

The SEEK Project: Stimulating Exploration in the East Kootenays, Southeastern British Columbia (Parts of NTS 082F, G, J, K)

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Hartlaub, R.P. (2013): The SEEK Project: Stimulating Exploration in the East Kootenays, southeastern British Columbia (parts of NTS 082F, G, J, K); in Geoscience BC Summary of Activities 2012, Geoscience BC, Report 2013-1, p.119-124.

Introduction

Geoscience BC, in partnership with the East Kootenay Chamber of Mines (EKCM), announced the launch of the SEEK (Stimulating Exploration in the East Kootenays) Project in November 2011. The goal of the SEEK Project is to increase economic activity related to mineral exploration in the Purcell Basin by acquiring, compiling and adding value to public and private sector mineral exploration information. The East Kootenay area in southeastern British Columbia has a long and successful history of mineral exploration and mining. The former Sullivan mine alone represented \$43 billion of production and sustained the economy of Kimberley and the East Kootenay area for almost 100 years.

A working group, composed of EKCM members and Geoscience BC staff, identified several main project activities, within the larger SEEK Project, focusing on the Purcell Basin (known as the Belt Basin in the United States; Figure 1). The first activity aims to categorize and add value to existing discoveries. This includes compiling the knowledge of local prospectors and exploration geologists, identifying high-interest mineral occurrences, and adding geological information that is not presently in the public record. A second activity focuses on the acquisition and dissemination of high value, historical, private sector, mineral exploration information, such as maps, core and core logs, and geochemical databases. To this end, Geoscience BC contributed funding to help support the development of a new EKCM core library. A third activity includes the acquisition, compilation and dissemination of public and private geophysical data. The final activity is the promotion of the mineral potential of the East Kootenay area. In particular, there is a need to highlight the key deposit types in the region and link up with current mineral exploration knowledge from the American side of the border. This paper reviews the geology and mineral potential of the East

Keywords: Purcell Basin, East Kootenay, SEDEX, Sullivan, Aldridge Formation, sediment-hosted copper, core library, MINFILE, geophysics, gravity

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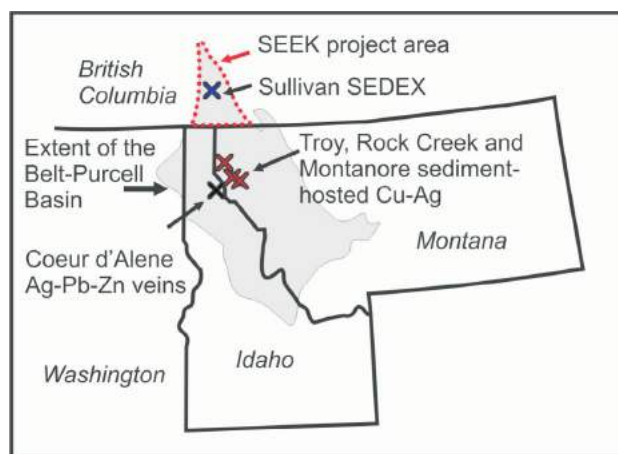


Figure 1. Approximate extent of the exposed Belt-Purcell Basin in British Columbia, Montana, Idaho and Washington (Purcell Basin in Canada and the Belt Basin in the United States). The locations of major mining areas discussed in the text are also included. Abbreviations: SEDEX, sedimentary exhalative; SEEK, Stimulating Exploration in the East Kootenays.

Kootenay area and highlights some results from the first year of the SEEK Project.

