



NORANDA/KUROKO MASSIVE SULPHIDE Cu-Pb-Zn G06

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Refer to preface for general references and formatting significance.

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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.**

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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	MINFILE	NAMES	STATUS
105G 008	HASSELBERG, WOLF	DEPOSIT	116C 124	TOP OF THE WORLD	PROSPECT
105G 072	FETISH, WOLVERINE	DEPOSIT	105F 013	CPA	SHOWING
105G 117	TAG, KUDZ ZE KAYAH, ABM	DEPOSIT	105F 025	MUM	SHOWING
105G 143	GP4F	DEPOSIT	105F 042	MT. COOK	SHOWING
106D 009	MARG	DEPOSIT	105F 087	RAMPANT	SHOWING
105B 143	CONVERT	DRILLED PROSPECT	105F 088	GROWTH	SHOWING
105F 012	MM, ARNOLD	DRILLED PROSPECT	105F 095	TREE	SHOWING
105F 021	BOX, MAT	DRILLED PROSPECT	105G 081	MONEY	SHOWING
105F 028	GULL MINERAL, HAYDN, ANISE	DRILLED PROSPECT	105G 090	FAIRBANK	SHOWING
105F 036	TUB, FOX	DRILLED PROSPECT	105G 120	BLUE LINE	SHOWING
105F 071	CHZERPNOUGH, FIRE	DRILLED PROSPECT	105G 121	NET	SHOWING
105F 073	BNOB, ICE	DRILLED PROSPECT	105G 122	OVERTIME	SHOWING
105G 032	PACK	DRILLED PROSPECT	105G 127	COBB	SHOWING
105G 040	JAY, FISHER	DRILLED PROSPECT	105L 062	GOVERNMENT	SHOWING
105G 077	FLIN	DRILLED PROSPECT	105L 063	HIGHWAY	SHOWING
105G 083	PY	DRILLED PROSPECT	115G 089	FRIEBERGS	SHOWING
105G 098	ANT	DRILLED PROSPECT	115N 162	PEAK	SHOWING
105G 124	RED LINE	DRILLED PROSPECT	115O 055	RAVEN	SHOWING
105G 130	LEAGUE	DRILLED PROSPECT	115O 141	GONZALES	SHOWING
105G 133	AREA 18	DRILLED PROSPECT	115O 161	READFORD	SHOWING
105G 134	PUCK	DRILLED PROSPECT	116C 112	PUB	SHOWING
105G 135	ELLEN CREEK	DRILLED PROSPECT	116C 168	MORT	SHOWING
105G 136	WHITE CREEK	DRILLED PROSPECT	105G 128	DOG	ANOMALY
105G 139	ON	DRILLED PROSPECT	105G 129	MAJOR	ANOMALY
105G 141	VERMILLION	DRILLED PROSPECT	105G 131	DOT	ANOMALY
106D 015	SPRING	DRILLED PROSPECT	105G 132	NECK	ANOMALY
116A 001	TIMBERWOLF	DRILLED PROSPECT	105G 137	MASK	ANOMALY
105A 047	SAMBO, SIMPSON	PROSPECT	105G 142	BLAKE	ANOMALY
105F 020	EROS	PROSPECT	105L 059	GOO	ANOMALY
105F 112	GRAHAM, BID	PROSPECT	105M 049	VACA	ANOMALY
105G 016	EL	PROSPECT	106D 034	STEAMBOAT	ANOMALY
105G 123	GOAL	PROSPECT	115N 100	BORED	ANOMALY
105G 138	POP	PROSPECT	115O 113	BRONSON	ANOMALY
105G 140	NAD	PROSPECT	106D 073	BARRY	UNKNOWN

