Felsic metavolcanic rocks at Matt Berry: A new deposit model

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ABSTRACT

Exhalative Pb-Zn-Cu mineralization of the Matt Berry deposit is hosted in polydeformed black shale that is underlain by a strongly deformed felsic schist. The copper-rich nature of the ore, volcanic textures in the ore contacts, and the presence of alkaline felsic metavolcanic rocks beneath the deposit, suggest that the mineralization fits a mineral deposit model intermediate between sedimentary exhalative (SEDEX) and volcanogenic massive sulphide (VMS) end members.

RÉSUMÉ

La minéralisation de plomb-zinc-cuivre du gisement de Matt Berry est logée dans un shale noir polydéformé qui repose sur un schiste felsique fortement déformé. La forte teneur en cuivre du gisement, les textures volcaniques aux contacts de minerai, et la présence de roches métavolcaniques felsiques alcalines sous le gisement, indiquent que la minéralisation correspond a un modèle de gisement minéral intermédiaire entre un gisement sédimentaire exhalatif et un gisement de sulfure massif volcanogène.

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INTRODUCTION

During the 2000 field season, YTG Mineral Resources Branch carried out fieldwork in order to refine the mineral deposit models applicable to the western part of Selwyn Basin in Frances Lake map area (105H; Fig. 1). The Matt Berry deposit, Maxi prospect and the Simpson Tower area, were the principal areas of study of sedimentary exhalative (SEDEX)-type mineralization. Geological work involved mapping at 1:10 000 (Matt Berry), 1:20 000 (Simpson Tower), and 1:50 000 (Maxi) scales, as well as field checks at 1:250 000 scale (Nipple Mountain and Cenozoic basalts). Collection of samples for geochemical analyses, radiometric analyses (Pb-Pb and U-Pb), conodont dating, and petrographic studies were also conducted.

LOCATION AND ACCESS

The Matt Berry deposit is located on the northeastern shore of the East Arm of Frances Lake (Fig. 2). Access is by float plane from Finlayson or McEvoy lakes, or by boat

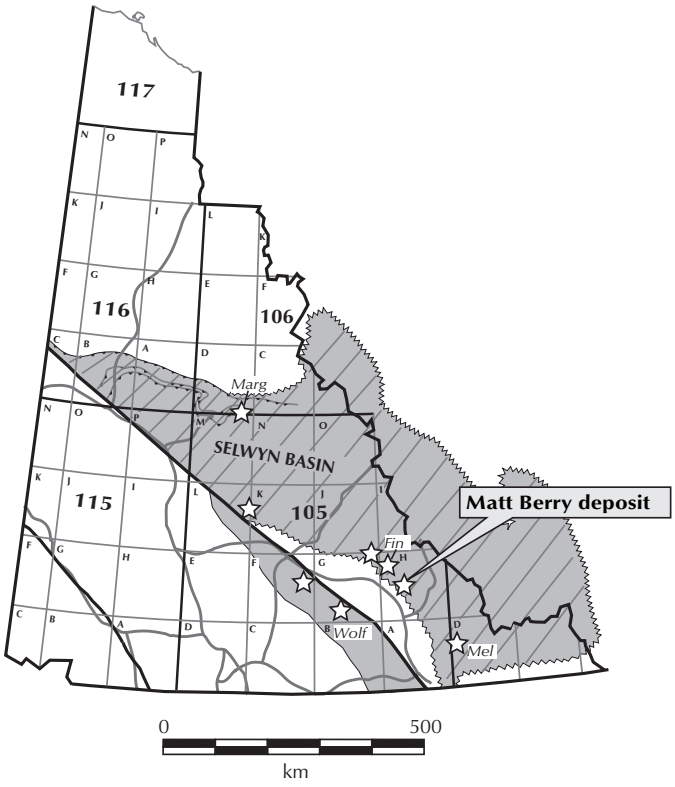

Figure 1. *Location map of Matt Berry deposit. Occurrences of felsic volcanic rocks (indicated by stars) in Devono-Mississippian strata of western Selwyn Basin and Cassiar Terrane (shaded).*

