CARBONATE-HOSTED NONSULPHIDE Zn-Pb DEPOSITS, SALMO DISTRICT,

British Columbia, Canada

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Executive Summary

Under favourable geological, climatic, topographic and hydrological conditions, the weathering of sulphide deposits may result in the formation of economically significant carbonate-hosted, nonsulphide, base-metal (CHNSBM) deposits. CHNSBM deposits were the main source of zinc prior to the1930s. Following the development of differential flotation and breakthroughs in smelting technology, the mining industry turned its attention to sulphide ore (Hitzman et al., 2003). The situation is changing as evidenced by the successful operation of a dedicated processing plant, extracting Zn through direct acid leaching, solid-liquid separation, solvent extraction and electrowinning, from nonsulphide and mixed ores from the Skorpion mine in Namibia.

The Salmo district (NTS 082F/03) of British Columbia is renown for its Irish and MVT massive sulphide deposits (Paradis, 2007). It also contains associated direct-replacement CHNSBM deposits and has a potential to host undiscovered Zn-rich wallrock replacement-type CHNSBM deposits.

Carbonate-hosted Nonsulphide Deposits Background

When carbonate-hosted, base-metal sulphide mineralization is subject to intense weathering (supergene environment), metals are liberated by the oxidation of sulphides. During the formation of a ***"direct-replacement"*** CHNSBM deposit (Figures 1, 2a), the primary ore oxidizes and base metals pass into a solution, are redistributed and then trapped within the space originally occupied by the sulphides (Heyl and Bozion, 1962; Hitzman et al., 2003; Reichert and Borg, 2008). Depending on the extent of the replacement of the sulphides by Zn-, Pb- and Fe- bearing oxides, silicates, carbonates and phosphates, the resulting ore is called ***"mixed ore"*** (sulphide & nonsulphide) or nonsulphide ore. If the base metals liberated by the oxidation of sulphides are not trapped locally, they are transported by circulating supergene solutions down and/or away from sulphide mineralization to form ***"wallrock-replacement"*** CHNSBM deposits (Figure 1, 2b) or are dispersed over large areas in sub-economic concentrations. Figure 1 summarizes the genetic model adopted for the Salmo area. The concept is well known and the concentrations of metals used in Figure 1 are from mass balance calculations of Reichert and Borg (2008). The economic significance of the CHNSBM deposits are apparent from the compilation by Hitzman et al. (2003) summarized in Figure 3. The main nonsulphide Zn-, Pb- and Fe- bearing minerals and their characteristics are listed in Table 1.

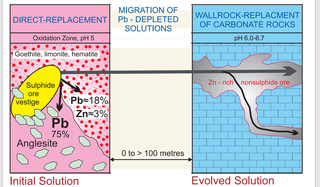

Figure 1: Concepts of the "direct-replacement" and "wallrock-replacement" processes explaining the origin of carbonate-hosted nonsulphide base metal deposits.

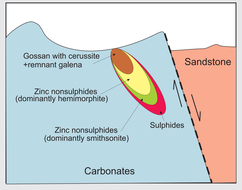

Figure 2a: Idealized representation of the "direct-replacement" CHNSBM deposit, Modified from Hitzman et al. (2003).

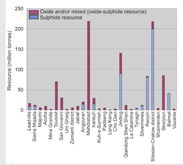

Figure 3: Importance of nonsulphide ("oxide") and mixed (nonsulphide + sulphide) resources and associated sulphide ores. Based on the compilation of Hitzman et al. (2003).

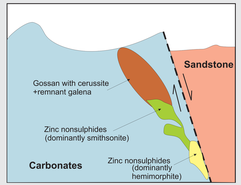

Figure 2b: Idealized representation of the "wallrock-replacement" CHNSBM deposit. Modified from Hitzman et al. (2003).

