *milarite and other beryllium species.* Emerald crystals may contain actinolite-tremolite, apatite, biotite, bityite, chlorite, chromite, columbite-tantalite, feldspar, epidote, fuchsite, garnet, hematite, phlogopite, pyrrhotite, rutile, talc, titanite and tourmaline inclusions.

ALTERATION MINERALOGY: Limonitization and pyritization are reported in the host rocks. Kaolinite, muscovite, chlorite, margarite, bavenite, phenakite, epidimyte, milarite, bityite, bertrandite, euclase are reported as alteration products of beryl.

WEATHERING: Weathering contributes to the economic viability of the deposits by softening the matrix, and concentrating the beryl crystals in the overlying soil or regolith.

ORE CONTROLS: 1) The principal control is the juxtaposition of beryllium and chromium-bearing lithologies along deep suture zones. Emerald crystals are present mainly within the mafic schists and in some cases so called “blackwall zones” as described ultramafic-hosted talc deposits (M07). In this setting it may be associated with limonite zones. 2) This commonly occurs near the contacts of pegmatoids with mafic schists. Emerald crystals are present mainly within the mafic schists, although in some cases some of the mineralization may be hosted by pegmatoids. 3) Another prospective setting is along fracture-controlled glimerite zones. 4) Mineralization may be concentrated along the planes of regional metamorphic foliation, especially in cores of the folds where the relatively high permeability favours chemical exchange and the development of synmetamorphic reaction zones between chromium and beryllium-bearing lithologies.
5) Serpentinite roof pendants in granites are prospective.

GENETIC MODELS: The origin of schist-hosted emerald deposits is controversial as is the case with many deposits hosted by metamorphic rocks. All emerald deposits require special geological conditions where chromium (± vanadium) and beryllium coexist. Where pegmatoids or plagioclase-rich lenses occur within ultramafic rocks, the crystallization of emeralds is commonly explained by interaction of pegmatites or pneumatolytic-hydrothermal, Be-bearing fluids with Cr-bearing mafic/ultramafic rocks. In other cases, emeralds in schists form by syn- or post-tectonic regional metamorphic chemical exchange (metasomatism) between felsic rocks, such as felsic gneisses, garnet mica schists or pre-metamorphic pegmatoids, with the adjacent Cr-bearing rocks such as schists, gneisses or serpentinites. Contacts between Cr- and Be-bearing source rocks may be tectonic, as is the case for "suture zone-related" deposits.

ASSOCIATED DEPOSIT TYPES: Feldspar-quartz and muscovite pegmatites (O03, O04). Mo and W mineralization may be associated with emeralds. Some porphyry W deposits (L07) have associated beryl. Tin-bearing granites are in some cases associated with emeralds. Gold was mined at Gravelotte Emerald Mines (no information about the gold mineralization is available).

COMMENTS: Recently, microprobe studies have shown that the green color of some beryls is due to vanadium rather than chrome. In most cases both Cr and V were detected in the beryl crystal structure. There are two schools of gemmologists; the first believes that strictly-speaking the vanadium-rich beryls are not emeralds. The second school believes that gem quality beryls should be named based on their physical, and more particularly, colour properties. It is possible that pegmatoid-related or suture zone-related emerald deposits hosted by black shales or other chromium and/or vanadium-bearing rocks will be discovered. In those cases it will be difficult to decide if these deposits are schist-hosted or Columbia-type (Q06) emeralds.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: The presence of beryl in eluvial and alluvial deposits is good pathfinder. The distribution of beryllium in stream sediments proved to be useful in Norway when coupled with identification of the individual drainage basins and knowledge of the geological environment.

GEOPHYSICAL SIGNATURE: A portable field detector that uses ^{124}Sb as a gamma radiation source, the berylometer, is used to detect Be in outcrop. The instrument should be held less than 4 cm from the sample. Radiometric surveys may be useful in detecting associated radioactive minerals where pegmatites are involved. Magnetic and electromagnetic surveys may be useful in tracing suture zones where ultramafic rocks and felsic rocks are faulted against each other.

