Exploration and mining in the Kootenay-Boundary Region, British Columbia

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1. Introduction

The Kootenay-Boundary Region, in the southeast corner of the province (Fig. 1), offers a variety of mining and exploration opportunities, and is accessible by well-developed infrastructure. Five operating metallurgical coal mines in the Elk Valley account for the majority of Canada's coal production, and exports. Several mines produce industrial minerals including silica, magnesite, gypsum, and graphite. The region also hosts the historic lead-zinc-silver Sullivan Mine, which contributed over $50 billion in current US dollars throughout its life, and the Trail smelter is still in operation. Exploration for both base metals and precious metals continues to be an exploration focus for the region.

In 2015, total exploration spending was similar to 2014 (Fig. 2), with about $50.8 million spent on exploration in the region. Relative to last year, spending on mine lease projects remained flat (40%), and there was an increased amount spent on mine evaluation projects (46%), as mine expansion plans moved forward in Environmental Assessment. There were fewer projects in the early (5%) and advanced (7%) exploration stages, and an increased focus on grassroots work (2%) as companies completed assessment work to maintain their claims in good standing (Fig. 4). The decrease in early and advanced stage projects is also reflected by decreased exploration drilling (approximately 92,000 m for 2015; Fig. 3).

Highlights for 2015 include:

- conditional EA approval of the Fording Swift mine expansion
- continued advances in major mine expansion plans at operating coal mines, with several projects in pre-application of Environmental Assessment, including the Elkview Baldy Ridge extension (BRE), and Line Creek Burnt Ridge extension (BRX); and the Greenhills Cougar Pit extension (CPX) nearing pre-application
- advances in new coal projects such as Crown Mountain (NWP Coal Canada Ltd.), and the Michel Creek/Loop Ridge project (CanAus Coal Limited). Both of these entered pre-application stages of Environmental Assessment in 2014 and 2015 respectively
- advancement of the Kootenay West gypsum mine (CertainTeed Gypsum Canada Inc.), which entered Environmental Assessment in 2014
- lease application for the Driftwood Magnesite magnesite project for quarry development
- submission of a project description for a restart proposal on the Gallowai Bul River mine
- further exploration and process optimization at the Black Crystal graphite mine
- plant construction at Moberly Silica to redesign operations for silica frac sand
- ongoing base metal, precious metal, and industrial mineral exploration.

2. Geological overview

The Canadian Cordillera has long been of interest to the exploration industry for the mineral resources it contains. The diverse assemblage of rocks, varied structural elements, and diversity of metallogenic styles is evidence that the western margin North America has undergone a complex history of plate-tectonic processes and terrane accretion, spanning over 1.8 billion years (Nelson et al., 2013). The Cordillera is now a tectonic collage of terranes, and offshore and basement rocks from Ancestral North America, with a complex history of deformation, intrusion, metamorphism, and mineralization.

The Kootenay-Boundary Region (Fig. 1) contains autochthonous and parautochthonous elements of ancestral North America (Laurentia) including: Archean to Mesoproterozoic basement rocks; Proterozoic rift and intracratonic basin successions (Belt-Purcell and Windermere Supergroups); Paleozoic to Jurassic passive-margin, shelf, and slope carbonate and siliciclastic successions that were deposited on the western flank of the ancient continent (Kootenay terrane, and North American platform); and Jurassic to Cretaceous foreland basin deposits. It also contains parts of the Slide Mountain terrane, which records mid- to late-Paleozoic back-arc extension that split the western flank of ancestral North America to form the Slide Mountain Ocean; and Quesnellia and its basement (Okanagan subterrane) which are entirely exotic to North America (Nelson et al., 2013). By mid-Jurassic, the emerging Canadian Cordillera had been fundamentally transformed from a set of loosely connected arc and pericratonic terranes, to a progressively thickening and