Table 1: Main nonsulphide Zn, Pb and Fe minerals

		Formula	Color	Luster	Density	Hardness	comments
Main zinc-bearing minerals*							
	Smithsonite	$ZnCO_3$	white	earthy, dull	4.5	4-4	HCl-soluble, botroidal, reniform, earthy, or granular; may be fluorescent - greenish or bluish or whitish in UV light
	Hemimorphite	$Zn_4Si_2O_7(OH)_2 \cdot H_2O$	white, brown, greenish gray	vitreous	3.6	5	weakly soluble in HCL, massive, botroidal, stalactitic
	Hydrozincite	$Zn\ (CO_3)_2(OH)_6$	white, pale yellow, pale gray	pearly	3.6-3.8	2-2.5	massive, fibrous, bladed aggregates; fluorescent pale blue or lilac in UV light; soluble in acids and ammonia
	Sauconite	$Na_{0.2}Zn_3Si_3AlO_{10}(OH)_2 \cdot 4(H_2O)$	white, pale brown, reddish brown	dull, earthy	2.45 (variable)	1.0 - 2.0	earthy - clay-like texture
	Willemite	$ZnSiO_4$	white, green, red, brown, black, pinkish, bluish	vitreous/resinous	3.9-4.2	5.5	massive, granular, prismatic; fluorescent green in short UV light
	Zn-bearing aragonite	$(Zn,Ca)\ CO_3$	white, gray, yellowish	vitreous	3	3.5-4.0	fluorescent green in short UV light; HCl-effervescence, fibrous, prismatic, columnar,
	Minrecordite	$Ca\ Zn\ (CO_3)_2$	white to colorless, brown, blue-green	vitreous to pearly	3.5	3.5-4	rhombohedral, sometimes saddle-shaped
Main lead-bearing minerals							
	Cerussite	$PbCO_3$	colorless, white, tan, gray	adamantine	6	3	massive granular, reticulate, well formed prims; fluorescent yellow in long wave UV light.
	Anglesite	$PbSO_4$	white, colorless, gray, bluish, yellow	vitreous to adamantine	6.3	3-3.5	granular, anhedral to subhedral crystals; commonly fluorescent yellow in UV light
	Pyromorphite	$Pb_5(PO_4, As O_4)_3Cl$	green, brown, yellow	resinous -adamantine	6.7 - 7	4	prismatic or reniform and globular textures
	Plumbojarosite	$PbFe_6(SO_4)_4(OH)_{12}$	golden to dark brown	vitreous to dull	3.6	1.5 - 2.0	HCl soluble, earthy, concretionary; encrustations, lumps
	Litharge	PbO	red	grassy	9.14 - 9.3	2	encrustations
	Mimetite	$Pb_5(AsO_4, PO_4)Cl$	brown, yellow, tan, brown, white	resinous	7.1 - 7.3	3.5 - 4	reniform, globular, sometimes prismatic
Main iron-bearing minerals							
						3.5 - 4	earthy, botroidal, stalactitic
	Goethite	$FeO(OH)$	dark or rusty brown, black	dull, resinous	4 - 4.4		
	Hematite	Fe_2O_3	red to nearly black	typically dull	5.2	5	coatings, stains, fracture filings

Geological Setting

The Kootenay Arc extends over 400 km from Revelstoke to across the Canada - U.S.A. International Boundary (Fyles, 1964). It separates the Purcell Anticlinorium to the east and the Monashee metamorphic complex to the west (Figure 4). The Arc consists of deformed, thrust-imbricated Proterozoic to Lower Mesozoic sedimentary and volcanic rocks (Brown et al., 1981). The stratigraphic succession consists of siliciclastic and carbonate rocks of the Ecombrian Hamill Group and the Mohican Fm, overlain by carbonate rocks from the Lower Cambrian Badshot Fm and its equivalent, the Reeves Member of the Laib Fm (Fyles and Eastwood, 1962; Fyles, 1964; Read and Wheeler, 1976; Colpron and Price, 1995). The Badshot Fm is characterized by marbles and minor schists. In the southern part of the Arc, the carbonates are overlain by siliciclastics, shale and mafic volcanic rocks of the Lower Paleozoic Lardeau Group (Colpron and Price, 1995). Carbonate-hosted Zn-Pb deposits occur mainly within the Badshot Fm or its equivalent, the Laib Fm (Reeves Member). The main concentrations of these deposits define the Salmo and Duncan camps (Figure 4).