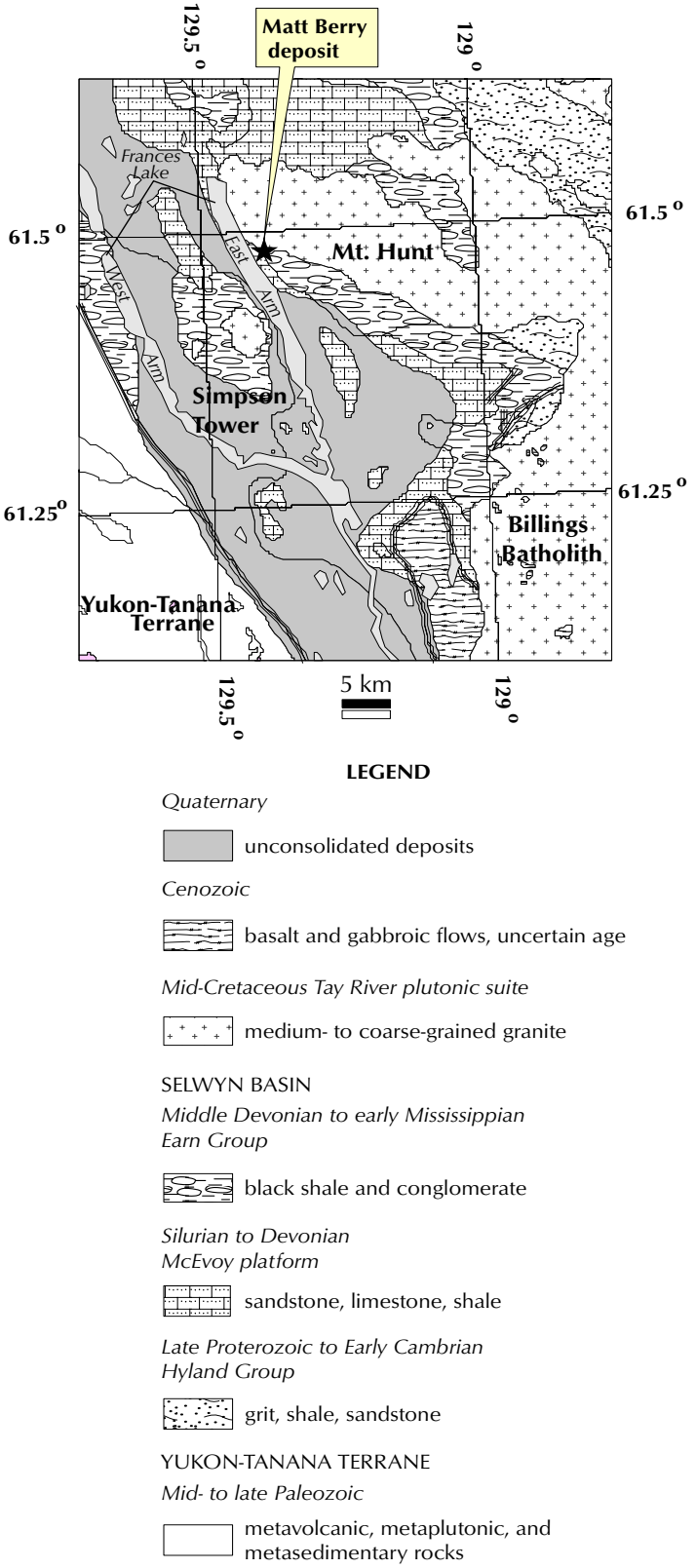

Figure 2. *Regional geology of central Frances Lake area (modified from Gordey and Makepeace, 1999).*

(approximately 60 km) from the Frances Lake campground. Remains of an old exploration camp are located at the mouth of Thompson Creek, immediately northwest of the deposit.

REGIONAL GEOLOGY AND MINERALIZATION OF FRANCES LAKE AREA

Frances Lake map sheet (105H) was mapped at 1:250 000 scale by Blusson (1965). Gordey and Makepeace (1999) compiled and further interpreted the geology of Frances Lake area (Fig. 2).

