Geological Survey of Canada

CURRENT RESEARCH
2007-A4

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2007

Natural Resources Canada
Ressources naturelles Canada

Canada

CURRENT RESEARCH

ISSN 1701-4387
Catalogue No. M44-2007/A4E-PDF
ISBN 978-0-662-45281-2

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Publication approved by GSC Pacific

Correction date:

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J-P. Paiement, G. Beaudoin, and S. Paradis, 2007: Geological setting of Ag-Pb-Zn veins in the Purcell Basin, British Columbia; Geological Survey of Canada, Current Research 2007-A4, 10 p.

Abstract: The Proterozoic Purcell Basin in Canada (Belt Basin in U.S.A.) contains numerous Ag-Pb-Zn vein deposits and stratiform massive sulphide Pb-Zn-Ag deposits. In the Coeur d'Alene district in Idaho, veins have been divided in two types: Proterozoic Pb-Zn-rich veins and Mesozoic Ag-Pb-Zn rich veins. Based on previous Pb-isotope work, the vein deposits of the Purcell Supergroup in British Columbia can be divided into the same two groups. Representative veins of the Purcell Supergroup having a Proterozoic and Mesozoic Pb-isotope signature were sampled during the 2006 field season and are described in this paper. Preliminary results show that the Pb-Zn-rich veins are massive and only present in the Aldridge Formation, and the Ag-Pb-Zn-rich veins mainly consist of galena in a quartz gangue, and crosscut various strata of the Purcell Supergroup. Further work will attempt to characterize the sources of the mineralizing fluids, and the O, S, C, and Pb isotopic composition in both types of veins and compare them to the Coeur d'Alène district in Idaho, U.S.A.

Résumé : Le bassin de Purcell du Protérozoïque au Canada (bassin de Belt aux É.-U.) contient plusieurs essaims de veines à Ag-Pb-Zn et des gîtes de sulfures massifs stratiformes à Pb-Zn-Ag. Dans le district de Cœur d'Alene, en Idaho, les veines à Ag-Pb-Zn sont divisées en deux types : les veines riches en Pb-Zn du Protérozoïque et les veines riches en Ag-Pb-Zn du Mésozoïque. En se fondant sur des travaux antérieurs sur les isotopes de Pb, les veines à Ag-Pb-Zn dans les roches du Supergroupe de Purcell en Colombie-Britannique peuvent aussi être divisées suivant les deux mêmes groupes. Des veines représentatives dans les roches du Supergroupe de Purcell montrant des signatures isotopiques de Pb propres aux veines du Protérozoïque et du Mésozoïque ont été échantillonnées durant la saison sur le terrain 2006 et sont décrites ici. Les résultats préliminaires indiquent que les veines riches en Pb-Zn sont massives et encaissées exclusivement dans la Formation d'Aldridge et que les veines riches en Ag-Pb-Zn contiennent principalement de la galène dans une gangue de quartz et qu'elles recoupent toutes les unités du Supergroupe de Purcell. La suite des travaux tentera de caractériser la source des fluides minéralisateurs, les compositions isotopiques de O, de S, de C et de Pb dans les deux types de veines et de comparer ces veines à celles du district de Cœur d'Alene (Idaho, É.-U.).

INTRODUCTION

The Purcell Basin in Canada and its correlative the Belt Basin in the United States are well known for the world-class Sullivan SEDEX Pb-Zn-Ag deposit in British Columbia, and the Ag-Pb-Zn polymetallic veins in the Coeur d'Alene district in Idaho. More than two dozen Ag-Pb-Zn veins were exploited in British Columbia at the end of the 19th and beginning of the 20th centuries, but none are currently in production.

Based on $^{40}Ar/^{39}Ar$ age spectra and Pb-isotope results, Leach et al. (1998) suggested two major vein-forming events in the Belt Basin of the Coeur d'Alene district: a Proterozoic event with Pb-Zn-rich veins and a Late Cretaceous to early Tertiary event with Ag-rich veins. In British Columbia, the Ag-Pb-Zn veins in rocks of the Purcell Basin show similar Pb isotopic compositions to those of the Coeur d'Alene district with two vein-forming events (LeCouteur, 1973). The Proterozoic Zn-Pb-rich veins have a Pb-isotope composition that is less radiogenic than the Proterozoic Sullivan SEDEX deposit (LeCouteur, 1973; Beaudoin, 1997), which was interpreted to be the result of mixing of Pb leached from rocks of the Purcell Supergroup and primitive Pb from the Moyie sills (Beaudoin, 1997). Silver-lead veins with a more radiogenic Pb signature than the Sullivan deposit have been interpreted to contain radiogenic Mesozoic Pb (LeCouteur, 1973).