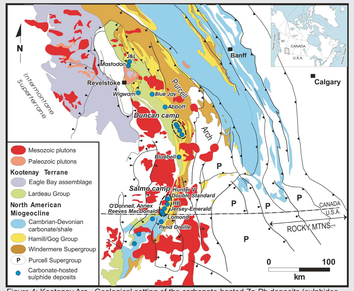

Figure 4: Kootenay Arc - Geological setting of the carbonate-hosted Zn-Pb deposits (sulphides and nonsulphides). Modified from Paradis (2007).

Carbonate-hosted Sulphide Deposits of the Salmo Camp

Most of the carbonate-hosted Zn-Pb deposits of the Salmo camp are interpreted as metamorphosed MVT- or Irish-type Pb-Zn deposits (Paradis, 2007, 2008). They range in size from 6-10 million tonnes with average grades of 3-4% Zn, 1-2% Pb, 0.4% Cd and traces of Ag (Höy, 1982; Höy and Brown, 2000). With the exception of Lomond and Caviar (in Cambrian Nelway Fm), these deposits are in dolomitized Limestone of the Reeves Member. The mineralized dolomite is dark grey, poorly layered and mottled with black flecks, wisps and layers of impurities. The deposits, their dolomitic envelopes, and the limestone host rock lie within secondary isoclinal folds along the limbs of regional anticlinal structures. Most of the deposits are stratabound and stratiform lens-shaped concentrations of sphalerite, galena, pyrite, local pyrrhotite and rare arsenopyrite in isoclinally folded dolomitized or silicified carbonate layers (Paradis, 2007). Brecciated zones are common within the more massive sulphide mineralization (Fyles and Hewlett, 1959). Several deposits are Past producers (e.g., Reeves MacDonald, Jersey and HB) and others are advanced prospects.

Figure 5: Jersey-Emerald mine portal. From left to right Ed Lawrence, Suzanne Paradis, Laura Simandl, Hannah Mills and Alan Duffy.

Figure 6: View of the HB Mine complex (past producer - now abandonned). July, 2008.

Carbonate-hosted Nonsulphide Deposits (Salmo Area)

The near-surface portions of the several previously described carbonate-hosted sulphide deposits are strongly oxidized. The mineralogy and paragenesis of oxidized zones are poorly known but indicative of the direct replacement of sulphides by base metal-bearing carbonates, silicates, oxides and phosphates.

Lomond (082FSW0184)

This group of ocurrences, 56 km south of Nelson are oxidized Pb-Zn sulphides within the Middle Cambrian to Early Ordovician Nelway Formation, which consist of dolomite and dolomitic siltstone (Fyles and Hewlett, 1959). The main showing (Figure 7) was mined as a source of iron for cement-making between 1947 and the early 1950s. Galena nodules were hand sorted and sent to the Trail smelter. Two oxidized zones, 1.5 and 3.5 m thick and 3 m apart consist mainly of consolidated yellow iron oxide limonite (?) containing Harder areas of goethite (Figure 8) and locally anglesite-coated nodules of galena and transparent to translucent crystals of cerussite (0.5-2mm long). A sample of the main oxidized zone assayed 10.3 g/t Ag, 1.2% Pb and 2.7% Zn (Fyles and Hewlett, 1959). The results of 2008 sampling are pending.

Figure 7: Lomond CHNSBM deposit.

Figure 8: Lomond; soft "limonite" ore armoured by gray-black goethite in places containing anglesite-armoured galena nodules.