OTHER EXPLORATION GUIDES: Any Be occurrences in a favourable geological setting should be considered as positive indicators. If green, chromium and/or vanadium-bearing beryls are the main subject of the search then ultramafic rocks, black shales or their metamorphic equivalents represent the most favourable host rocks. If exploration is focused on a variety of gem-quality beryls (not restricted to emerald), or if the targeted area is not mapped in detail, then Be occurrences without known spatial association with Cr- or V-bearing lithologies should be carefully considered. Minerals associated with emeralds in the ores may be considered as indirect indicators. A wide variety of field-tests based on fluorescence, alkalinity, staining, density and refractive index have been used in the past to distinguish beryl.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: The grade and tonnage of these deposits is difficult to estimate due to erratic emerald contents (gram/tonne), episodic nature of the mining activity which often results in high grading, and variability in the quality of gemstones (value/carat). For example, at the Mingora mines in Islamia Trench two, 15 to 30 centimetres thick layers of talc-rich rock surrounding quartz lenses contained 1000 to 5000 carats of good stones up to 30 carats in size. Some of the individual pits in the area produced less than 1000 carats. The cumulative production of the Mingora emerald mines was reported between 20 000 to over 50 000 carats/year between 1979 and 1988. At Gravelotte Emerald Mine, at least 23 000 kg of emeralds of varying grades have been produced since 1929 from several zones. For the same mine promotional literature states that " conservative estimates" of ore within the Cobra pit are 1.69 million tonnes that could result in production of 17 000 kg of emeralds (approximately 1gram /tonne). It is estimated that about 30% of the emeralds could be sold, but only 2-3% of these are believed to be gem quality. In the Urals the Mariinsky deposit was explored to an average depth of 500 metres by boreholes and underground workings. To determine emerald content, bulk samples as large as 200 tonnes are taken systematically at 100 metres interval along the favourable zone. No grade and tonnage are available.

ECONOMIC LIMITATIONS: Mining of precious stones in underdeveloped countries and smaller deposits is done using pick and shovel with limited use of jackhammers and bulldozers. Larger schist-hosted emerald deposits may be successfully exploited by a combination of surface and underground mining. The Mariinsky deposit was mined by open pit to the depth of 100 metres and is exploited to the depth of 250 metres by underground methods. “Low impact” explosives, expanding plastics or hydraulic wedging are used to break the ore. The ore is milled, screened and manually sorted.

END USES: Transparent and coloured beryl varieties, such as emerald, morganite and aquamarine, are highly valued gemstones. Industrial grade beryls commonly recovered as by-products are a source of Be oxide, Be metal alloys used in aerospatial and defence applications, Be oxide ceramics, large diameter beryllium-copper drill rods for oil and gas, fusion reactors, electrical and electronic components. Berylium metal and oxides are strategic substances, and may be substituted for by steel, titanium and graphite composites in certain applications. Phosphor bronze may replace beryllium-copper alloys. However, all known substitutes offer lower performance than Be-based materials.

IMPORTANCE: Schist-hosted deposits are the most common source of emeralds, although the largest and most valuable gemstones are most frequently derived from the Colombia-type deposits. Besides schist-hosted deposits and pegmatites, beryl for industrial applications may be also be present in fertile granite and syenite complexes that may be parent to pegmatites. A major portion of the beryl ore used in the U.S.A. as raw material for beryllium metal is recovered as a byproduct of feldspar and quartz mining from pegmatites.