Regional Geology of the Purcell Basin

The seminal report by Höy (1993) provides a structural and stratigraphic framework for the Purcell Basin in southeastern BC. The oldest rocks of the Purcell Supergroup are exposed along the core and western margin of a north-northeast-trending large-scale anticlinorium. Regional compression during the Jurassic–Early Cretaceous and again during the Late Cretaceous–Paleocene transported the basin to the east and northeast (Price and Sears, 2000). The base of the Canadian portion of the basin, south and east of Cranbrook, contains ‘rift-fill’ turbidite rocks up to 12 km thick (Lydon, 2007). These turbidites make up the Aldridge Formation in Canada and the Prichard Formation in the United States. These turbidites are cut by the Moyie sills, a voluminous series of mafic intrusive rocks. These mafic magmas are believed to be syndepositional to the Aldridge Formation, and have a U-Pb crystallization age of 1468 ± 2 Ma (Anderson and Davis, 1995).

Overlying the Aldridge Formation, the Creston Formation (Ravalli Group in the United States) represents the begin-

ning of the upper shallow-water ‘rift-cover’ sequence. The Kitchener Formation is a distinctive horizon of carbonate rocks, which include oolitic limestone and dolomitic siltstone (Höy, 1993), and has been correlated with the Wallace, Empire and Helena formations in the United States (Winston, 1986). A recent study by Gardner and Johnston (2007) refined the stratigraphy of the upper Purcell Supergroup, those rocks lying above the Kitchener Formation. Maroon to green siltstone and argillite of the Van Creek Formation predates eruption of flood basalts of the Nicol Creek Formation, which have been indirectly dated at 1443 ± 7 Ma (Evans et al., 2000). An erosional unconformity locally separates the Nicol Creek Formation from overlying coarse clastic and stromatolitic carbonate rocks of the Sheppard Formation. The Sheppard Formation is, in turn, overlain in the northern Purcell Basin by shallow-water, fine-grained clastic rocks of the Dutch Creek, Gateway, Phillips and Roosville formations (Gardner and Johnston, 2007).

Metallogeny and Mineral Potential of Belt-Purcell Basin

The East Kootenays have a rich exploration history that is centred on the world class Sullivan Pb-Zn sedimentary exhalative (SEDEX) deposit (Figure 1). The Sullivan mine operated for nearly 100 years and exploration in the East Kootenay area has generally focused on discovering another SEDEX deposit in equivalent rocks. Whereas SEDEX mineralization remains an attractive exploration target, precious metal veins, sediment-hosted Cu and intrusion related porphyry or iron oxide copper gold (IOCG)-type deposits have recently gained more attention.

SEDEX Zn-Pb

The ‘rift-fill’ rocks of the Aldridge Formation host the Sullivan SEDEX Zn-Pb deposit and readers are directed to the wealth of information available on the subject (e.g., Lydon, 2000). The SEDEX deposit formed by deposition of sulphides on, or just below, the sea floor from hydrothermal fluids that were $>250^{\circ}\text{C}$ (Lydon, 2007). Tourmalinites and fragmental sedimentary bodies within the Aldridge Formation (Prichard Formation in the United States) are believed to represent the conduits and eruption breccias of mud volcanoes (Anderson and Höy, 2000). A study of BC MINFILE (BC Geological Survey, 2012) entries for strata of the Purcell Basin indicates that the Aldridge Formation has the largest number of showings, prospects and developed prospects. This is clearly related to the high mineral potential of these rocks and the clear focus on SEDEX mineral exploration. In 2012, an active SEDEX drill exploration program was carried out on the Findlay property through a MMG Limited joint venture with Eagle Plains Resources Ltd.

Precious Metal Veins (Ag-Pb-Zn and Au)

The largest economic concentration of Ag-Pb-Zn vein systems in the Belt-Purcell Basin lie within the Coeur d’Alene Mining District in Idaho (Figure 1). Mineralization is found as galena-sphalerite-tetrahedrite with variable amounts of quartz, carbonate, barite and/or iron oxides. In the Coeur d’Alene Mining District, Pb-Zn-rich veins formed during the Proterozoic, but the economically more important Ag-rich veins formed during the Cretaceous (Fleck et al., 2002). In BC, Pb-Zn-rich veins are Proterozoic and occur within the Aldridge Formation, and Ag-rich veins are Mesozoic and cut all units of the Purcell Basin (Paiement et al., 2007). The St. Eugene deposit is the largest known Ag-Pb-Zn vein deposit on the Canadian side of the border (Joncas and Beaudoin, 2002). The discovery of boulders with massive sulphide galena during a field trip south of Cranbrook in 2012 is a testament to the potential for additional discoveries (Figure 2). In addition to Ag-Pb-Zn, numerous vein- and sediment-hosted Au occurrences also lie within the East Kootenay area. Recent exploration has focused on the ‘Kimberly gold trend’ near Cranbrook. Notable occurrences west of Cranbrook include the Zinger, Eddy and Dewdney trail properties of PJX Resources Inc. Major Pb-Zn, Ag-Pb-Zn and Au trends in the Purcell Basin are thought to be inherited from original Precambrian basement structures (McMechan, 2012).

Sediment-Hosted Cu Mineralization

The siliciclastic sedimentary rocks of the Belt-Purcell Basin were deposited in a relatively rapid period (Evans et al., 2000) leading to the formation of numerous sediment-hosted stratabound Cu-Ag occurrences in the quartzite-dominated Revett Formation (Creston Formation in BC; Hayes and Einaudi, 1986; Boleneus et al., 2005). These deposits, including the Troy, Rock Creek and Montanore, are all located in western Montana (Figure 1); however, evi-



Figure 2. A boulder of massive sulphide galena newly discovered in 2012 at the Spikes Great Adventure property, south of Cranbrook, British Columbia.

dence for sediment-hosted Cu mineralization has recently been identified in southeastern BC (Hartlaub, 2009; Hartlaub et al., 2011). Deposits in the Revett Formation can be viewed as their own subtype since the known deposits are hosted in quartz-rich sandstone. Unlike the redbed deposits, however, a reductant in the form of pyritic sandbodies, or possibly hydrocarbon fluids, is believed to have localized Cu and Ag mineralization (Boleneus et al., 2005; T. Hayes, pers. comm., 2008).

Intrusion-Related Mineral Occurrences

The Butte area of southwestern Montana is a major Cretaceous porphyry-epithermal-style polymetallic Cu district within the Belt-Purcell Basin. Cretaceous intrusions on the Canadian side of the border include the Reade Lake and Kiakho stocks (Höy, 1993), but significant porphyry-style mineralization has not been identified in this area. Cretaceous alkaline K-feldspar porphyritic plutons, termed the Howell Creek suite, occur along the eastern side of the Belt-Purcell Basin. These small hypabyssal and intrusive bodies are associated with low-grade, disseminated Au mineralization (Barnes, 2002). A 105.0 ± 2.5 Ma K-feldspar porphyritic syenite associated with polymetallic sediment-hosted mineralization occurs at Sheep Mountain, just west of Cranbrook (Hartlaub et al., 2011).

A significant number of Cu-polymetallic occurrences associated with mafic sills and dikes are found within the Cranbrook area. A large proportion of these showings occur where Moyie sills cut the middle Aldridge Formation. The Moyie sills have been interpreted to be roughly syndepositional, with crystallization occurring prior to lithification of the surrounding sediments (Höy, 1993). Although the Moyie sills are a voluminous component of the Aldridge Formation, there are a significant number of mafic sills and dikes that cut the Creston, Kitchener and Van Creek formations. These dikes have been postulated to be feeders to flood basalts of the Nicol Creek Formation. The King occurrence, located 8 km north of Cranbrook, is of particular interest. At this site, a number of roughly northeast-striking gabbroic intrusions cut carbonaceous fine-grained clastic rocks of the Kitchener Formation.