Reeves MacDonald (082FSW026), Annex (082FSW219), Red Bird (082FSW024) and Related Deposits

Between 1949 and 1971, the combined production from these deposits, located 56 km south to southwest of Salmo, totalled 5 848 021 t of sulphide ore grading 3.50% Zn and 1.39% Pb. Structure is characterized by east-striking foliation and south westerly trending fold axes. A series of north-striking faults that dip 25-45° east offset the mineralized zones. The Reeves, B.L. (082FSW026) and O'Donnell (082FSW028) deposits are interpreted as faulted segments of the same orebody (Fyles and Hewlett, 1959; Gorzynski, 2001). The Red Bird, Annex, MacDonald, Point (082FSW027) and Prospect (082FSW029) deposits may be faulted segments of the above mineralized zones (Fyles and Hewlett, 1959; G. Klein, pers. comm., 2007). The sulphides form bands, lenses and layers of massive to disseminated material parallel to compositional layering within grey dolostone. Layering varies from millimetre-scale to several centimetres in thickness and is highly contorted. Lenses of non-mineralized dolomite interlayered with thin bands of argillite are common within the ore zones. Sulphides also form a matrix to breccias, which consist of fragments of dolomite, limestone and quartz. The sulphide mineralization consists of pyrite, sphalerite, minor galena and traces of chalcopyrite. Cu and Cd content is typically less than 0.5% and 1g/t, respectively. Ga and Ge have been reported in above background concentrations. Oxidized zones consisting of limonite, goethite, cerussite, anglesite, smithsonite and hemimorphite were not mined. The deposits and prospects are exposed over a distance of 4 km. Locations and projections of the main mineralized zones to the surface are sketched on Figures 10 and 11. Some of these zones, consisting at least in part of nonsulphide base-metal-bearing minerals, are described below.

MACDONALD ADIT collapsed prior to 1954. It was driven within "earthy calcareous and limonitic materials containing secondary Pb and Zn minerals" (Fyles and Hewlett, 1959).

POINT (ZONE Z), located on Figures 10 and 11, consists of limonitic gossan in a roadcut beside the Reeves MacDonald mine road (Figure 9). The sulphide mineralization consists of two sulphide horizons, each about 6 m thick and separated by 20 m of Reeves dolostone. Mineralization forms in bands and lenses of massive and disseminated pyrite, sphalerite and galena. Disseminated sphalerite with traces of galena also occurs in a matrix of brecciated dolomite (Fyles and Hewlett, 1959). A small tonnage of ore, grading 10% zinc, was extracted from this zone in the past (Gorzynski, 2001).

PROSPECT ZONE represents sparse mineralization containing locally 10% Pb and 9% Zn over widths of 60 cm (Walker, 1934), but according to Fyles and Hewlett (1959), surface trenching has exposed oxidized zones over 4 m across. Four holes were drilled in the Prospect dolomite member (south of zone C). Best intersections are 13.7% Zn over 9 m, 8.24% Zn over 4 m and 2.02% Zn over 16.98 m (Klein, 1999).

ANNEX MINE, consisting mainly of zones E and F (Figures 10 and 11), produced 763 314 t of sulphide ore at a recovered grade of 5.59% Zn, 0.93% Pb and 44.81 g/t Ag. Several holes drilled from 1986 to 2000 returned significant Zn, Pb and Ag grades within the nonsulphide portions of the Annex mineralization (George Cross News Letter, 1998; Klein, 1998). The last two holes were drilled in 2000. The first of these two holes averaged 9.64% Zn over 21 m, with a high-grade footwall (18.47% Zn over 3.9 m) and hangingwall (23.75% Zn over 2.3 m). The second hole averaged 14.62% Zn over 15 m without internal dolostone sections. These are the only holes in the area known to encounter nonsulphide mineralization below the water table (Gorzynski, 2001).

ZONE G is interpreted as a faulted section of the Annex mine (Figure 11). The first 500 m from the portal of the Reeves 1900 level is in leached limestone with CHNSBM zones formed by oxidation of the MacDonald sulphide orebody (Fyles and Hewlett, 1959). The best drill intersection of the CHNSBM mineralization was 8.21% Zn, 1.08% Pb and 6.5 g/t Ag over 11.6 m (Gorzynski, 2001).

