Diverse Base and Precious Metal Mineralization of the Mesoproterozoic Purcell Supergroup and Recurrent Magmatism in Southwestern Alberta

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Summary

This paper focuses on the distinct types of metallic mineralization within the Mesoproterozoic Purcell Supergroup in the Clark Range of southwestern Alberta. The numerous sedimentary- and igneous rock-hosted Cu-Ag, Pb-Zn-Cu and Au-Ag occurrences mark two major metallogenic events in southwestern Alberta: 1) Mesoproterozoic intracontinental rifting, mafic magmatism and hydrothermal convection, probably caused by the mantle plume, and 2) Cretaceous-Tertiary Laramide tectonics and igneous activity. The preliminary results of the field studies and new geochemical analyses by the Alberta Geological Survey will be discussed.

Introduction

Several world-class base and precious metal deposits exist in the Mesoproterozoic (1.50 – 1.32 Ga) Belt-Purcell basin of western North America (e.g., Sullivan and St. Eugene Pb-Zn-Ag-Au past-producers in British Columbia; Coeur d'Alene Ag-Pb and Blackbird Cu-Co mining districts in Idaho; Butte Cu-Ag-Au-Mo, Sheep Creek Cu-Co and Montanore Cu-Ag deposits in Montana) (Lydon, 2007). Since the first description by G.M. Dawson in 1886, numerous sediment- and igneous rock-hosted Cu-Ag, Pb-Zn-Cu and Au-Ag showings have been explored and partially developed within the Purcell Supergroup in the Clark Range of southwestern Alberta (Fig. 1). Although potentially economic mineralization was found, little work was performed in the area since the late 1970s. During 2008 and 2009, Alberta Geological Survey (AGS) studied some of these metallic showings in the field to better characterize the mineralization and its relation to synsedimentary rifting and magmatic activity. In addition to the laboratory geochemical analyses of rock samples, a portable Niton® XL3t 900SHe XRF analyzer from Thermo Scientific® was used for *in-situ* detection of metal concentrations. Here I present the preliminary results.

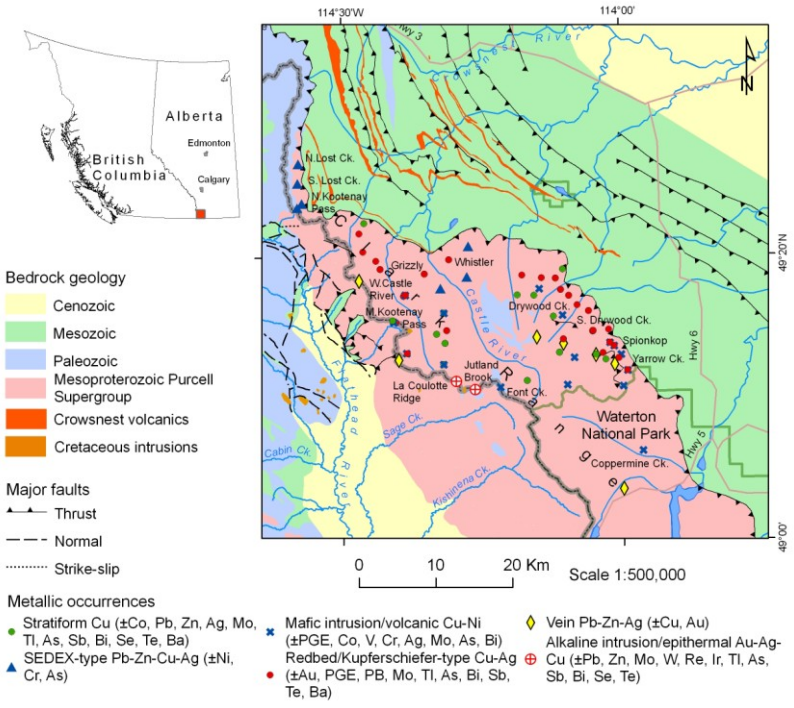

Figure 1. Simplified geological map and distribution of metallic occurrences in the Clark Range of southwestern Alberta.

Geological setting of the Purcell basin

The Purcell strata of the Canadian Cordillera comprise marine turbidites deposited in the intracontinental rift in the west and stratigraphically equivalent shallow-water carbonates and clastic rocks of the surrounding rift platform in the east, overlain by shallow-marine and nonmarine mud flat, lagoonal, lacustrine and fluvial sediments of a rift-cover sequence. The Purcell basin, nonconformably underlain by the 2.60 – 1.78 Ga crystalline basement and unconformably overlain by the Neoproterozoic Windermere rift-to-drift transition (770 - 570 Ma) strata, or by the Lower-Middle Cambrian or Devonian passive margin strata, has been imbricated and transported northeastward by Middle Jurassic to Eocene tectonism (Ross et al., 1989).