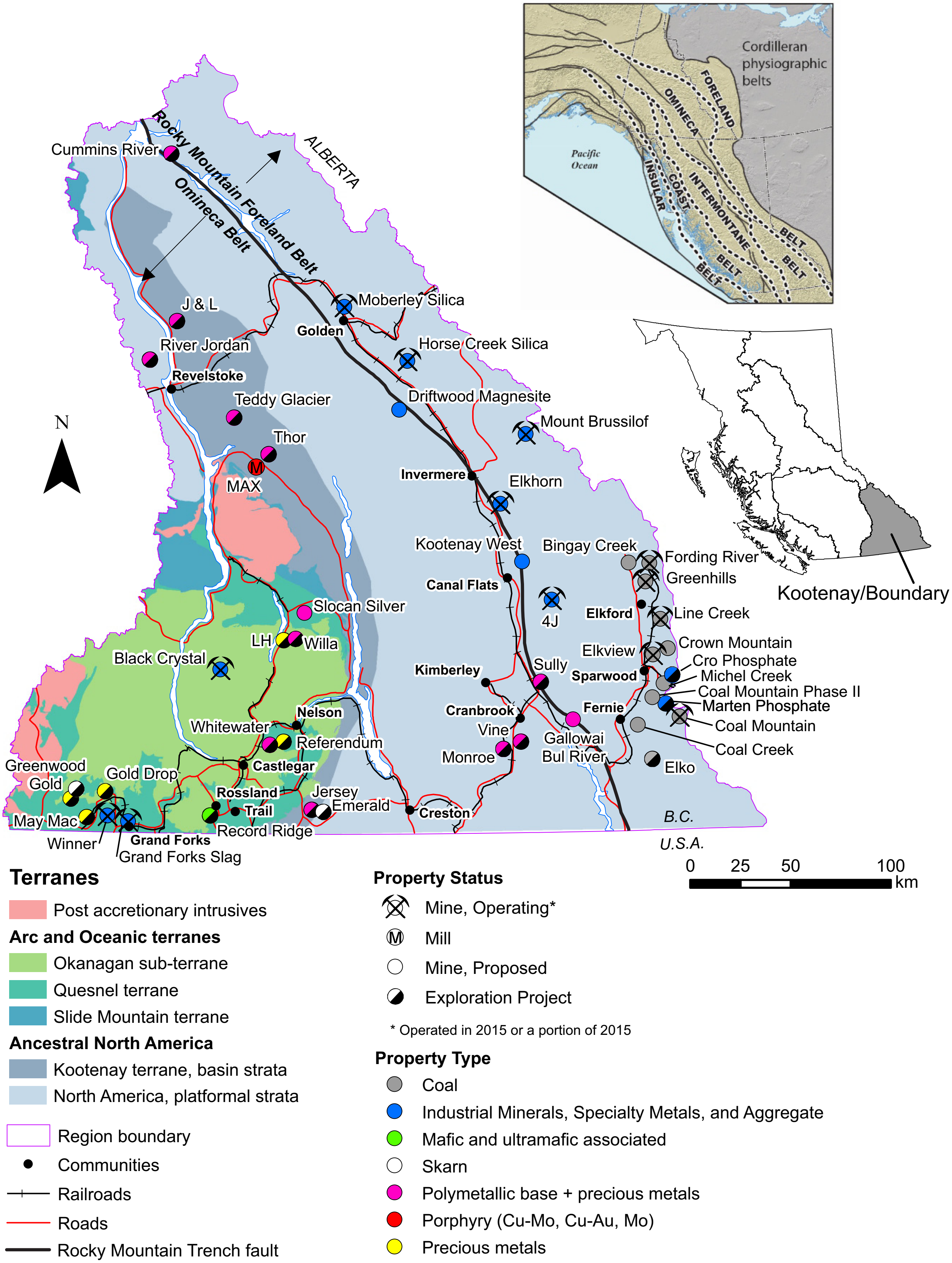

Fig. 1. Mines and selected exploration projects, Kootenay-Boundary Region, 2015. Terranes from Cui et al. (2015).

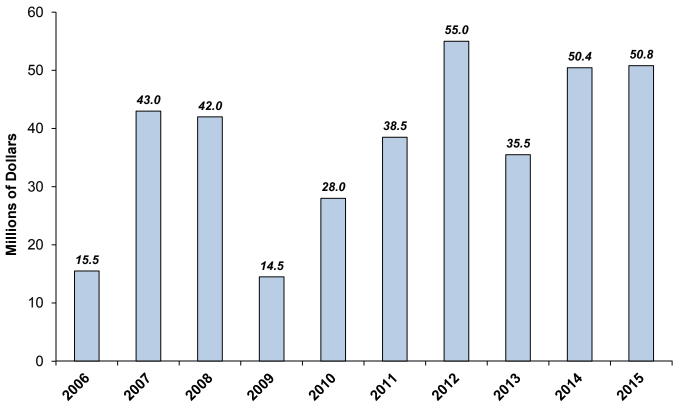

Fig. 2. Exploration spending in the Kootenay-Boundary Region, 2015.

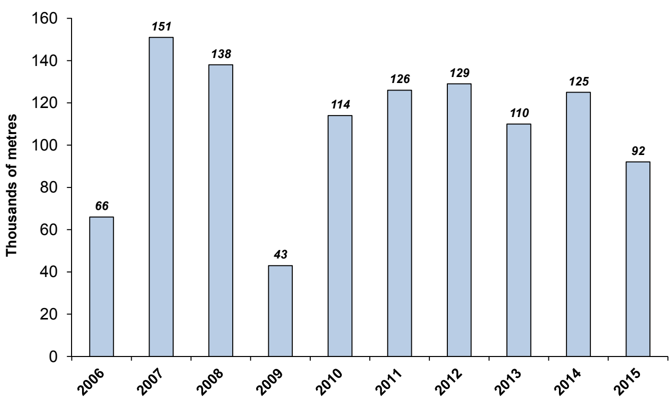

Fig. 3. Drilling in the Kootenay-Boundary Region, 2015.