ZONE H is interpreted to continue at depth (Figure 11), where grab samples of zinc oxides grading 20-25% Zn were collected from underground workings (G. Klein, pers. comm, 2000; Gorzynski, 2001). One of the two holes returned 10.98% Zn over 8.9 m, including 14.71% Zn over 5.3 m. A second drillhole, located 55 m to the east, returned 6.35% Zn over 4.4 m, but the intersection was near the surface (Gorzynski, 2001).

ZONE P was discovered in 2000. A drillhole returned two intersections, 6.68% Zn over 4.4 m (near the surface) and 13.25% Zn over 3.5 m at depth (Gorzynski, 2001).

Figure 10: Surface sketch - locations and projections of the main mineralized zones including Reeves MacDonald, Annex and Red Bird (Modified from: Sultan Minerals and Gorzhynski, 2001).

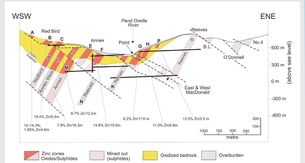

Figure 11: Idealized longitudinal vertical section looking WNW showing main mineralized zones including Reeves MacDonald, Annex and Red Bird (Modified from: Sultan Minerals and Gorzhynski, 2001).

Red Bird prospect

The Red Bird prospect includes zones A, B, C and D described below. The workings consist of four adits, a shaft, trenches and roadcuts. The indicated resource (predating NI 43-101) within the Red Bird prospect is reported at 2 177 040 t grading 18.5% Zn, 6.5% Pb and 68.5 g/t Ag (Price, 1987).

ZONE A corresponds to a roadcut of the old Red Bird no. 4 tunnel. Gorzynski (2001) reported values Of 5.4% Zn over 1.6 m, 6.42% Zn over 1.3 m and 16.11% Zn over 1.5 m.

BEER BOTTLE ZONE (ZONE B), known since the 1920s, located 300 m east of zone A (Figures 12, 13), has a strike length of 110 m (Klein, 1999; Gorzynski, 2001). One of the trenches exposed a section Of red-brown limonite intercalated with dolostone and returned 15.0% Zn over 12.8 m. The footwall portion of this zone assayed 22.16% Zn over 6.3 m and the hangingwallportion returned 8.08% Zn over 6.5 m (Gorzynski, 2001). Four other trenches were disappointing.One roadcut exposed a 10 m long section of a collapse breccia consisting of angular dolostone and limestone and rounded hemimorphite-rich clasts varying in size from pebbles to boulders (Gorzynski, 2001). Five sampled hemimorphite-rich boulders contained 18-32% Zn. Four vertical channel samples taken overthe 10 m breccia exposure averaged 17.76% Zn (Gorzynski, 2001).

ZONE C outcrops and is interpreted as a down-faulted portion of zone B Red Bird tunnel no. 1 exposed a nonsulphide section of 140 m in length, including a 75 m long and 6 m wide zone averaging 18.55% Zn, 5.97% Pb and 36.7 g/t Ag (Emendorf, 1927; Sorensen, 1942; Gorzynski, 2001). One of the roadcuts, 85 m in elevation below tunnel no. 1, exposed a limonite-rich section that returned 6.93% Zn over 21 m (Gorzynski,2001). Highgrade zones in the footwall and hangingwall of this section assayed 12.30% Zn over 4.4 m and 9.75% Zn over 5.6 m.

ZONE D is poorly constrained and interpretation is based on a 16.7 m long drillhole intersection of a nonsulphide zone assaying 7.2% Pb, 8.95% Zn and 23.5 g/t Ag, directly overlying a 1.5 m sulphide-rich dolomite section that assayed 5.64% Zn, 0.38% Pb, 8.8 g/t Ag and 0.06% Cd (Price, 1987).

Caviar Showing (MINFILE 082FSW060)

The Caviar showing (Figure 10) consists of lenses and stringers of sphalerite in dolomite of the Nelway Fm (Fyles and Hewlett, 1959; Gorzynski, 2001). The best drill intersection assayed 8.5% Zn over 6 m (Crosby, 1956). The nonsulphide (near surface) portion of the mineralization is believed to be few metres thick.