During the summer of 2006, fieldwork was conducted in order to document and sample Ag-Pb-Zn veins hosted by rocks of the Purcell Supergroup. Twenty-two deposits were visited in the Creston, Cranbrook, Fort Steele, and Invermere areas (Fig. 1). The deposits were chosen from the BC MINFILE database to be representative of Ag-Pb-Zn vein deposits in rocks of the Purcell Supergroup. The samples will be studied by petrographic methods and analyzed for Pb-, O-, and S-isotope geochemistry. These data will allow researchers to improve metallogenic models for Ag-Pb-Zn veins in the Purcell Basin and will aid in the comparison of the Ag-Pb-Zn veins in rocks of the Purcell Supergroup to veins from the Coeur d'Alene district in Idaho. This will help define new or improved exploration guidelines for this type of deposit.

GEOLOGICAL SETTING

The Purcell Basin (Belt Basin) is a Middle Proterozoic sedimentary basin with a surface exposure over 200 000 km^2 in Canada and in the U.S.A. The Purcell Supergroup in British Columbia is the stratigraphic correlative to the Belt Supergroup in Idaho and Montana (Fig. 1). The Purcell Basin (Belt Basin) contains a 16 km thick succession, named the Purcell Supergroup, of predominantly Middle Proterozoic clastic, carbonate, and volcanic rocks, deposited in an intracratonic rift setting (Chandler, 2000). The major structural feature of the basin is the Purcell anticlinorium, which is a broad, generally north-plunging structure that is cored by rocks of the Purcell and Windermere supergroups and flanked by Paleozoic rocks (Pope, 1990; Höy, 1993). Detailed stratigraphic and structural studies have been conducted in the west half of Fernie map area (NTS 82 G west half) by Höy (1993), and in the Horsethief Creek and Toby Creek areas in the northern part of the basin (82 K east half) by Pope (1990).

The lowermost stratigraphic unit of the Purcell Supergroup is the Fort Steele Formation. It is characterized by thick, massive or crossbedded quartz arenite deposited in a braided fluvial system (Chandler, 2000). The Fort Steele Formation is overlain by the Aldridge Formation, which is divided in three units (Reesor, 1958; Höy, 1993): the lower Aldridge Formation unit is mainly composed of fine-grained quartz wacke and siltstone; the middle Aldridge Formation unit is characterized by well bedded and medium-grained quartz arenite, wacke, and siltstone; and the upper Aldridge Formation unit is composed of medium to dark grey siltstone, argillaceous siltstone, and argillite. The Sullivan SEDEX deposit is located at the contact between the lower and middle Aldridge Formation units. The Aldridge Formation is interpreted to represent a succession from distal and proximal turbidite units grading into the final subaerial and aerial infill of the sedimentary basin (Höy, 1993).

The lower Aldridge Formation unit and lower part of the middle Aldridge Formation unit are intruded by the Moyie sill complex. Höy (1993) suggested that the Moyie sills intruded the unconsolidated sediments of the Aldridge Formation. Uranium-lead dating on zircon crystals from the sills yielded a concordant date of 1476 ± 3 Ma (Höy et al., 2000) with $^{207}Pb/^{206}Pb$ ratios indicating that the crystallization of the sill occurred within a maximum of 6 Ma (Anderson and Davis, 1995). These data give a minimum age for the deposition of the Aldridge Formation.

The Creston Formation overlies the Aldridge Formation. It is composed of green, mauve, and grey siltstone, argillite, and quartzite deposited in shallow-water to subaerial settings (Höy, 1993). The Creston Formation is overlain by carbonate beds of the Kitchener Formation that were deposited in a carbonate-shelf environment during decreasing input of terrigenous material (McMechan, 1980). Fine-grained clastic rocks of the Van Creek Formation were deposited in a shallow-water environment and gradationally overlie the Creston Formation (Höy, 1993). Basaltic volcanic rocks of the Nicol Creek Formation dated at approximatively 1075 Ma (Hunt, 1962) overlie the Van Creek Formation in sharp contact.

In the southern part of the Purcell Basin, the upper Purcell Supergroup comprises Helikian clastic and carbonate rocks of the Sheppard, Gateway, Philips, and Roosville formations that were deposited in a passive-margin environment (Pope, 1990). The Sheppard Formation that overlies the Nicol Creek Formation is composed of stromatolitic dolomite, quartz arenite, siltstone, and argillite deposited in a shallow-lacustrine environment or a marine-shelf environment (Höy, 1993). The Sheppard Formation is overlain by siltite, argillite, arenite, and dolomite of the lower Gateway Formation that represents a shallow-water environment (Daly, 1912). Overlying the

Gateway Formation, in a gradational contact, the Philips Formation is composed of red to purple quartzite and siltstone deposited in a shallow-water to subaerial environment (Höy, 1993). The Roosville Formation overlies the Philips Formation and is comprised of argillite, siltstone, quartzite, and dolomite (Höy, 1993). The Roosville Formation correlates with the upper Dutch Creek Formation in the Lardeau area of the Kootenay Arc (Reesor, 1973).