The area of study is located at the western edge of Selwyn Basin, where siliciclastic and carbonate deposition took place under different tectonic environments, from Late Proterozoic through Triassic time. Throughout its existence, four main extensional (rift) events have been documented. These extensional events produced down-dropped blocks, localized volcanism, SEDEX mineralization on and near the seafloor, and deeply penetrating normal faults that were reactivated throughout the geological history of Selwyn Basin.

Siluro-Devonian limestone, calcareous shale, and possibly quartz-arenite are interpreted as McEvoy Platform — a high-standing block to the west of Selwyn Basin (Gordey and Makepeace, 1999). McEvoy Platform may represent an eastern-most, autochthonous part of Cassiar Platform.

Mesozoic deformation started in Permo-Triassic time, and ended before the emplacement of mid-Cretaceous granitic batholiths and plutons. The timing of emplacement of eastern Yukon-Tanana Terrane (Finlayson Lake district) onto Selwyn Basin is pre-Triassic. Cenozoic strike-slip movement along Tintina Fault juxtaposed metamorphic rocks of Yukon-Tanana Terrane (Finlayson Lake district) to those of Cassiar Platform, and Selwyn Basin to Cassiar Platform and Yukon-Tanana rocks. Cenozoic magmatism produced basaltic rocks that crop out in the southern Frances Lake map area.

MATT BERRY DEPOSIT

The Matt Berry deposit is an unusually copper-rich, small tonnage SEDEX deposit (105H 021, Yukon MINFILE, 1997). Calculated reserves are 533,434 tonnes grading 6.1% Pb, 4.8% Zn, and 102.9 g/t Ag. Copper grades are not quoted in the reserves.

Work history

Galena-sphalerite-rich float in the Thompson Creek area was first reported by Dawson (1887). The area was first staked in 1944. Between 1966 and 1969, Matt Berry Mines Limited carried out trenching and EM surveys, and drilled 29 holes (2298 m). Between 1970 and 1971, the property was under option by Inco and Metallgesellschaft (now Inmet), who drilled 4 holes (426.7 m). In 1974, Anvil Mining Corporation conducted soil sampling and geophysical surveys (ground magnetics and gravity). In 1978, Welcome North Mines Limited conducted a pulse-EM survey. In 1979, Sovereign Metals Corporation, in a joint venture with Cominco, conducted trenching, geological mapping, geochemical surveys, and drilled 5 holes (1229 m). Sovereign changed name to Barytex Resources, which currently owns the claims. Pulse Resources optioned the property in 1986 and carried out the following work between 1987 and 1991: magnetic and geochemical surveys followed by staking of the BETH claims (1987); cutting and staking the BINTI claims (1988); geological mapping, soil sampling and geophysical surveys (1989); and drilling contracted to Pamicon Consultants (four diamond-drill holes, 303 m, 1991). After Pulse Resources dropped the option, Barytex Resources Corporation cut 53 km of line (1993), and staked the PAT claims (1994), which have since lapsed.

Geology and mineralization

The Matt Berry deposit is located in a densely vegetated area, where outcrops are rare and restricted to riverbanks or the shore of Frances Lake. Stratigraphic and structural relations to shallower water facies to the south and northwest are poorly defined. Two Pb-Pb analyses of galena from the Matt Berry deposit were used to constrain the 'Shale Curve' of Godwin and Sinclair (1982) and yielded a Devonian age, suggesting that the black shales hosting the mineralization are coeval with Earn Group rocks.

The area is underlain by dark grey to black phyllite, which is the host to mineralization. A trench exposes a 45-cm-thick massive sulphide layer on the south shore of Thompson Creek (Fig. 3). The sulphide bed consists of mainly galena, sphalerite and quartz, with lesser chalcopyrite and bornite, hosted in dark grey to black phyllite to carbonaceous phyllite. Mineralization thickens and is open to the east. Sulphide-bearing quartz veins, up to 1 m thick, crosscut carbonaceous phyllites to the south of the deposit along the eastern shore of Frances Lake.