Jersey-Emerald Deposits (MINFILE 082FSW009)

The historic Jersey Zn-Pb deposit was in production from 1906 to 1925. During that period 25 850 t of ore were mined and 705 292 g of Ag, 6 788 936 kg of Pb and 19 771 kg of Zn were recovered. In1948, when the Emerald tungsten mine was in production, a large tonnage of Pb-Zn ore was discovered. Over 8 million t of ore grading 1.95% Pb and 3.83% Zn were mined from Jersey and Emerald orebodies between 1949 and 1973 (MINFILE 082FSW009). The Jersey and Emerald Zn-Pb mineralization occurs within a dolomitized zone, near the base of the Reeves Member and varies from 8 to 30 m in thickness. The Truman Member of the Laib Formation forms the mine footwall (Fyles and Hewlett, 1959). The galena-sphalerite-pyrite-pyrrhotite (minor arsenopyrite) ores are banded and similar to ores from the HB deposits, except that Pb dominates. Cd is associated with sphalerite and Ag with galena. In 1995, during a tungsten exploration drilling the Lower Jersey Pb-Zn horizon was discovered 55-60 m below the Jersey mine (Sultan Minerals Inc., 2008). The widest mineralized intercept was 9 m, and the best single intersection graded 8.1% Zn and 3.8% Pb across 1 m (George Cross News Letter, 1997). A Fe-rich gossan (Figure 14) was sampled at 1394 m of elevation, west of the Emerald Zn-Pb mine portal no.1 during our visit and results of the geochemical analyses are pending.

Figure 9: Point Zone. Gossan in a road cut (on the Reeves MacDonald mine road.

Figure 12: Beer Bottle zone, Red Bird prospect area.

Figure 13: Dolomite-hosted nonsulphide zone, Red Bird prospect area.

Figure 14: Large gossan zone, Jersey-Emerald Property.

HB Mine (MINFILE 082FSW004)

The HB mine, 8 km south east of the village of Salmo, includes the HB and the Garnet zones. The HB zone consists of five orebodies and the Garnet zone is a single lens in Reeves limestone. The mine produced 6 656 101 t of ore between 1912 and 1978. Measured and indicated reserves (predating NI 43-101) reported by Canadian Pacific Ltd, were 36 287 t grading 0.1% Pb and 4.1% Zn (Anonymous, 1983). Sedimentary rocks in the area form a broad synclinorium, and carbonates hosting the orebodies are on the west limb of this structure. The HB mineralization consists of three elongated, ellipsoidal orebodies dipping toward the east and plunging 15-20° south. These orebodies are connected by two gently dipping tabular sulphide breccia bodies. Sulphide mineralization consists of pyrite and subordinate sphalerite, galena and minor pyrrhotite within a dolomitized zone. The northern portions of the mineralized zones are oxidized to a depth of 100 m (Fyles and Hewlett, 1959). Hemimorphite, smithsonite, cerussite and anglesite pyromorphite, hopeite, spencerite and salmoite were reported from oxidized zone by Fyles and Hewlett (1959).

Oxide Prospect (MINFILE 082FSW022)

The main showings (Figure 15) outcrop 5.5 km east-southeast of Ymir. The area is underlain by black argillite/slate (Active Formation), Reeves limestone, and quartzite. The fault zone (<9 m thick) contains a 0.5 m thick muddy clay-like gouge (Fyles and Hewlett, 1959; MINFILE). The CHNSBM zone at the Oxide adit extend 458 m along strike with a maximum width approaching 9 m and extending more than 180 min depth. The limonitic gossan contains hemimorphite (Figures 16, 17) and parahopeite as the main Zn minerals (McAllister, 1951). Figure 15 shows the typical exposure near the Oxide fault. Galena (nodules) and pyromorphite are the main Pb-bearing minerals (McAllister, 1951). The highest assay from the adit was 15.7% Zn, 1.4% Pb, 0.34 g/t Au and 3.4 g/t Ag (Fyles and Hewlett, 1959). Up to 23% Mn and minor pyritic quartz, with low Au assays, are reported in MINFILE. The International adit, located 830 m to the south of the Oxide adit, intersects CHNSBM zone up to 7.3 m in width. There are not enough data to decide if the Oxide deposit is of the direct- or wallrock-replacement type (Figures 2a, 2b, 15) but the dominance of hemimorphite is probably linked to high silica activity.