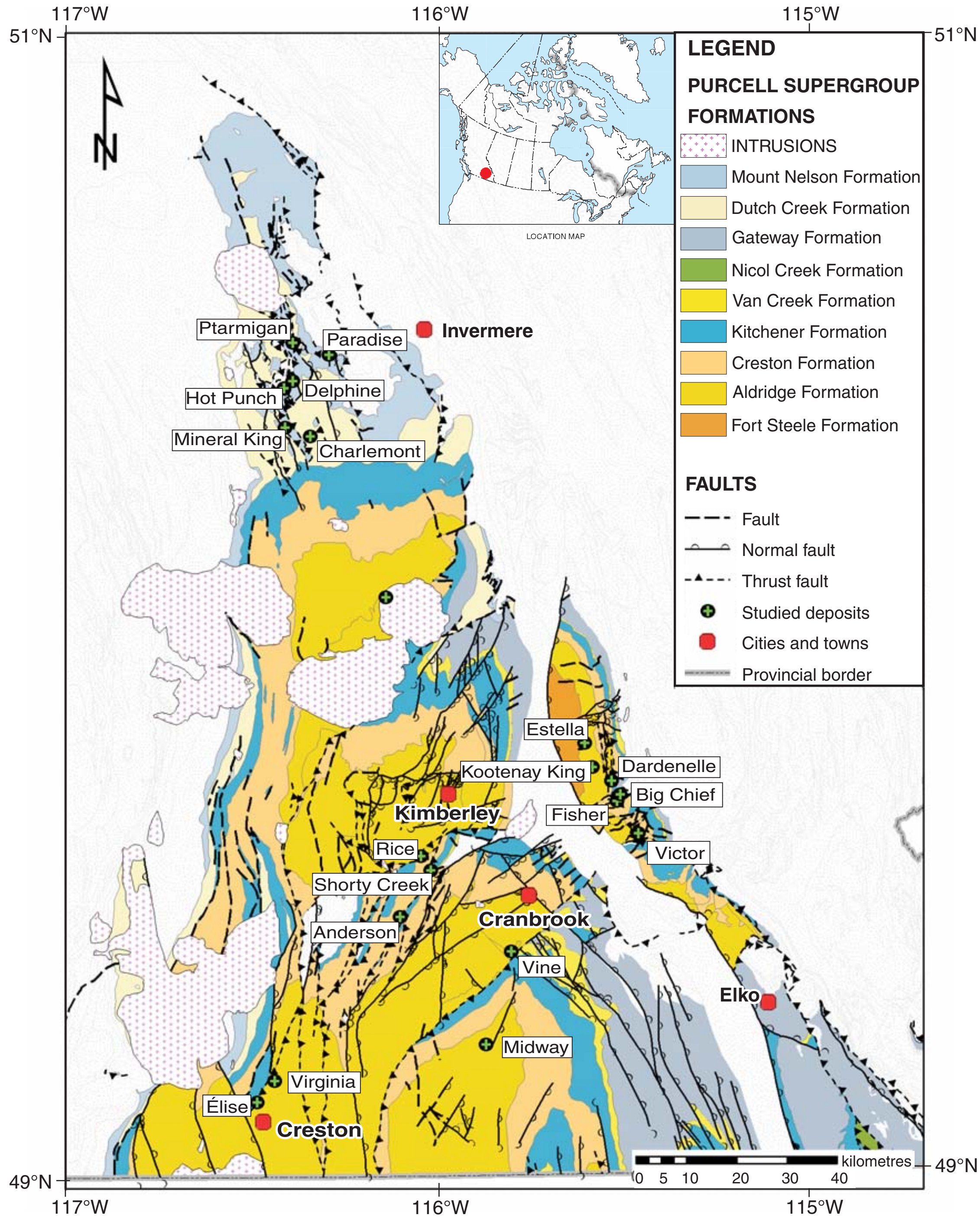

Figure 1. Simplified geology map of the Purcell Supergroup showing the deposits studied (*modified from* MapPlace data,<http://www.em.gov.bc.ca/Mining/Geolsurv/MapPlace/>, [accessed 2006-06-19]).