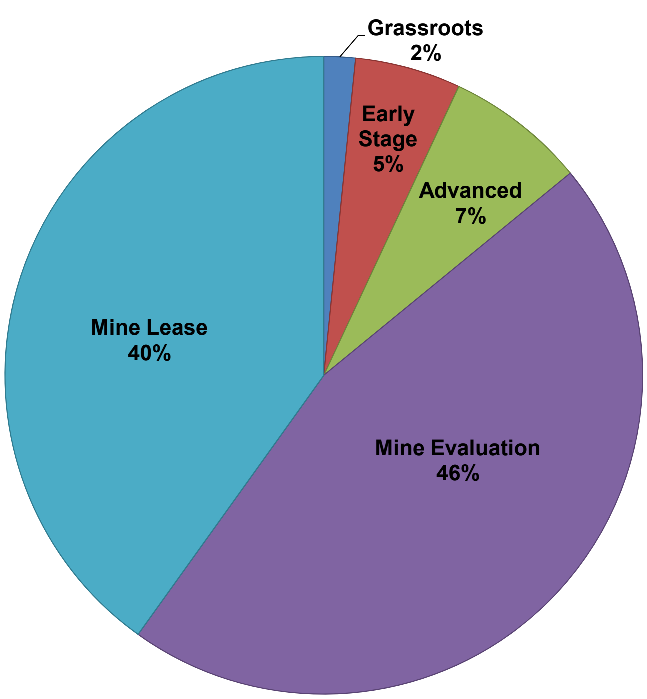

Fig. 4. Expenditures by exploration stage, Kootenay-Boundary Region, 2015.

complexly structured accretionary wedge.

Historically, the Canadian Cordillera has been divided into five northwest-trending physiographic belts. The Kootenay-Boundary Region includes two of these belts (Fig. 5): the Rocky Mountain Foreland belt, which consists mainly of unmetamorphosed sedimentary successions that were thrust northeastward in thin-skinned sheets; and the Omineca belt, which includes more deformed and higher grade (greenschist to amphibolite) siliciclastic and volcanic rocks, and basement-cored gneiss domes (Monger, 1999). The Omineca belt and the Rocky Mountain Foreland belt are separated by the southern Rocky Mountain Trench, which formed during Tertiary transtensional collapse (Monger et al., 1982; Nelson et al., 2013). The Rocky Mountain Trench fault is a normal fault on the eastern edge of the trench, with approximately 5 km of west-side down displacement.

2.1. Omineca Belt

2.1.1. Laurentian basement (ancestral North America) and Metamorphic Core Complexes

Laurentian basement rocks form the core of the North American continent and extend beneath the Cordillera west of the southern Rocky Mountain Trench. It is an assemblage of microcontinents and magmatic arcs that formed through progressive accretion from Archean to Mesoproterozoic time. The successive orogenic events that formed the basement assemblage imparted on it a structural grain, which is seen on the regional aeromagnetic map of western Canada (Fig. 6). Northeast-trending basement structures influenced both Cordilleran tectonism and metallogeny (e.g., McMechan, 2012; Nelson et al., 2013; Ross et al., 1991). For example, the Moyie-Dibble Creek (MDC) fault has been interpreted by Price (1981) and McMechan (2012) as the surface expression of the Vulcan Low (Vulcan Tectonic zone, Fig. 5; MDC, Fig. 6). Abrupt changes in thickness and facies in Proterozoic to early Paleozoic strata across northeast-trending structures along this trend suggest periodic reactivation. In the West Kootenays, the southwestward shift in trend at the south end of the Kootenay Arc also suggests a deep structural influence of the basement Vulcan Low.

Although generally deeply buried, crystalline basement is also locally exposed in structural culminations such as the Shuswap-Monashee complex (Fig. 5; MC, Fig. 6; Fig. 7). Located west of the east-dipping Columbia River fault (Fig. 5), the complex is bounded by early Tertiary normal faults, and was exhumed during Tertiary extension (Monger, 1999). Paleoproterozoic granitic and granodiorite gneisses are unconformably overlain by a Neoproterozoic to Paleozoic platformal paragneiss assemblage of calc-silicate gneiss, pelitic gneiss, psammitic gneiss, quartzite and marble. The Valhalla metamorphic complex forms a structural dome and is located at the eastern exposed edge of the Shuswap metamorphic complex. Lithologies consist of amphibolite-facies pelitic schist, marble, calc-silicate gneiss, psammitic gneiss, quartzite and metaconglomerate, amphibolite gneiss, and ultramafic