Figure 15: Lloyd Addie (in blue) explaining exploration history of the Oxide deposit to visiting geologists.

Figure 16: Hemimorphite nodule (Oxide deposit) .

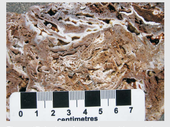

Figure 17: Inside of a hemimorphite nodule (Oxide deposit) .

Origin of the CHNSBM mineralization in the Salmo Area

The Reeves MacDonald group of deposits are the best examples of CHNSBM mineralization in BC (Figures 10 and 11). Several CHNSBM zones are underlain by sulphides, and their shape suggests that they formed by direct-replacement process. Sulphides are oxidized up to 450 m below the surface. The key controls on the formation of CHNSBM deposits are climate, nature and availability of near-surface protore, carbonate lithology, favourable hydrology and the rate of uplift. The climate controls the oxidation conditions and the transport of metals. The most favourable conditions for oxidation are in an arid climate, which maximizes the quantity of metals available for transport by supergene solutions. This is done by minimizing biogenic activity within the soil, making more oxygen available for sulphide oxidation (Reichert and Borg, 2008). Dry climate also lowers water table, preventing premature dilution of metal-bearing supergene solutions by barren ground waters within aquifers and dispersion of metals (Reichert and Borg, 2008). Non glaciated areas have higher potential to contain preserved CHNSBM deposits than glaciated ones. However, studies from southern BC indicate that after the last glacial maximum (17 000 to 14 000 BP) there was a warm and dry climate around 10 000-7000 BP (Palmer et al. 2002; Hebda, 2007). According to Clague (1991, Figure 12.1), the Salmo area is located about 100 km north of the maximum southern limit of the corresponding ice sheet. The glaciers in the Salmo area may have been thin and isostatic rebound (related to the glacial retreat), was probably less than in areas originally covered by thick ice. Sulphide mineralization in the Salmo area is predeformational (pre-Mid Jurassic). The sulphide oxidation is post-Mid Jurassic, and may have started before or slightly after the last glacial maximum (17 000-14 000 BP). The relatively warm and dry climate, which prevailed 10 000-7000 BP may have been particularly favourable for oxidation of outcropping sulphides. If this scenario is correct, the CHNSBM deposits nearly contemporaneous with glacial retreat.

EXPLORATION CONSIDERATIONS

KEY PARAMETERS FOR THE SELECTION OF THE FAVOURABLE EXPLORATION AREA

KNOWN MASSIVE SULPHIDE DISTRICT (MVT, Irish, SEDEX, VMS, Pb-Zn skarns, polymetalic veins etc.)

KNOWN CHNSBM DEPOSITS

FAVORABLE CLIMATE / PALEOCLIMATE

CARBONATE HOST / PROXIMAL LITHOLOGY (pH buffer)

UPLIFT RATE (tectonic / isostatic rebound)

WEATHERING

PERMEABILITY (karst, breccia and faults, permeable lithology)

WATER TABLE DEPRESSION

PROTECTION FROM GLACIATION

FAVOURABLE TOPOGRAPHY

SHAPE AND ORIENTATION OF SULPHIDE DEPOSITS

EXPLORATION TOOLS TO CONSIDER

Bibliographic search - known sulphide / nonsulphide mineralization (confirmation of favourable setting)

Traditional prospecting - gossan, boulder tracing, mineralogy) and Zinc Zap

Remote sensing and **short-wave infrared spectroscopy** (SWIR)

Portable XRF

Geochemistry (soil, stream sediments, water, vegetation, lithology)

Geophysics

Geobotany

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REFERENCES

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