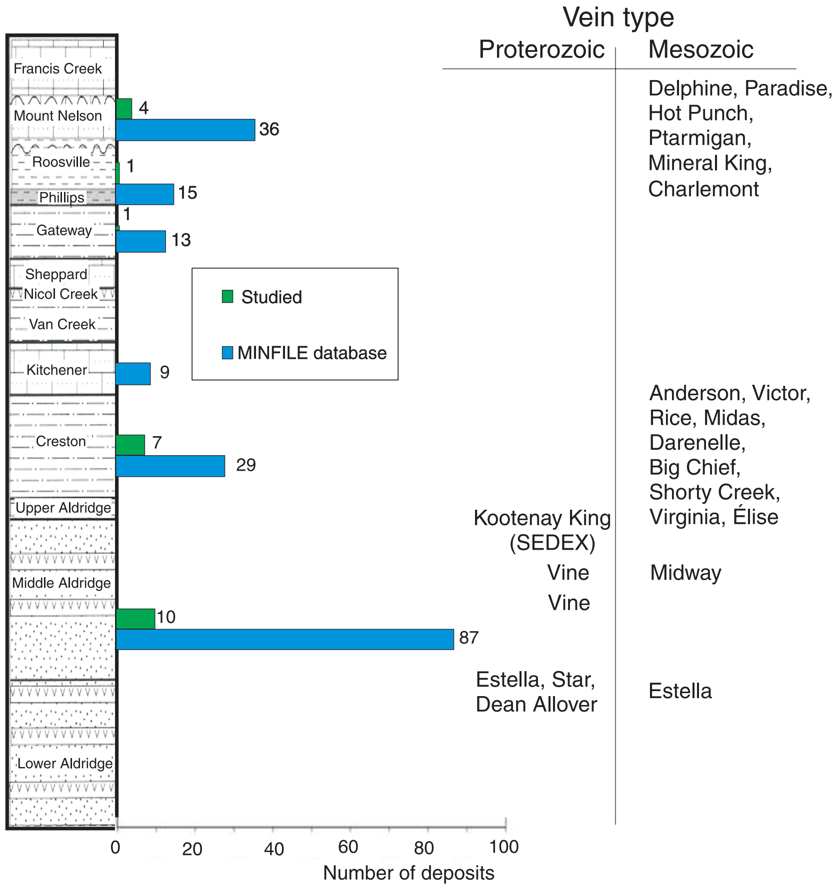

Figure 2. Stratigraphic distribution of Ag-Pb-Zn veins in the Purcell Supergroup with classification according to Proterozoic and Mesozoic vein types.

In the northern part of the Purcell Basin, Pope (1990) described the following stratigraphy within the upper Purcell Supergroup: lower Gateway Formation, Dutch Creek Formation, and Mount Nelson Formation. The Dutch Creek Formation, which overlies the Gateway Formation along a parallel unconformity (Pope, 1990), comprises fine-grained quartzite and argillite (Pope, 1990; D. Gardner and S.T. Johnston, unpub. manuscript, 2006). According to Höy (1993), the Sheppard Formation correlates with the lower part of the upper Dutch Creek Formation in the northern part of the Purcell Basin. On the other hand, Pope (1990) interpreted the Sheppard Formation as the stratigraphic equivalent to the lower Gateway Formation. The Dutch Creek Formation is overlain by the Mount Nelson Formation, which is composed of distinctive, thick, well bedded white quartzite, dolomite, and argillite (Pope, 1990). The contact between the Dutch Creek Formation and the Mount Nelson Formation is sharp and represents a major change in sedimentary and hydrodynamic environment. Lying uncomfortably over the Mount Nelson Formation is the Toby Formation of the Cambrian Windermere Supergroup.

Rocks of the Purcell Supergroup experienced polymetamorphism characterized by low-grade greenschist facies or lower metamorphic grade (Höy et al., 2000). The rocks were first metamorphosed and deformed during the East Kootenay Orogeny at 1.35–1.3 Ga, then a second time at about 0.9–0.8 Ga, and finally during the Mesozoic-Cenozoic (McMechan and Price, 1982).

Mesozoic intrusions are scattered across the Purcell Supergroup and the central part of the basin is intruded by the Jurassic granodioritic Whitecreek Batholith (Fig. 1; Reesor (1958)). The small intrusions such as the Reade Lake Stock, the Kiakho Stock, and the Estella Stock have a granitic composition and intrude the rocks of the Aldridge to the Kitchener formations (Höy, 1993).

STRUCTURAL EVOLUTION

A first Middle Proterozoic extensional event led to the formation of the Purcell Basin (Belt Basin) and the deposition of the Fort Steele, Aldridge, Creston, Kitchener, and Van Creek formations (Höy, 1993). Eruption of basaltic volcanic rocks of the Nicol Creek Formation record a second extensional event followed by block faulting and deposition of the Sheppard, Gateway, Philips, Dutch Creek, and Mount Nelson formations (Höy, 1993). At the end of the Middle Proterozoic, the East Kootenay Orogeny marked the end of the deposition of rocks of the Purcell Supergroup (Elston and Breasler, 1980). This compressive event produced regional greenschist-grade metamorphism (Höy, 1993). The Goat River event is an extensional tectonic event that occurred at the end of the Late Proterozoic and resulted in block faulting of the Purcell Basin.

The dominant structures in the Purcell Mountains are the result of the Late Jurassic to Tertiary Laramide Orogeny. This horizontal compression event thickened the Proterozoic sequence and displaced it towards the east (Price, 1981). The Laramide Orogeny created complex thrust-fault patterns, normal faults, and broad to tight folds (Höy, 1993). The Rocky Mountain Trench and the normal movements along thrust faults are the result of late Tertiary extension (Leech, 1966).

FIELDWORK AND METHODOLOGY

Twenty-two Ag-Pb-Zn veins were described and sampled during the field season in July and August 2006. The deposits were selected from the BC MINFILE database, according to their regional distribution and the fact that they comprise examples of veins with Proterozoic and Mesozoic Pb-isotope composition (LeCouteur (1973), Godwin et al. (1988); Fig. 1, 2). Deposits were described and sampled to conduct future petrographic and Pb, O, C, and S isotopic studies.