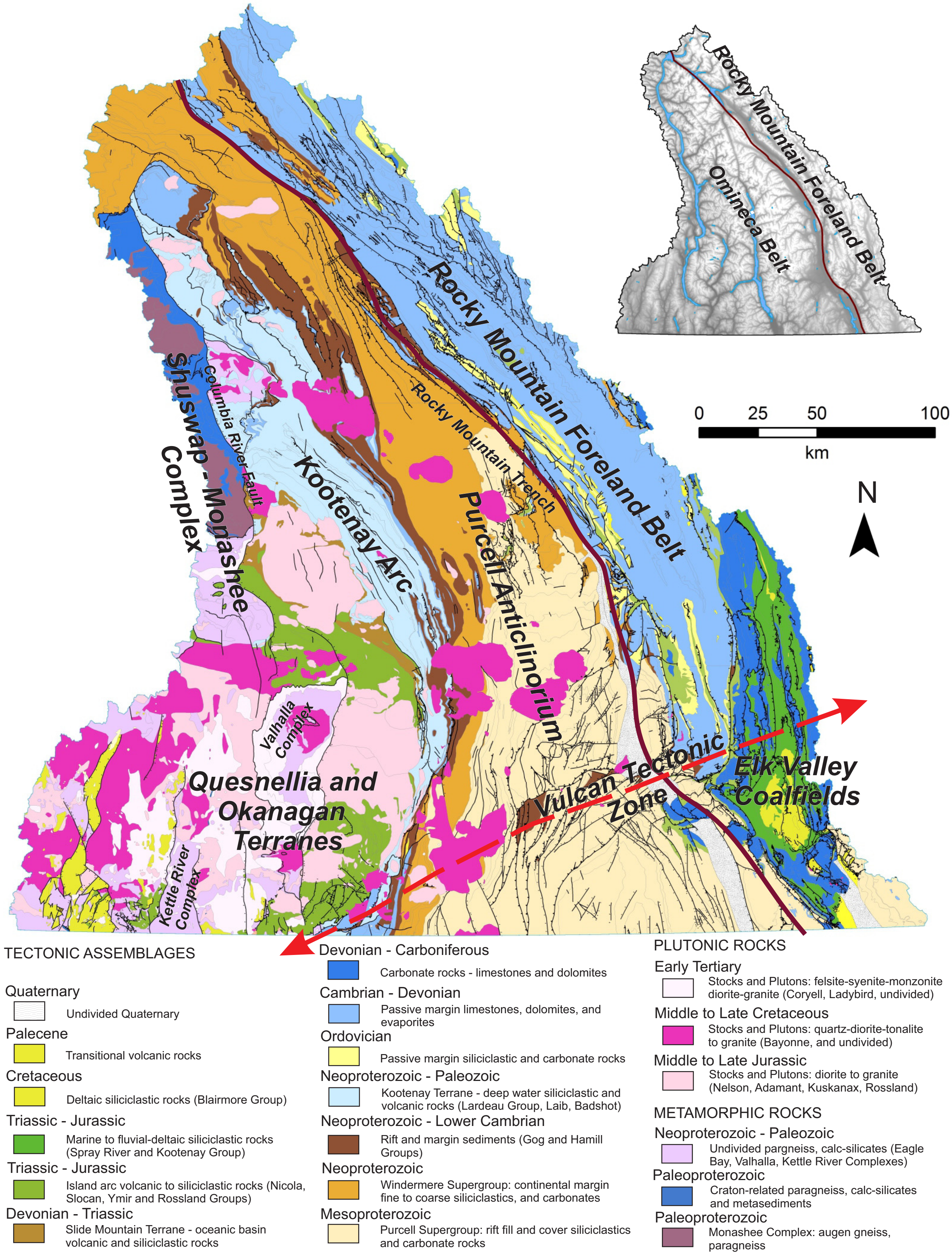

Fig. 5. Geology and physiographic belts of the Kootenay-Boundary Region. Physiographic belts after Nelson et al. (2013). Bedrock units are after Cui et al. (2013), and generalized to highlight temporal and lithological differences in the region for this report. Vulcan tectonic zone is after McMechan (2012).