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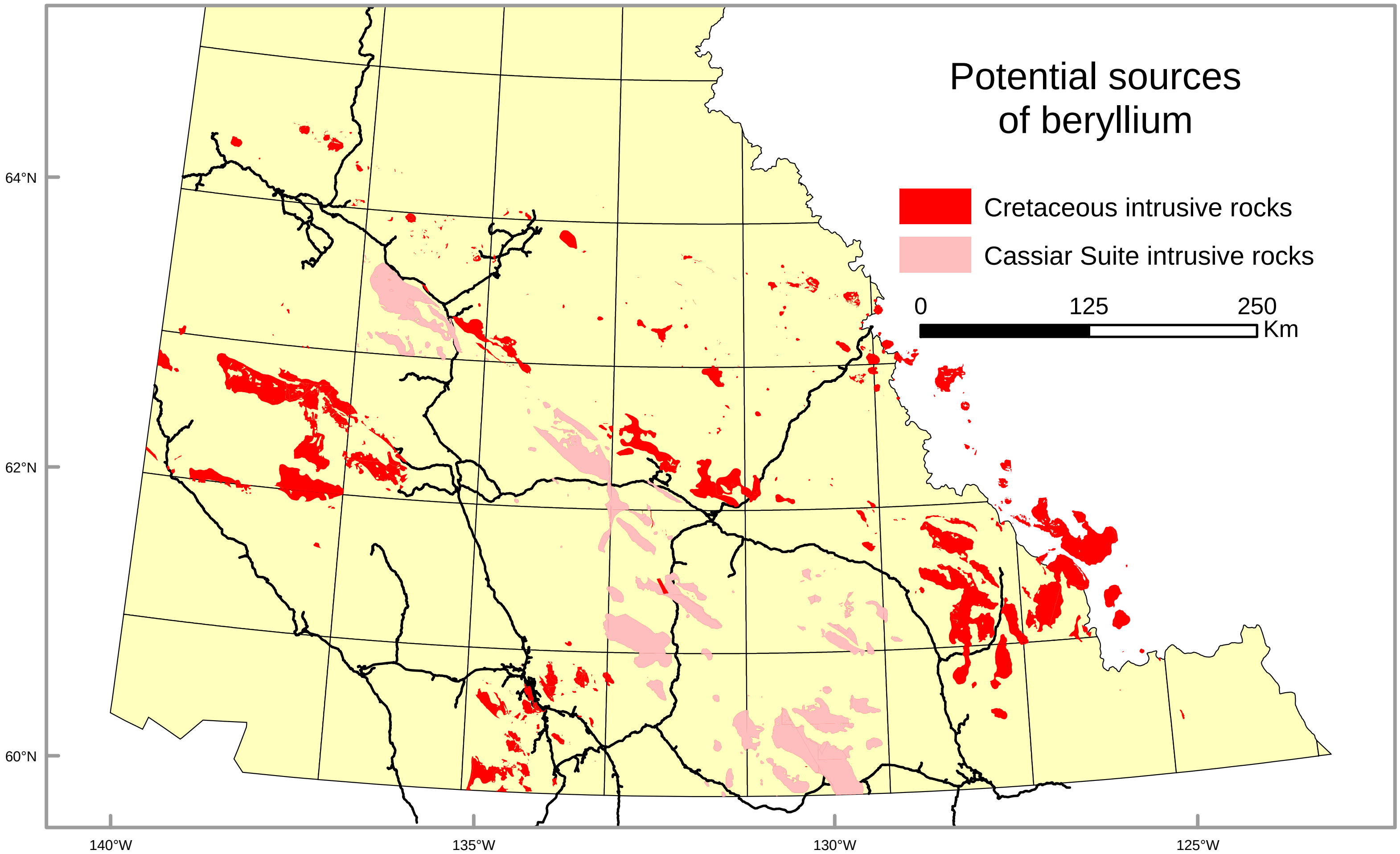
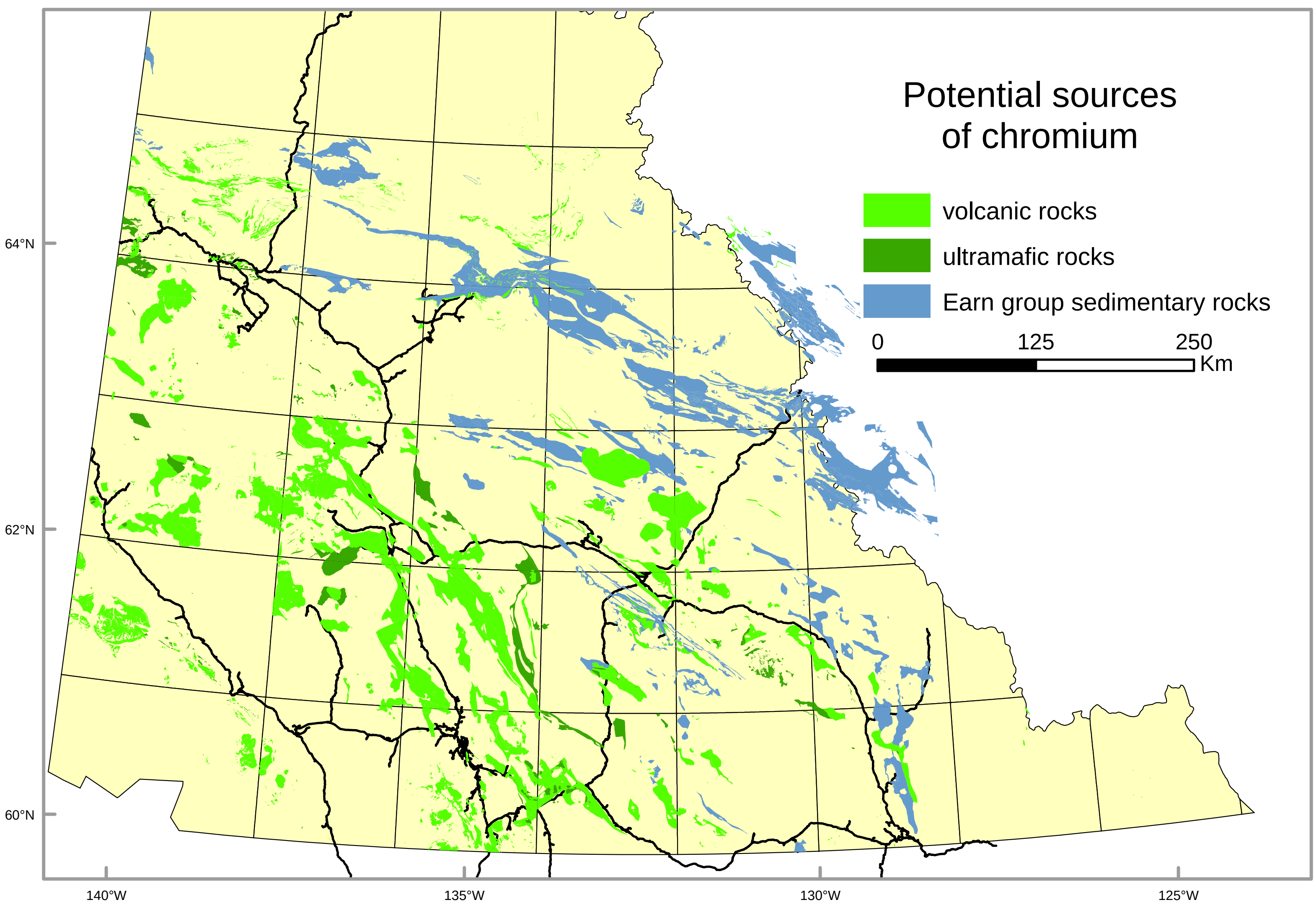

Potential sources of beryllium
Cretaceous intrusive rocks
Cassiar Suite intrusive rocks
0
125
250
Km
64°N
62°N
60°N
140°W
135°W
130°W
125°W


Potential sources of chromium
volcanic rocks
ultramafic rocks
Earn group sedimentary rocks
0
125
250
Km
64°N
62°N
60°N
140°W
135°W
130°W
125°W