Deposit descriptions

This section gives a brief overview of the deposits selected for this study. The Ag-Pb-Zn veins in rocks of the Purcell Supergroup have been described by Schofield (1915), Rice (1937), and Höy (1993). Pope (1990) described the tectonic setting of the Ptarmigan, Delphine, Hot Punch, and Paradise deposits. The deposits are located on Figure 1 and are listed in Table 1. Figure 2 illustrates the stratigraphic position and the present authors' preliminary classification of the deposits.

Anderson (B.C. MINFILE No. 082FNE056)

The Anderson deposit (Fig. 1) is hosted by clastic rocks of the Creston Formation. It is a 5 m thick vein in a fault zone striking 096° and dipping 72°. The mineralization comprises coarse-grained quartz with disseminated galena and rare visible gold. The abundance of quartz and the occurrence of gold suggest that the Anderson vein could be Mesozoic (Table 1).

Big Chief (B.C. MINFILE No. 082KNE026)

The Big Chief deposit is located about 500 m north of the Fisher deposit (Fig. 1). Mineralization comprises a stockwork of narrow (2 cm wide) veins (150°/60°) perpendicular to bedding (048°/60°) and crosscutting the dolomitic limestone and quartzite of the Creston Formation. The quartz vein contains pods of galena and pyrite that suggests a Mesozoic age (Fig. 2).

Charlemont (B.C. MINFILE No. 082KSE066)

The Charlemont deposit is hosted by variably silicified dolostone of the Dutch Creek Formation (Fig. 1). Two types of mineralization are found: quartz-dolomite-galena-sphalerite veins with minor malachite and azurite, and vuggy quartz and galena stockwork in brecciated and silicified dolostone (Fig. 3a). The sulphide mineralogy and quartz gangue indicates a Mesozoic age (Fig. 2).

Table 1. List of the deposits studied in Purcell Supergroup rocks.

MINFILE No.	Name	Easting (UTM 11)	Northing (UTM 11)	Host rock	Type *	Minerals **	Commodities
082GSW02	Midway	580704	5454141	Middle Aldridge	2	td-gn-py-sp	Pb, Zn, Ag, Au, Cu
082FNE056	Anderson	569663	5488819	Creston	2	gn-vg(Au)	Au, Ag, Pb
082KSE032	Delphine	542208	5586275	Mount Neilson	3	gn-td-py-mal-az	Ag, Pb, Zn, Cu
082GNW008	Estella	600301	5514149	Lower Aldridge	1, 2	gn-sp-py(td)	Ag, Pb, Zn, Cu, Au
082GSW050	Vine	585714	5472667	Middle Aldridge	1	gn-sp-po-py	Pb, Zn, Ag, Cu, Au
082GNW004	Victor	610982	5496157	Creston	2	gn-td-py-mal-az	Pb, Ag, Zn, Au, Cu
082FNE055	Rice	567749	5491655	Creston	2	gn-cpy-bn-mal	Au, Ag, Cu, Pb Zn
082GNW022	Midas	606738	5502664	Creston	2	gn-py	Pb, Ag, Au, Cu
082GNW019	Dardenelle	605677	5506701	Creston	2	gn-td-py-mal-az	Pb, Zn, Ag, Au, Cu
082GNW002	Big Chief	607412	5503904	Creston	2	py-gn	Pb, Ag, Au, Cu
082GNW009	Kootenay King	601810	5509332	Middle Aldridge	SEDEX	gn-py-po	Ag, Pb, Zn, Au, Cu
082KSE001	Mineral King	540708	5576979	Upper Gateway	3	gn-sp-py	Ag, Zn, Pb, Cu
082GNE057	Shorty Creek	563608	5479485	Creston	2	py-sp-gn	Pb, Zn, Ag, Au
082FSE041	Virginia	538213	5446286	Upper Aldridge	2	gn-pm	Pb, Ag, Zn, Au, Cu
NA	Élise	535307	5442758	Upper Aldridge	2	gn-sp	Ag, Pb, Zn, Au, Cu
082KSE029	Paradise	549467	5591449	Mont Nelson	3	gn-sp-py	Ag, Pb, Zn, Au, Cu
082FSE002	Star (DDH)	549974	5450873	Aldridge	1	po-gn-sp	Ag, Pb, Zn, Cu
082FNE135	Dean-Allover (DDH)	570842	5504813	Aldridge	1	po-gn	Pb, Zn
082GSW050	Vine (DDH)	585714	5472667	Lower Aldridge	1	po-cpy-gn-sp	Pb, Zn, Ag, Cu, Au
082KSE034	Hot Punch	540489	5584786	Mont Nelson	2, 3	gn-sp-py-Cu	Ag, Pb, Zn, Au, Cu
082KSE066	Charlemont	545752	5575262	Dutch Creek	2	gn-sp-mal-az	Ag, Pb, Zn, Cu
082KSE030	Ptarmigan	542190	5593903	Mont Nelson	2, 3	py-sp-td-gn	Ag, Au, Cu, Pb, Zn

* 1 Pb-Zn Proterozoic veins
2 Ag-Pb-Zn Mesozoic veins
3 Ag-Pb-Zn Mesozoic replacements