An examination of drill core from Pulse Resources' 1991 exploration program revealed dark phyllites in the footwall of the Matt Berry zone which are underlain by a strongly deformed, quartz-sericite augen schist (Fig. 4). Abundant angular quartz grains, and quartz and muscovite replacing feldspar prisms in thin section, suggest a felsic volcanic protolith for the schist (Figs. 5 and 6). Small outcrops of the felsic schist were reported by Cominco geologists south of the Matt Berry camp, and above treeline on the Simpson Tower. Efforts to locate these outcrops during the 2000 field season were unsuccessful.

Geochemistry of samples from drill core (Table 1) indicates that these rocks are trachytic in composition (Fig. 7a). Trace element discriminants suggest that they formed in a within-plate setting such as an intracontinental rift (Fig. 7b). Less deformed felsic volcanic rocks in Earn Group are reported 30 km to the northwest, in Cominco's Quest and Fin SEDEX prospects (D. Rhodes, pers. comm., 2000).

Figure 3. *Photo of the Matt Berry showing. Galena-sphalerite-chalcopyrite mineralization exposed in a trench.*

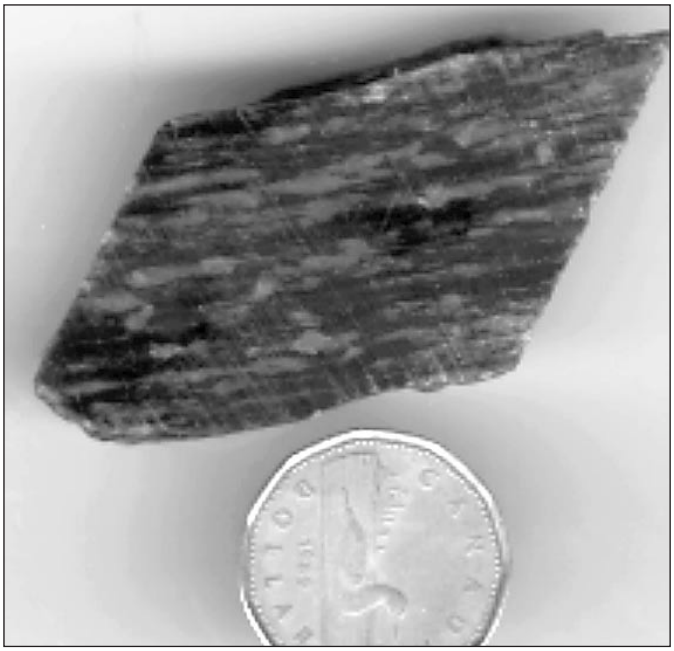

Figure 4. *Strongly deformed quartz-sericite augen schist from drill core at the Matt Berry zone.*

Figure 5. *Thin section of angular quartz eye in felsic metavolcanic unit. Field of view = 7.2 mm.*

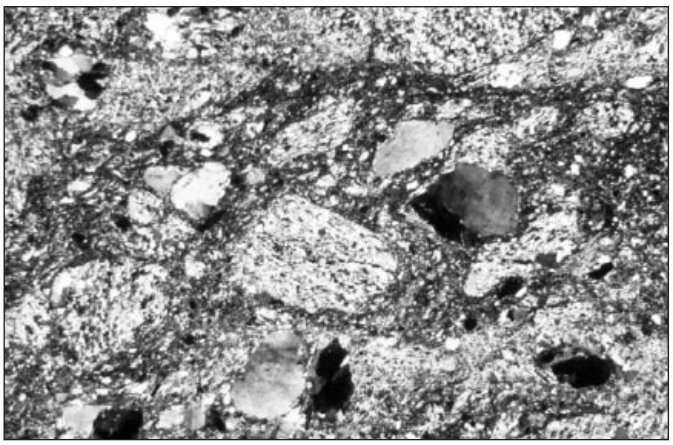

Figure 6. *Quartz and sericite replacing elongate feldspar grains in felsic metavolcanic unit. Field of view = 7.2 mm.*