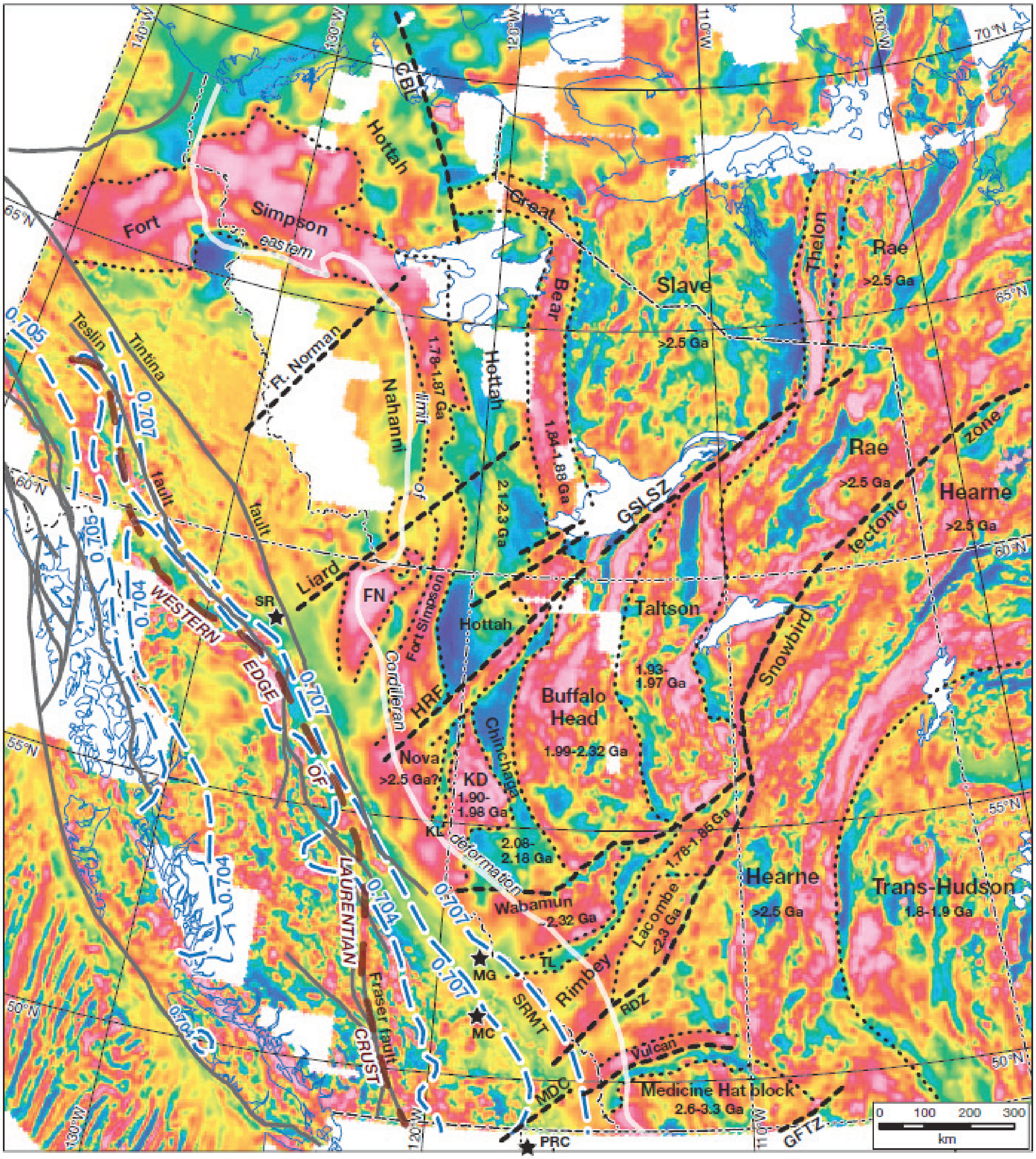

Fig. 6. Residual total field aeromagnetic map of western Canada, showing Precambrian basement domains of the western Laurentian craton with respect to the Cordilleran orogen (eastern limit of Cordilleran deformation indicated by white line). Precambrian basement domains are after Hoffman (1988), Ross et al. (1991), Villeneuve et al. (1993), Ross (2002), Hope and Eaton (2002), and Aspler et al. (2003). Aeromagnetic image is derived from a 2010 compilation in the Canadian aeromagnetic database (http://gdr.agg.nrcan.gc.ca/geodap). Precambrian domain boundaries are delineated by dotted lines; major basement structures are shown by short dashed lines. Some major structures extend beneath the Cordillera, including the Moyie-Dibble Creek fault (MDC) and related structures in the south (after McMechan, 2012), and the Liard and Fort Norman lines in the north (after Cecile et al., 1997). Stars show location of Precambrian basement exposures in the Omineca belt: MC = Monashee complex (1.86–2.10 Ga; Crowley, 1999); MG = Malton complex and Gold Creek gneiss (ca. 1.87–2.09 Ga; McDonough and Parrish, 1991; Murphy et al., 1991); PRC = Priest River complex (ca. 2.65 Ga; Doughty et al., 1998); SR = Sifton Ranges (ca. 1.85 Ga; Evenchick et al., 1984). Initial $^{87}Sr/^{86}Sr$ ratio isopleths for Mesozoic granitic rocks of the Cordillera (dashed blue lines) are after Armstrong (1988). Dashed brown line indicates inferred extent of North American crust beneath the Cordilleran orogen from geophysical, geochemical, and geological. Other abbreviations: CBL = Cape Bathurst line, FN = Fort Nelson high, GFTZ = Great Falls tectonic zone, GSLSZ = Great Slave Lake shear zone, HRF = Hay River fault, KD = Ksituan domain, KL = Kiskatinaw low (1.90–1.98 Ga), LD = Lacombe domain, RDZ = Red Deer zone, SRMT = Southern Rocky Mountain trench, TL = Thorsby low (1.91–2.38 Ga). From Nelson et al. (2013).