** td: tetrahedrite; gn: galena; py: pyrite; sp: sphalerite; vg(Au): visible gold; mal: malachite; az: azurite; po: pyrrhotite; cpy: chalcopyrite; bn: bornite; pm: pyromorphite; NA: not applicable


a)
b)
c)
d)
e)
f)
Qtz-Py
Qtz-Gn
g)
h)
i)
Do
Sw
Qz
Mx
Qz
Sw
Do
j)
k)
l)

Dardenelle (B.C. MINFILE No. 082GNW019)

Adit #1 of the Dardenelle deposit (Fig. 1) shows a 1 m wide sheared quartz vein striking 050° and dipping 16°. The vein extends at least 15 m and is hosted by clastic rocks of the Creston Formation (Fig. 2). The quartz vein contains galena and tetrahedrite pods (Fig. 3b) in the hanging wall of the vein. Adit #3 is 100 m below adit #1 and shows a quartz vein less than 1 m wide, striking 127° and dipping at 22° in faulted contact with the host rock. Mineralization consists of disseminated galena in vuggy quartz. The two veins are interpreted to be Mesozoic (Table 1).

Dean-Allover (B.C. MINFILE No. 082FNE135)

The Dean-Allover deposit is a massive quartz-pyrrhotite-sphalerite-galena vein hosted by pyrrhotite-rich mudstone of the Aldridge Formation. Samples were taken from the core library of David Pighin (Ruby Red Resources). The mineralogy of the deposit indicates a Proterozoic age (Table 1).

Delphine (B.C. MINFILE No. 082KSE032)

The Delphine deposit (Fig. 1) is a quartz-sulphide vein within a normal fault striking 150° and dipping 78°. The 0.3–1 m wide vein cuts dolomite of the Mount Nelson Formation. The mineralization is composed of galena and pyrite in a quartz stockwork and of coarse-grained dolomite with galena typical of a replacement deposit. The succession from quartz stockwork to replacement of dolostone by sulphide minerals is similar to that found at the Paradise deposit.

←

Figure 3 (opposite). Photographs of textures and structures of Ag-Pb-Zn veins; **a)** quartz stockwork with galena and tetrahedrite in dolostone (Charlemont); sample is 18 cm across; **b)** galena in a quartz vein (Dardenelle); sample is 14 cm across; **c)** galena, pyrrhotite, and pyrite vein in contact with silicified host rock (Estella); sample is 19 cm across; **d)** quartz and galena veins cutting the Mesozoic Estella stock (Estella); person is 1.60 m tall **e)** massive sphalerite, pyrite, and galena pod (Hot Punch); sample is 14 cm across; **f)** quartz-galena (Qtz-Gn) vein cutting a quartz-pyrite (Qtz-Py) vein (Hot Punch); sample is 15 cm across; **g)** stratiform galena beds (Kootenay King); **h)** galena and tetrahedrite vein with quartz fragments (Midway); sample is 23 cm across; **i)** replacement zonation showing the mineralization (Mx) in the centre in contact with the quartz vein (Qz) grading to a quartz stockwork (Sw) in a fresh dolostone (Do) (broken lines) (Paradise); bike is 1.45 m tall; **j)** massive pyrite body with rafts of black chert cut by vertical quartz veins (Ptarmigan); pen is 14 cm long; **k)** extension of the vein (broken lines) at Vine deposit; person is 1.60 m tall; and **l)** pyrrhotite and galena with quartz fragments (Vine); sample is 21 cm across.

Elise (new showing)

The Elise showing (Fig. 1) was discovered during the summer 2006 fieldwork (UTM co-ordinates in Table 1). The showing is hosted by the Aldridge Formation. It consists of a quartz-sulphide vein cutting a Moyie sill. The vein selvage has a chlorite-albite alteration. The sheared and brecciated quartz vein is 30 cm wide, strikes 222° and dips 72°. It is cut by small chlorite-muscovite veins. The mineralization is composed of galena pods and rare pyrite in a gangue of quartz. The quartz gangue and the sulphide mineralogy suggest a Mesozoic age (Fig. 2).

Estella (B.C. MINFILE No. 082GNW008)

The Estella deposit is a Ag-Pb-Zn vein hosted by clastic rocks of the lower unit of the Aldridge Formation. The old workings show two types of veins. Type 1 are vein samples collected in the mine dump, and show sheared, massive sphalerite, galena, pyrrhotite, and pyrite containing fragments of quartz (Fig. 3c) . The contact with the host rock is silicified and cut by a stockwork of quartz and galena (Fig. 3c). Type 1 veins are interpreted to be Proterozoic based on the abundance of galena and sphalerite and the Pb-isotope composition of 16.39–16.66 for $^{206}Pb/^{204}Pb$ and 15.44–15.63 for $^{207}Pb/^{204}Pb$ (LeCouteur, 1973; Godwin et al., 1988). Type 2 veins are quartz-galena-pyrite veins striking 360° and dipping 25° that cut the Aldridge Formation and the Mesozoic Estella syenite stock. The mineralogy and crosscutting relation with the Estella stock (Fig. 3d) suggest a Mesozoic age for type 2 veins (Table 1).