SAMPLE	MB91-1-67	MB91-3-78.6	MB91-4-74.2
unit	MB	MB	MB
SiO_2	78.86	77.85	78.46
Al_2O_3	11.90	12.00	12.22
Fe_2O_3	1.52	2.70	1.79
MnO	0.006	0.065	0.070
MgO	0.44	0.94	0.53
CaO	0.04	0.11	0.29
Na_2O	0.17	0.16	0.10
K_2O	3.56	3.07	3.75
TiO_2	0.256	0.172	0.153
P_2O_5	0.04	0.04	0.02
LOI	2.04	2.06	2.05
TOTAL	98.82	99.15	99.43
V	7	9	-5
Cr	-20	-20	-20
Co	1	2	1
Ni	-20	-20	-20
Cu	26	-10	-10
Zn	737	80	42
Ga	25	23	28
Ge	1.2	1.4	1.3
As	1,200	7	221
Rb	203	166	210
Sr	15	22	19
Y	35.9	52.4	42.2
Zr	222	157	172
Nb	116	85.6	129
Mo	5	6	5
Ag	-0.5	-0.5	-0.5
In	0.6	0.3	-0.1
Sn	18	6	6
Sb	14.5	5.4	4.6
Cs	2.4	3.8	3.1
Ba	162	183	82
Hf	9.6	7.6	8.2
Ta	11.2	11.2	13.2
W	6.9	4.9	4.9
Tl	0.85	0.98	1.23
Pb	8	13	64
Bi	4.4	0.5	2.0
Th	36.9	32.3	45.6
U	5.28	8.44	12.5
La	106	57.4	83.8
Ce	208	106	172
Pr	22.9	11.0	19.1
Nd	81.6	38.2	69.1
Sm	13.3	6.53	12.2
Eu	1.60	1.37	1.11
Gd	10.0	6.83	9.40
Tb	1.47	1.48	1.47
Dy	7.57	8.91	7.98
Ho	1.42	1.71	1.49
Er	4.14	5.03	4.40
Tm	0.620	0.743	0.654
Yb	3.76	4.57	4.12
Lu	0.500	0.626	0.554

Table 1. *Major element XRF, trace element and REE ICP-MS analyses of drill core samples of quartz-sericite schist.*