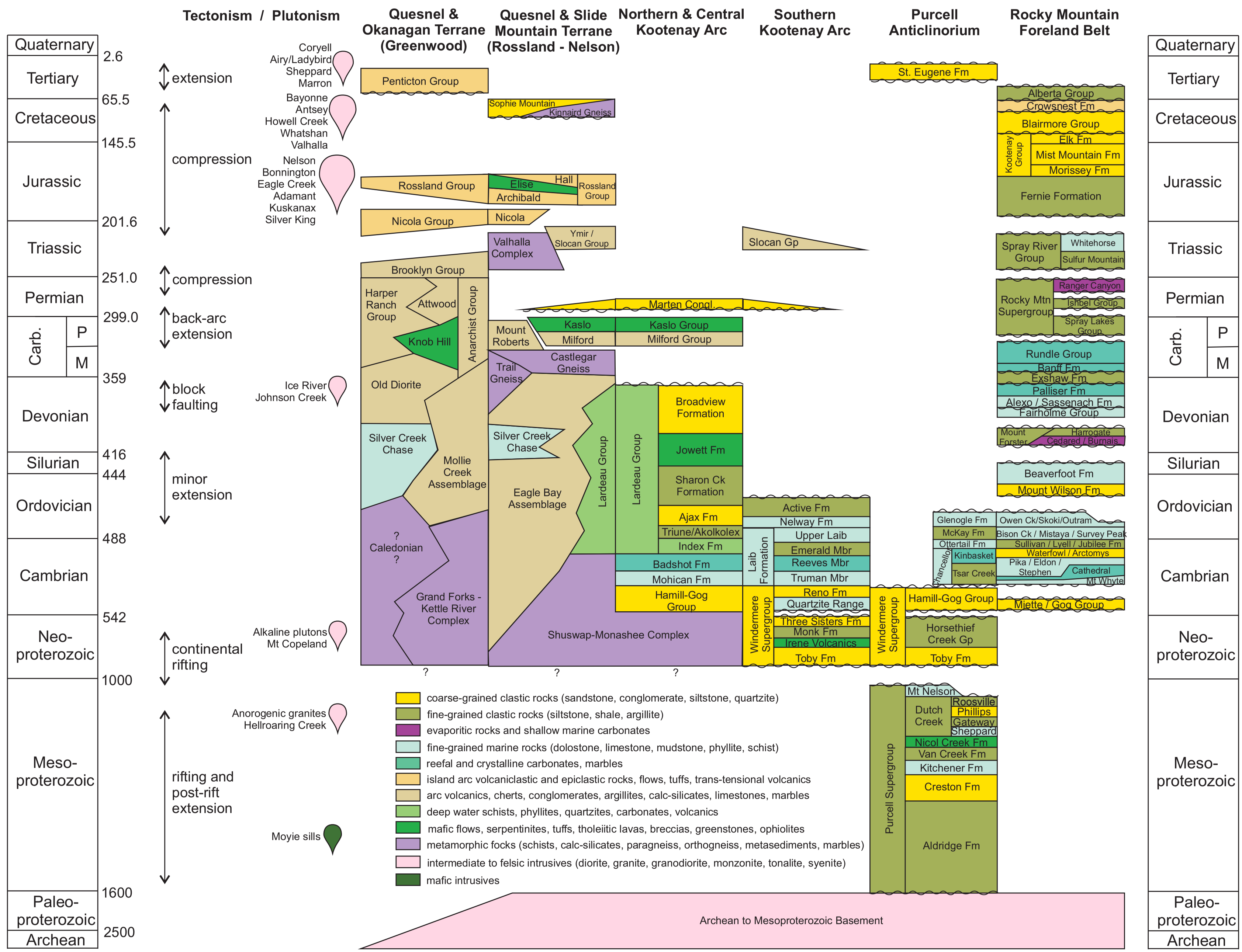

Fig. 7. Generalized stratigraphy, Kootenay-Boundary Region. Tectono-stratigraphic events modified from Nelson et al. (2013). Selected stratigraphy and approximate ages derived from Poulton et al. (2012), Hein and McMechan (2012), Colpron and Nelson (2009), Grieve (1993), Fyles (1967 and 1990), Höy et al. (1995), Logan (2002), Monger et al. (1991), Price (2012), Slind et al. (2014). Geological timescale from Waker and Geissman (compilers), (Geological Society of America; 2009).

schists, and mid-Cretaceous to Eocene igneous rocks. These paragneiss assemblages host stratabound lead-zinc deposits, including Ruddock Creek, Jordan River, and Big Ledge (Fyles, 1970; Höy, 1982b), as well as flake graphite deposits (Black Crystal).

2.1.2. Proterozoic rift successions and the Purcell Anticlinorium

Following the Hudsonian orogeny (2.0-1.8 Ga), but before the breakup of ancestral North America (780-570 Ma), sedimentary successions accumulated in the Canadian Cordillera (Nelson et al., 2013). In the Kootenay-Boundary Region, the Belt-Purcell basin (1.47-1.4 Ga) was a north-northwest trending intra-continental pericratonic rift system that extended into what are now northern Idaho and Montana, and formed at the leading edge of Ancestral North America. The 10-12 km thick rift-fill succession of the Belt-Purcell is a shallowing upwards sequence of rusty-weathering deep-water turbidites (Aldridge Formation), shallow-water platform and fan-delta deposits at the margins of the rift and surrounding shelf, and shallow-water carbonates, mud flat, lagoonal, and alluvial deposits of the rift-cover succession (Figs. 7, 8). Synsedimentary faulting during graben extension and sporadic tholeiitic to alkaline magmatism (1468 ±2 Ma) characterize the lower Belt-Purcell stratigraphic successions (i.e., Moyie sills; Lydon, 2010 and 2007).