Fisher (B.C. MINFILE No. 082GNW022)

The Fisher deposit (Fig. 1; showing is listed as Midas in MINFILE) is hosted by dolostone of the Creston Formation. Boulders show coarse-grained quartz veins in sharp contact with the host rock and local replacement of dolostone by coarse-grained, white sparry dolomite. The quartz veins contain pods of massive galena with minor pyrite. Presence of galena in a quartz gangue suggests a Mesozoic age (Table 1).

Hot Punch (B.C. MINFILE No. 082KSE034)

The Hot Punch deposit is a quartz-sulphide vein crosscutting sheared siltstone and dolomite of the Mount Nelson Formation (Fig. 1). The host rocks and the vein show pyrite cubes up to 1 cm. Two types of veins are described: quartz-pyrite with minor chalcopyrite and galena in a quartz gangue, and galena with sphalerite and pyrite in a gangue of dolomite and quartz (Fig. 3e) representative of a replacement-type deposit. The quartz-pyrite veins are cut by the galena-quartz veins (Fig. 3f). The mineralogy of the veins and replacement suggests a Mesozoic age.

Kootenay King (B.C. MINFILE No. 082GNW009)

The Kootenay King is a SEDEX deposit hosted by siltstone and sandstone of the middle Aldridge Formation unit (Fig. 1). It is a concordant, massive, and bedded galena-pyrite lens (Fig. 3g). A stockwork of narrow quartz veins cuts the sulphide lens and silicify the host rocks. The stratiform mineralization suggests a Proterozoic age (Fig. 2).

Midway (B.C. MINFILE No. 082GSW021)

The Midway deposit (Fig. 1) is hosted in the middle unit of the Aldridge Formation. The deposit consists of quartz-sulphide veins with width ranging from hairline to over 2 m. The vein sampled is 1.5 m in width, strikes 315°, and dips 41°. It is composed of brecciated quartz fragments cemented by galena and tetrahedrite (Fig. 3h) and massive quartz cut by tetrahedrite and galena stringers. On the basis of its mineralogy and Pb-isotope composition of 17.94 for $^{206}Pb/^{204}Pb$ and 15.56 for $^{207}Pb/^{204}Pb$ (LeCouteur, 1973; Godwin et al., 1988), this deposit is classified as a Mesozoic vein (Table 1).

Mineral King (B.C. MINFILE No. 082KSE001)

The Mineral King deposit was one of the larger producers in the Purcell Basin (2.1 Mt production). Three types of mineralization are found in the mine dumps: stringers of galena-sphalerite-pyrite in fine-grained dolostone of the Mount Nelson Formation; massive and coarse-grained galena and barite in white crystalline dolostone; and banded galena-sphalerite in altered dolostone of the Mount Nelson Formation. The mineralogy of the deposit suggests a Mesozoic age (Table 1).

Paradise (B.C. MINFILE No. 082KSE029)

The Paradise deposit is hosted within the upper dolomite member of the Mount Nelson Formation. Pope (1990) described the Paradise mine as a series of replacement mantos near the upper contact of dolomite with the overlying sandstone of the Toby Formation; however, the mineralization that was sampled for this study consists of a subvertical, fracture-controlled quartz-carbonate-sulphide vein striking 300° and extending over 1 km. From the centre to the selvage of the vein it consists of massive galena-cerussite-sphalerite-pyrite, to massive quartz, and finally brecciated dolostone cemented by quartz (Fig. 3i). The ore and gangue mineralogy suggests a Mesozoic age (Fig. 2).

Ptarmigan (B.C. MINFILE No. 082KSE030)

The Ptarmigan deposit is hosted by dolostone, silicified siltstone, and quartzite of the Mount Nelson Formation (Fig. 1). According to Pope (1990), the Ptarmigan deposit occurs within a fault zone that downthrows the Windermere Supergroup to the east against the Mount Nelson Formation in the footwall.

Two types of mineralization are documented. The first is a massive pyrite replacement body containing rafts of black chert (Pope, 1990) and cut by vertical quartz veins (Fig. 3j). The replacement body is located at the hinge of an anticlinal structure. The second type is sulphide mineralization controlled by a 1 cm to 30 cm wide fault zone with quartzite in the footwall and dolostone in the hanging wall. The faults contain three types of veins: pyrite-sphalerite-quartz veins, sphalerite-tetrahedrite veinlets, and pyrite-quartz veinlets. From crosscutting relationships, the sphalerite-tetrahedrite veins are older than the quartz-pyrite veins. The mineralogy of the veins indicates a Mesozoic age (Fig. 2).

Rice (B.C. MINFILE No. 082FNE055)

The Rice deposit consists of a quartz-sulphide vein hosted by argillaceous quartzite of the Creston Formation (Fig. 1). Mineralized samples from mine dumps comprise disseminated galena and pyrite in a quartz gangue. Malachite and azurite suggest tetrahedrite in the samples. The mineralogy of this deposit suggests a Mesozoic age (Table 1).

Shorty Creek (B.C. MINFILE No. 082GNE057)

The Shorty Creek showing consist of two types of veins: narrow quartz veins (1 cm) with disseminated pyrite, and thick quartz veins with sphalerite and minor galena. The quartz, pyrite, and galena mineralogy suggest a Mesozoic age (Fig. 2).