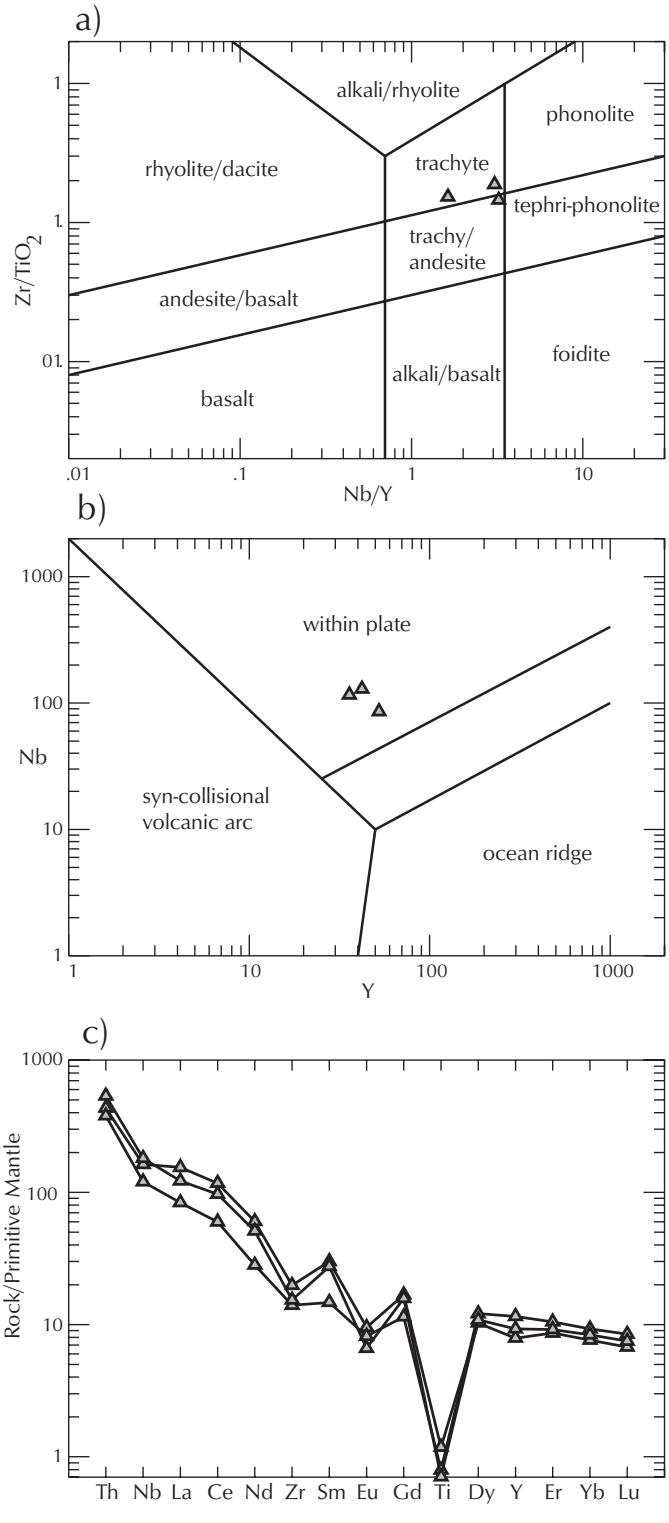

Figure 7*. (a) Zr/Ti – Nb/Y diagram of Winchester and Floyd (1977) as modified by Pearce (1996). (b) Nb-Y discriminant diagram of Pearce* et al. *(1984). (c) Primitive mantle-normalized incompatible element diagram. Primitive mantle values of Sun and McDonough (1989).*

Structural geology

Three foliations are observed in outcrop (Fig. 8), suggesting that three phases of deformation affected the deposit. Northeast-oriented cross-sections (Fig. 9) show the interpreted geology of the deposit. The felsic volcanic unit consistently underlies the mineralization, but the distance between mineralization and the volcanic unit varies from 23 m to over 75 m. Easterly to east-northeasterly directed thrusting and folding brings the mineralized sequence closer to surface towards the east. The variable thickness of low-grade to barren phyllite between the quartz-eye felsic volcanic unit and the mineralization is interpreted as the result of folding along an approximate east axis. This interpretation implies repetition of the mineralization at greater depth, and is in line with structural observations recorded in the area. Alternatively, this variation in thickness may result from a combination of transposition of bedding and variable distance to the volcanic centres.

Figure 8. *Outcrop along shoreline of East Arm of Frances Lake, south of Matt Berry deposit. First phase foliation (S_1) is parallel to the photograph. Second phase foliation (S_2) is folded and steeply dipping. Third phase foliation (S_3) is sub-horizontal and sub-parallel to bedding.*