Most exploration has focused on SEDEX Pb-Zn-Ag mineralization within the Aldridge Formation similar to that of the historic Sullivan mine at Kimberley (MINFILE 082FNE052). The mine operated from 1909 to 2001 and produced over 17.5 Mt of zinc, 18.5 Mt of lead, and 297 Moz of silver. The contact between the lower and middle Aldridge members hosts the Sullivan ore body (Fig. 8) and likely marks one period of active graben extension. Indicators of exhalative -style mineralization are distributed throughout the Belt-Purcell basin, including disseminated sphalerite and galena, tourmalinite-sericite-chlorite alteration, sections of fragmental sediments, anomalous Pb-Zn-Ag-Sn-Cu, and indicator element geochemistry. In addition to stratabound base metals, extensional tectonics also led to the development of vent and feeder pipe complexes and base metal vein deposits. Pb-Zn-Ag mineralization with characteristic tourmaline alteration is commonly localized at the intersections of north-northwest trending and northeast-trending faults, including the St Mary, Kimberley, and Moyie-Dibble Creek faults (Höy et al., 2000; McMechan, 2012; Price, 1981), and these fault intersections have been the focus of recent exploration. The upper part of the Purcell Supergroup contains carbonate-hosted, stratiform replacement-style sulphide mineralization in dolomites of the Mount Nelson Formation (Figs. 7, 8), and associated structurally related polymetallic Ag-Pb-Zn veins.

The Purcell Anticlinorium (Fig. 5) is now a shallowly northward plunging upright fold system that was formed during two early phases of deformation and metamorphism. The first phase was the East Kootenay orogeny (1350-1300 Ma; McMechan and Price, 1982), which marked the end of sedimentation in the Belt-Purcell rift basin, and involved folding, regional metamorphism, and granitic intrusion (i.e., Hellroaring Creek Stock). By the end of the Mesoproterozoic (ca. 1.0 Ga), the Precambrian supercontinent of Rodinia was assembled. Further block faulting and low-grade metamorphism of the Anticlinorium occurred during the Goat River orogeny (900-800 Ma), which produced higher grade, sillimanite-bearing rocks in the core of the anticlinorium (de Kemp et al., 2015).

The Purcell Supergroup is unconformably overlain by the Windermere Supergroup (Fig. 8) at the northern end of the north-plunging Anticlinorium, which is associated in part with rifting of Rodinia. Up to 2-3 km of strata were eroded from the uplifted Belt-Purcell succession and shed northward (Aitken, 1969; Simony and Aitken, 1990). Beginning in the Neoproterozoic, rifting of the Rodinian supercontinent occurred over an extended interval of time, in at least two main episodes (Colpron et al., 2002). The earlier phase (ca. 723-716 Ma) in southern BC resulted in the deposition of the Toby and Horsethief Creek Groups (Fig. 7). Thermal subsidence during the second phase (570-540 Ma) resulted in deposition of the Hamill-Gog Group unconformably over the Horsethief Creek Group (Nelson et al., 2013). Sediments of the Hamill-Gog Group are predominantly sandstones deposited on a subsiding continental margin at a time marked by a worldwide transgression (Vail et al., 1977). Deposition of the Windermere Supergroup may also have been locally affected by small- and large-scale structures, including the 'Windermere High', which was a northwest-trending offshore high that developed south of 53°N (Hein and McMechan, 2012). Though the Windermere Supergroup marks a major rifting episode, it hosts limited syngenetic and replacement (Irish, Mississippi Valley-type, and manto) and polymetallic vein mineralization, mainly along north-trending faults.

Deformation and uplift of the Purcell Anticlinorium and rift successions continued during the Columbian-Laramide orogeny (220-70 Ma), when imbricated thrusts faults carried up to 15 km of Belt-Purcell and Paleozoic margin sedimentary rocks eastward over a basement ramp (Fig. 9; Cook and Van der Velden, 1995). The anticlinorium is transected by steep north-northwest longitudinal faults and northeast-trending transverse faults, that were likely reactivated repeatedly over time from Proterozoic Belt-Purcell Supergroup and Windermere Supergroup sedimentation (Höy, 1982a) through the Paleozoic and Mesozoic, and into the Tertiary. Transverse structures and basement structures related to the Vulcan Tectonic Zone (Fig. 5) may also have influenced Mesozoic shear and vein gold, a trend which runs east-west through the historic gold rush town of Fort Steele (Kimberley Gold Trend; Seabrook, 2015).