Star (B.C. MINFILE No. 082FSE002)

The Star deposit consists of a quartz vein cut by stringers of galena-sphalerite-chalcopyrite-pyrrhotite, and a brecciated quartz vein with massive pods of galena-sphalerite-chalcopyrite-pyrrhotite-pyrite hosted by mudstone of the Aldridge Formation. The mineralogy of the vein suggest a Proterozoic age (Fig. 2).

Victor (B.C. MINFILE No. 082GNW004)

The Victor deposit (Fig. 1) comprises two adits driven along a vein system striking 295° and dipping at 55°, hosted by the Creston Formation. The veins are less than 1 m wide and extend over a distance of 30 m. The veins are composed of coarse quartz and galena pods. Malachite and azurite alteration suggests tetrahedrite with galena. The mineral composition and abundance of quartz suggests a Mesozoic age (Table 1).

Vine (B.C. MINFILE No. 082GSW050)

The Vine deposit (Fig. 1) is a 2 m thick vein striking 125° and dipping 77° that extends over 1 km in strike length and parallels northwest-trending faults. The massive sulphide vein (Fig. 3k) is hosted by grey siltstone of the middle Aldridge Formation unit. The vein is sheared and composed of galena, pyrrhotite, sphalerite, pyrite, and quartz fragments (Fig. 3l). Drill cores show that a stratiform massive pyrrhotite body, interpreted to be a syngenetic SEDEX sulphide lens, is cut by the Vine Pb-Zn vein system, which also cuts a Moyie sill. A cross-section shows that the vein is cut by a late calcite-galena vein (Höy et al., 2000). The vein mineralogy suggests a Proterozoic age for the massive sulphide vein.

Virginia (B.C. MINFILE No. 082FSE041)

The Virginia deposit consists of a sheared massive quartz vein (80 cm) striking 154°, dipping 57°, and extending over 20 m (Fig. 1). The Virginia deposit is hosted by the upper unit of the Aldridge Formation. The vein is composed of massive quartz with pods of galena and tetrahedrite at the centre of the vein. The mineralogy suggests a Mesozoic age (Fig. 2).

Vein classification

Based on $^{40}Ar/^{39}Ar$ age spectra and Pb-isotope results, the Ag-Pb-Zn veins of Coeur d'Alene district are divided in two types: Pb-Zn Proterozoic veins, and Ag-Pb-Zn Mesozoic veins (Leach et al., 1998). The Proterozoic Pb-Zn veins formed during a regional metamorphic hydrothermal event around 1 Ga (Leach et al., 1998), whereas the Cretaceous to Tertiary Ag-Pb-Zn veins formed during a hydrothermal at event around 115 Ma (Leach et al., 1998).

The Ag-Pb-Zn veins in rocks of the Purcell Supergroup are classified in two types Proterozoic and Mesozoic (Table 1). This preliminary classification is based on mineralogy and Pb-isotope composition (LeCouteur, 1973). Proterozoic Pb-Zn rich veins are characterized by a longer striking length (about 1 km). They consist of massive, fine-grained, and sheared galena-sphalerite-pyrite (±pyrrhotite) in brecciated quartz and calcite gangue. Proterozoic veins are only found in the lower part of the Purcell Supergroup, i.e. in the lower and middle units of the Aldridge Formation, a stratigraphic interval that also hosts SEDEX deposits (Fig. 2). Mesozoic Ag-Pb-Zn veins have a shorter strike length (about 200 m) than the Proterozoic veins. They are composed of coarse, brecciated to sheared quartz with rare calcite and dolomite gangue and pods, stringers, and stockworks of galena-tetrahedrite-sphalerite-pyrite and rare native gold. The Mesozoic veins can be divided in two subtypes: quartz-sulphide veins, and quartz-carbonate-sulphide replacement in dolostone.

CONCLUSION

Rocks of the Purcell Basin (Belt Basin) contain two types of Ag-Pb-Zn veins based on their mineralogy and isotopic Pb composition (LeCouteur, 1973; Leach et al., 1998). Proterozoic Pb-Zn veins of both the Purcell Basin and the Coeur d'Alène district of the Belt Basin have similar mineralogy consisting of sphalerite, galena, pyrite, and pyrrhotite. Mesozoic Ag-Pb-Zn veins in the Purcell Supergroup and the Coeur d'Alène district both comprise galena, tetrahedrite, chalcopyrite, and pyrite, but the Coeur d'Alène veins are characterized by a gangue of siderite compared to quartz for the British Columbia veins.

ACKNOWLEDGMENTS

The Geological Survey of Canada's Targeted Geoscientific Initiative (TGI-3) and NSERC Discovery Grant to Georges Beaudoin funded this research. The authors thank Dave Grieves (British Columbia Geological Survey) as well as prospectors Mr. Javorsky and Mr. Kennedy, and geologists Dave Pighin, Paul Ramson, and Trygve Höy for useful help in the field and fruitful discussions.

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