Magmatism and mineralization

Compositionally distinct intrusions of two age groups cut the Purcell Supergroup in southwestern Alberta: 1) the Mesoproterozoic ferrotholeiitic olivine-augite gabbro and augite mugearite sills and dykes up to 25 m-thick throughout the Clark Range (Höy, 1989); and 2) the Cretaceous (ca. 99 Ma) alkali feldspar syenite and melanite-bearing, aegirine-augite trachyte, latite, tephriphonolite and analcime phonolite sills and dykes (a few metres-thick) along the continental divide in the western Clark Range (Goble et al., 1999).

The Mesoproterozoic gabbroic intrusions are similar to the “Moyie sills” in the Purcell Mountains of southeastern British Columbia, which are up to several hundred metres-thick and persist laterally for tens of kilometres, with >2 km aggregate thickness of sills intercalated with the Aldridge Formation turbidites (Höy, 1989). These intrusions were emplaced at shallow depth into wet, unconsolidated sediment during intermittent magmatic events between 1.47 - 1.43 Ga, associated with the rifting and outpouring of up to 150 m-thick, pillowed and amygdaloidal basaltic Purcell lavas (Price, 1964), and a final mafic magma upflow at about 1.38 Ga (Lydon, 2007). The geochemistry of the sills in the Clark Range suggests magma derivation by partial melting of the mantle at 30-40 km depth and similarity to modern, within-plate alkali or tholeiitic ocean-island basalts (OIB). The geochemical evidence, along with the high volume of the mafic magma (>0.05 Mkm^3) emplaced during ~25 Ma (Lydon, 2007), similar to other continental flood basalt provinces (Ernst and Bell, 2009), implies that the Purcell magmatism might have been caused by the arrival and lateral spreading of a mantle plume, as opposed to the passive-type rifting due to lithospheric tension.

The Mesoproterozoic magmatism and related rift-basin hydrothermal convection produced several types of base- and precious-metal mineralization at different stratigraphic levels within the Purcell Supergroup in the Clark Range area of southwestern Alberta (Fig. 2), including:

- copper sulphides (±Ni, PGE, Co, V, Cr, Ag, Mo, As, Bi) in Purcell lava and gabbro intrusions within clastic and carbonate sedimentary rocks of the Appekunny, Grinnell, Siyeh, Phillips and Roosville formations (e.g., Blakiston Brook mine),
- sediment-hosted, laminated, ooidal to semi-massive pyrite Cu-Co (±Pb, Zn, Ag, Mo, Tl, As, Sb, Bi, Se, Te, Ba) within the Appekunny, Siyeh and Roosville formations (e.g., Spionkop Ridge and South Drywood Creek),
- siltstone-hosted, Sedex-type Pb-Zn-Cu-Ag (±Ni, Cr, As) within the Sheppard Formation (e.g., Carbondale River prospect),
- quartz-carbonate-sulphide vein Pb-Zn-Ag (±Cu, Au) within gabbro sills (e.g. Yarrow Creek), and
- Redbed/Kupferschiefer-type Cu-Ag (±Au, PGE, Pb, Mo, Tl, As, Bi, Sb, Te, Ba) in quartz arenite cycles of the Grinnell Formation (e.g., Whistler Mountain, Spionkop and Grizzly Creek prospects), and in black argillite of the lower Siyeh Formation (e.g., South Drywood Creek).

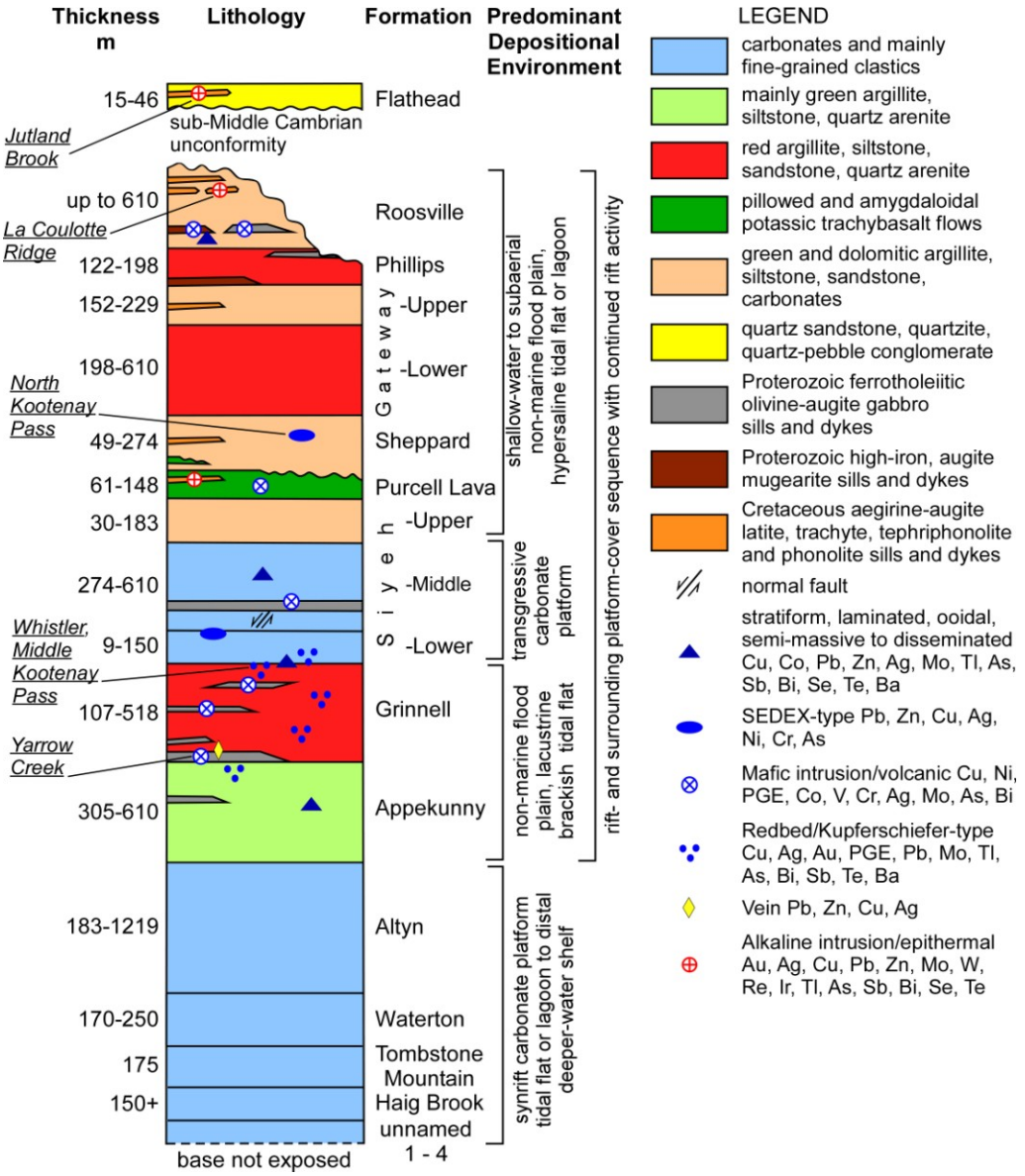

Figure 2. Generalized stratigraphy of the Mesoproterozoic Purcell Supergroup in the Clark Range of southwestern Alberta (after Price, 1964; Ross et al., 1989) with examples of metallic occurrences (not in scale).

The Cretaceous alkaline intrusions associated with the normal and tear faults in southwestern Alberta and southeastern British Columbia (“Flathead intrusions”) are compositionally similar to the coeval melanite-analcime phonolite, blairmorite and trachyte flows and domes of the Lower Cretaceous (96 Ma) Crowsnest Formation in the Crowsnest Pass area (Goble et al., 1999). The latter also includes proximal debris flows, and crystal and lithic tuff-, fallout tephra- and volcaniclastic deposits (Pearce, 1970). The Cretaceous alkaline intrusions are associated with the porphyry or epithermal Au-Ag (±Cu, Pb, Zn, Mo, W, Re, Ir, Tl, As, Sb, Bi, Se, Te) mineralization along the intrusive contacts in the upper Purcell and Middle Cambrian Flathead Formation strata (e.g., Jutland Brook and La Coulotte Ridge), marking a distinct metallogenic event during the Cretaceous-Tertiary Laramide Orogeny.

Conclusions

The diverse metallic mineralization within the Purcell Supergroup of southwestern Alberta reflects at least two distinct metallogenic intervals: 1) the accumulation of seafloor syngenetic, diagenetic and epigenetic base and precious metals related to the Mesoproterozoic intracontinental rifting and magmatism; and 2) the alkali intrusion-related or epithermal gold-silver and base metal occurrences and deposits associated with the Cretaceous-Tertiary Laramide Orogeny.

Acknowledgements

I thank A.P. Beaton, J.G. Pawlowicz, G.J. Prior and R. Mussieux for useful discussions and comments. I am also grateful to A.P. Beaton and J.G. Pawlowicz for their help with the field work in southwestern Alberta during 2008 and 2009. Bill Thresher, Forest Officer in Southern Rockies Area with Alberta Sustainable Resource Development, and Shell Canada Limited are thanked for their assistance with the road access in the Clark Range.

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