Mineralization in the Proterozoic to Paleozoic rift succession include: sedimentary exhalative (SEDEX) deposits (bedded sulphide, feeder pipe, and vein); massive sulphide replacement deposits (Irish, Mississippi Valley, and manto); Mesoproterozoic intrusion and fault-related Ag-Pb-Zn and Cu-Ag veins; Mesozoic shear and vein gold, and associated placer

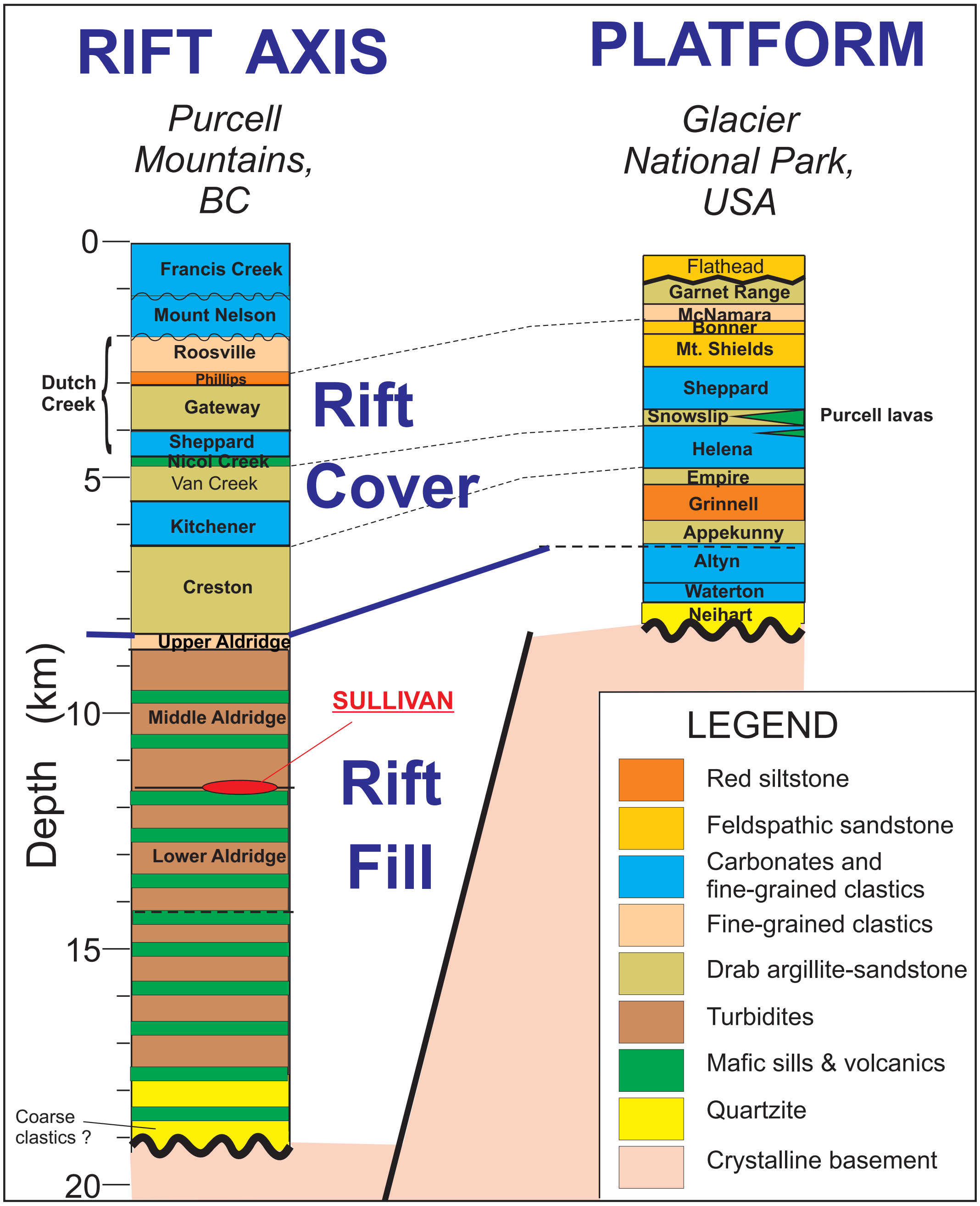

Fig. 8. Stratigraphic correlation and comparison of average thicknesses between formations of the rift-fill, rift-cover, and platform sedimentary sequences of the Belt-Purcell Supergroup. From Lydon (2007).

deposits (Höy, 1993; McMechan, 2012).

2.1.3. Kootenay Arc

The Kootenay Arc is a 400 kilometre-long curved belt of sedimentary, volcanic, and metamorphic rocks that lies between the Purcell Anticlinorium to the east, and the Shuswap-Monashee complex and the Quesnel terrane to the west (Fig. 5; Reesor, 1973). Deflection of the arc to a southwest trend near its southern end is coincident with the Vulcan Low (Vulcan Tectonic Zone; Fig. 5), and may reflect reactivation this basement structure (Vulcan, