Cu SKARNS K01

by Gerald E. Ray[1]
modified for Yukon by A. Fonseca
Refer to preface for general references and formatting significance.
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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.

SELECTED BIBLIOGRAPHY

Cox, D.P. and Singer, D.A., 1986. Mineral Deposit Models; *U.S. Geological Survey*, Bulletin 1693, 379 pages.

Dawson, K.M., Panteleyev, A. and Sutherland-Brown, A., 1991. Regional Metallogeny, Chapter 19, in Geology of the Cordilleran Orogen in Canada, Editors, Gabrielse, H. and Yorath, C.J., *Geological Survey of Canada*, Geology of Canada, Number 4, page 707-768 (also, *Geological Society of America*, The Geology of North America, Volume G-2).

Eckstrand, O.R., 1984. Canadian Mineral Deposit Types: A Geological Synopsis; *Geological Survey of Canada*, Economic Geology Report 36, 86 pages.

Einaudi, M.T., 1982. General Features and Origin of Skarns Associated with Porphyry Copper Plutons, Southwestern North America*; in* Advances in Geology of the Porphyry Copper Deposits, Southwestern U.S., Titley, S.R., Editor, *Univ. Arizona Press*, pages 185-209.

Einaudi, M.T. and Burt, D.M., 1982. Introduction - Terminology, Classification and Composition of Skarn Deposits; *Economic Geology*; Volume 77, pages 745-754.

Einaudi, M.T., Meinert, L.D. and Newberry, R.J., 1981. Skarn Deposits*; in* Seventy-fifth Anniversary Volume, 1906-1980, Economic Geology, Skinner, B.J., Editor, *Economic Geology Publishing Co.*, pages 317-391.

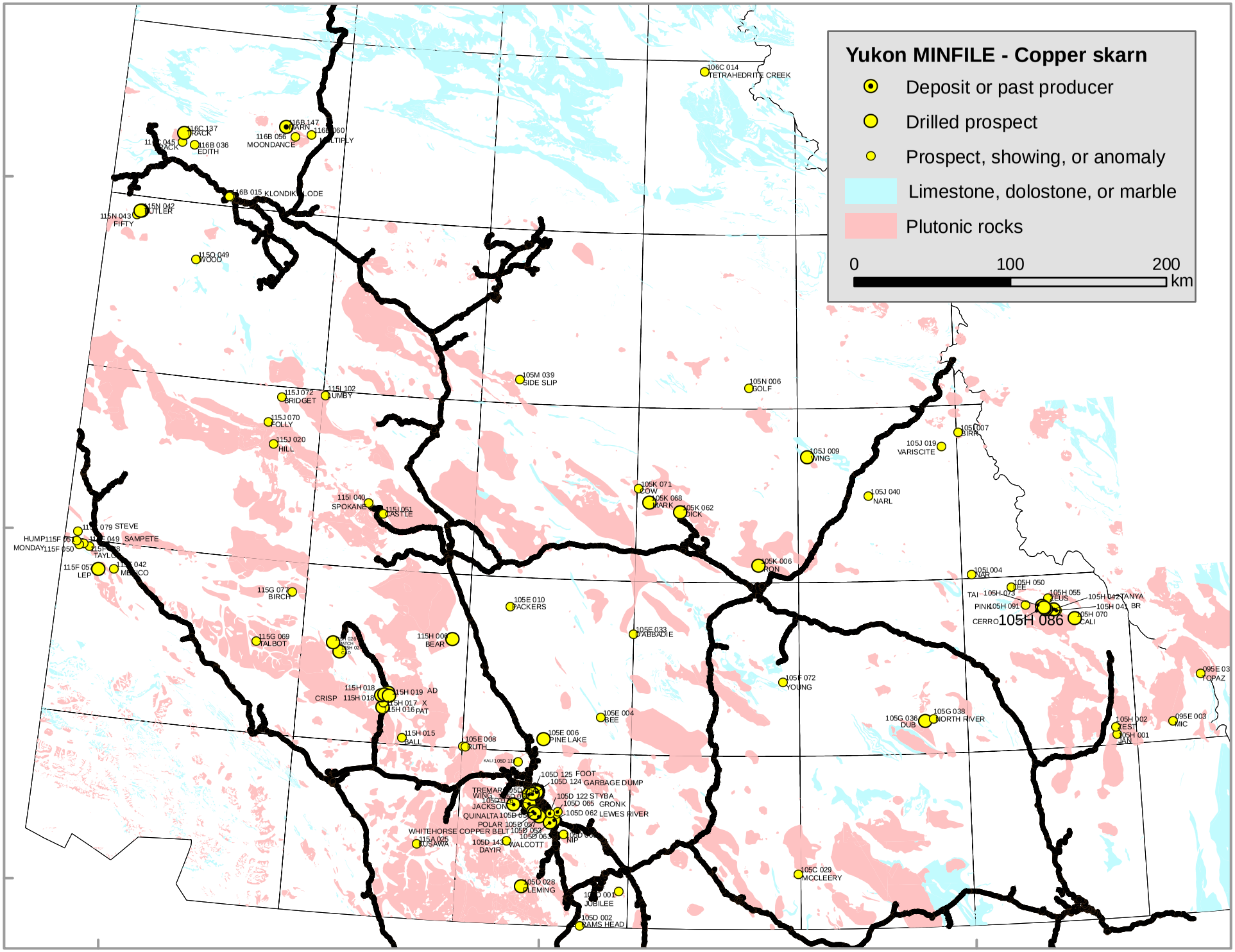
Meinert, L.D., 1983. Variability of Skarn-deposits: Guides to Exploration*; in* Revolution in the Earth Sciences - Advances in the Past Half-century, Boardman, S.J., Editor; *Kendall/Hunt Publishing Company*, pages 301-316.

K01 - Cu Skarns - BC and Yukon deposits

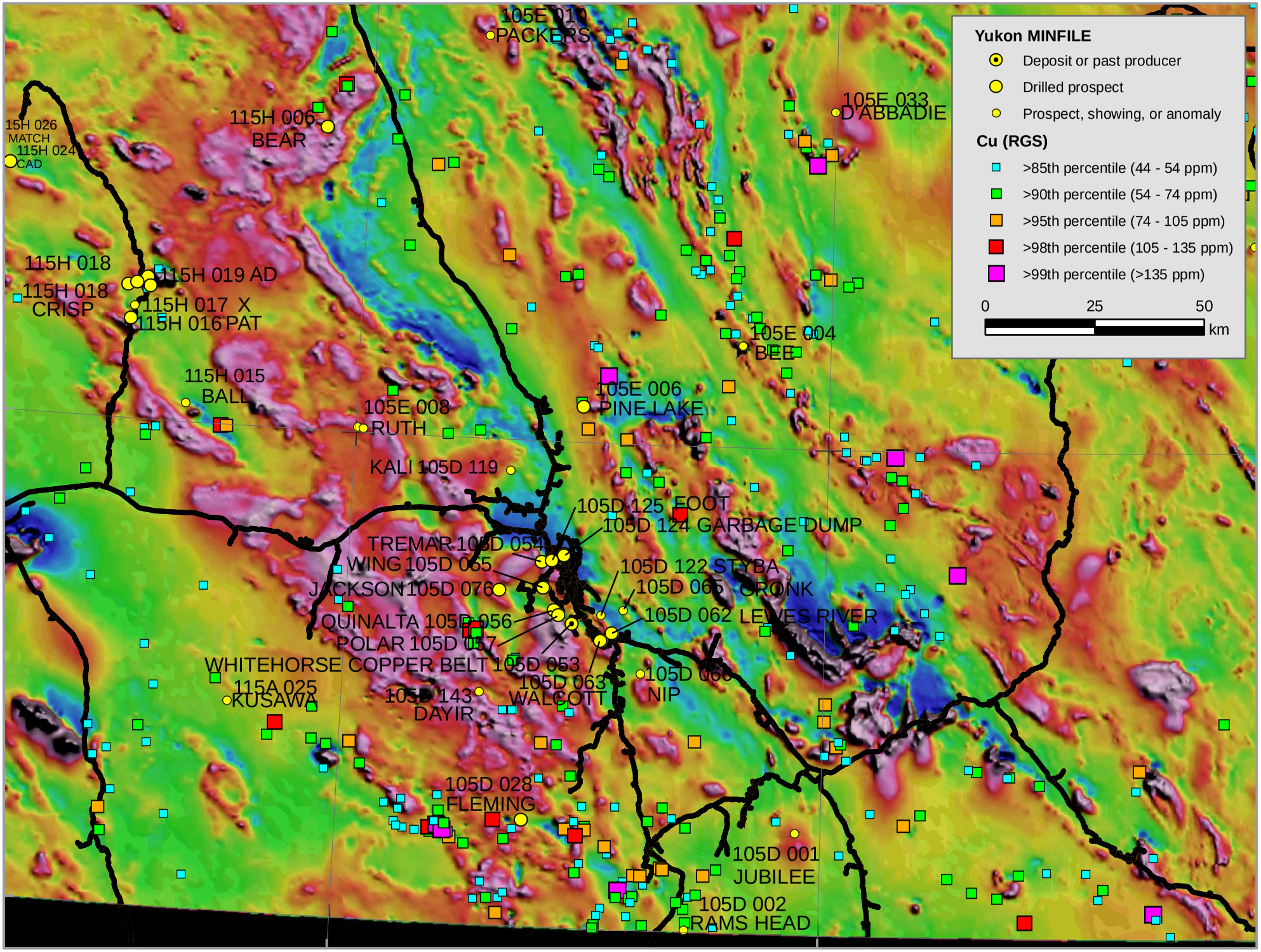
Deposit	country	tonnes	Au (g/t)	Ag (g/t)	Cu (%)
LILY	CNBC	36 085	3.82	64.33	2.56
QUEEN VICTORIA	CNBC	45 352	0.17	20.95	1.48
ORO DENORO	CNBC	124 001	0.94	7.69	1.36
YREKA	CNBC	145 334	0.34	31.22	2.71
EMMA	CNBC	241 538	0.88	10.08	0.97
LITTLE BILLIE	CNBC	245 133	10.10	30.26	1.81
BLUE GROUSE	CNBC	249 298	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