IOCG

Iron oxide breccia in the Iron Range, north of Creston, has been identified as a probable host of IOCG-type mineralization in the Belt-Purcell Basin (Galicki et al., 2012). Hematite-magnetite±chalcopyrite mineralization occurs along the Proterozoic Iron Range fault within the Aldridge Formation. In 2009, Eagle Plains Resources Ltd. reported a 7 m intercept grading 51.5 g/t (1.5 oz/ton) Au from the area (Eagle Plains Resources Ltd., 2009). Paleomagnetic age data support a possible linkage (Galicki et al., 2012) to intrusion-related mineralization of the mid-Cretaceous Bayonne plutonic suite (Logan, 2002).

The Idaho cobalt belt in southern Idaho has also been interpreted as possible IOCG-type mineralization based on the occurrence of high rare earth element (REE) and Y concentrations (Slack, 2006), although this belt has also been interpreted as an exhalative horizon (Nold, 1990). This belt is at least 64 km long and up to 10 km wide, centred on the Blackbird mine. In the Blackbird Mining District of Idaho, Co-Cu-Au deposits occur within banded siltite of the Mesoproterozoic Apple Creek Formation (Slack, 2006). At least 18 Co-Cu-Au deposits in this area are associated with metamorphosed mafic tuffs or volcanoclastic rocks, and typically occur within tourmaline-bearing chemical sediments (Nash and Hahn, 1989).

SEEK Project Activities and Deliverables 2011–2012

SEEK Project activities in 2011–2012 included

- providing support towards the establishment of a new EKCM core library,
- re-examining the MINFILE database and methods of collecting historical geoscience data, and
- completion of a ground geophysical gravity data compilation for the East Kootenay area.

The EKCM core library is being developed to archive a selection of historically important core from the region. The initial focus of this library is to collect, restore and catalogue core from the Sullivan SEDEX deposit and surrounding area. The contents of this library will be made available to individuals, companies and research institutions. Those engaging in mineral exploration in the area will be able to examine type sections of both mineralized and nonmineralized strata of the Purcell Basin (Figures 3, 4). Additional work will aim to maximize the effectiveness of this library by better identifying and documenting the location, orientation, quality and geological features of important core samples.



Figure 3. Core from the Sullivan deposit that will be organized and moved to the new East Kootenay Chamber of Mines core storage facility, southeastern British Columbia.



Figure 4. View of the new East Kootenay Chamber of Mines core storage facility, southeastern British Columbia. Core from the Sullivan Deeps and Vulcan projects have already been moved to the site. Older Sullivan deposit core boxes will require much more painstaking work to ensure the integrity and proper organization of the core prior to transport.

One of the key priorities of the SEEK Project is to compile the knowledge of local prospectors and exploration geologists, and identify high-interest mineral occurrences. An initial meeting with the BC Geological Survey (BCGS) was organized to discuss how to update the MINFILE database for the Purcell Basin. The SEEK Project team has decided to work with the BCGS and EKCM to publicize and help facilitate updates to the MINFILE Mineral Inventory for the East Kootenay area. In 2013, individuals and companies who are currently working in the East Kootenay area will be called upon to contribute to this project.

Compilation of historical geophysical data may prove to be one of the most challenging aspects of the SEEK Project. Ground geophysical gravity data has been demonstrated to be an excellent tool for the targeting of a variety of mineral deposit types. A project led by T. Sanders is focused on bringing together all of the existing ground gravity information into a single database. To do this, data from more than 2800 unique ground gravity stations are being compiled and reprocessed. This includes data from more than 25 publicly available assessment reports from the East Kootenay area, as well as pre-existing Geological Survey of Canada data. The database is designed so that future datasets can easily be added. The database, and a report detailing processing methods, was released on the Geoscience BC website in late 2012. A proposal to add new ground gravity survey stations to this database has been presented to Geoscience BC and is under consideration.

Acknowledgments

All funding for the SEEK Project has been provided by Geoscience BC. C. Kennedy and S. Kennedy are thanked for organizing an East Kootenay field trip. Constructive

and timely reviews of this paper were provided by R. Tafti and C. Sluggett.

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