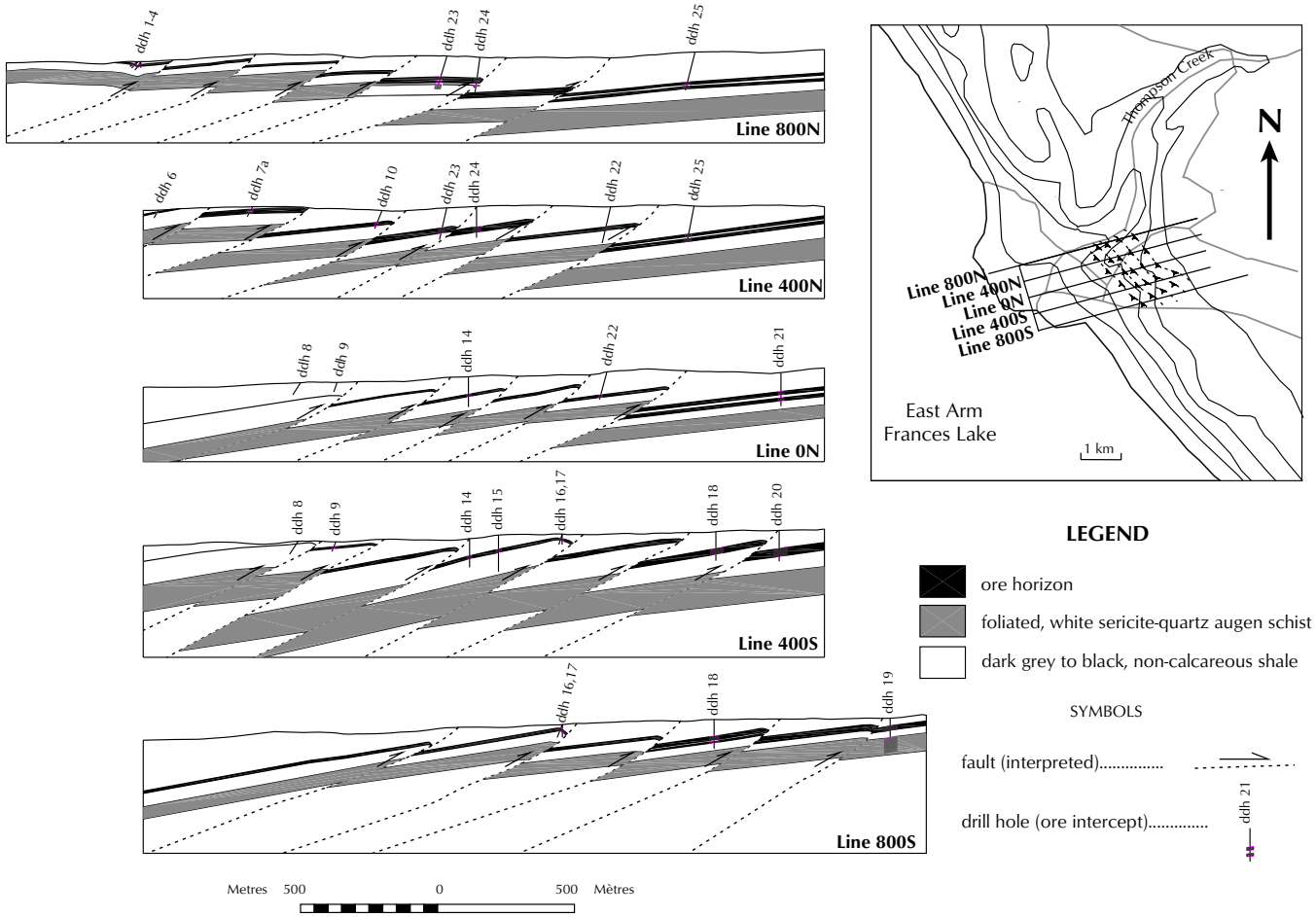

Figure 9. *Northeast cross-sections of the Matt Berry deposit (looking northwest, 400 m spacing, no vertical exaggeration) displaying interpreted easterly directed thrusting and folding, and a felsic volcanic unit underlying the mineralization.*

Ore petrography

A reflected light petrographic study of mineralization from the Matt Berry showing demonstrated the copper-rich nature of the deposit. Locally, chalcopyrite makes up to 2% of the rock volume. Typical paragenesis in the showing is: quartz → sphalerite → quartz, chalcopyrite, pyrite → galena → covelite, marcasite, quartz, sericite (Fig. 10). Chalcopyrite also occurs as exsolutions in sphalerite and is concentrated as fine-grained crystals along the contacts with unmineralized phyllite. Angular quartz eyes along the contacts of the mineralization suggest a volcaniclastic component to the mineralization (Fig. 11). Principal gangue minerals are quartz, carbonate, and sericite.

Deposit model

The presence of alkaline felsic volcanic rocks underlying mineralization, unusually high copper grades, small tonnage, and volcanic textures along the ore-wallrock contacts, demonstrate a strong volcanogenic component in the Matt Berry deposit. Intensely deformed quartz-eye schist underlying the mineralization resembles felsic metavolcanic rocks of Yukon-Tanana Terrane, or rocks in the Tombstone strain zone of Selwyn Basin.

The possibility that the Matt Berry deposit lies in Yukon-Tanana Terrane rocks was examined and rejected in the course of this research project. Rocks in the Simpson Tower area to the west, are dark grey chert-pebble conglomerate, sandstone and hornfelsed shale that do not show the same amount of strain as the quartz-eye schist underlying the Matt Berry ore, and are interpreted as Earn Group. The possibility that the Matt Berry deposit lies on a klippe of Yukon-Tanana Terrane, which is the northerly extension of greenstones mapped by Blusson (1965) and interpreted by Gordey and Makepeace (1999) as a klippe of Slide Mountain Terrane affinity, was also rejected. An examination of rocks from the greenstone unit showed that they are undeformed (recent and autochthonous) basaltic flows.

CONCLUSIONS

The previously unreported felsic volcanic unit that underlies the Matt Berry deposit may represent a significant metallogenic district in western Selwyn Basin. Occurrences of felsic volcanic rocks of Devono-Mississippian age are known from many localities in western Selwyn Basin (Fig. 1). Base-metal prospects are associated with many of the known occurrences of felsic rocks (e.g., Fin and Quest properties, Mel property and Marg deposit; see also Holbek et al., this volume). Other occurrences, such as felsic volcanic rocks in Earn Group of northeastern Glenlyon area (105L; Gordey and Makepeace, 1999), remain uninvestigated.

A strong volcanogenic component was observed in the host rock geology and ore contacts of the Matt Berry deposit, suggesting that the mineralization represents a hybrid mineral deposit type, which has characteristics of sedimentary-exhalative (SEDEX)- and volcanogenic massive sulphide (VMS)- type mineralization. Hybrid deposits of this type are more Cu- and possibly Au-rich

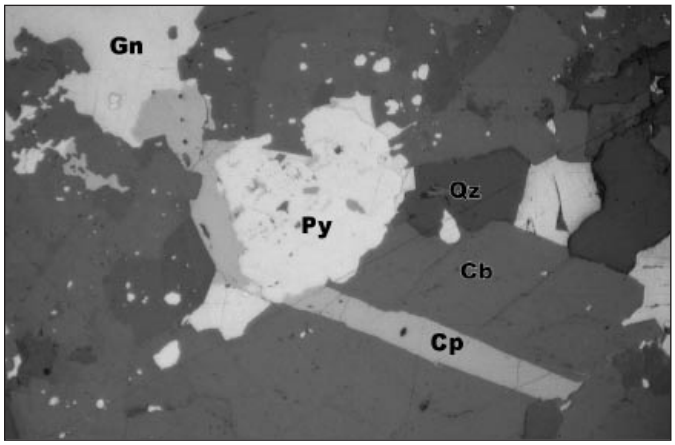

Figure 10. *Large chalcopyrite crystal interstitial to pyrite, carbonate, quartz, and sphalerite. Gn = galena; Py = pyrite; Qz = quartz; Cb = carbonate; Cp = chalcopyrite. Field of view = 1.75 mm.*

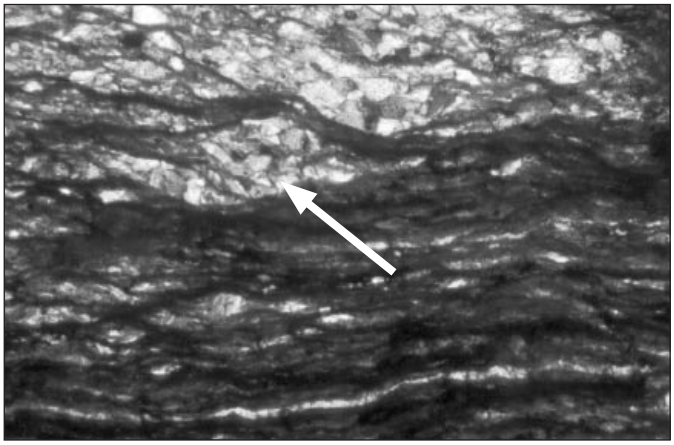

Figure 11. *Angular quartz along the contacts of the Matt Berry ore zone. Field of view = 7.2 mm.*

than those developed in more typical SEDEX environments. Proposed Pb-Pb analyses of galena in the mineralization and of pyrite in the volcanic unit will show conclusively whether or not there is a genetic relation between the extrusion of felsic volcanic rocks and mineralization.

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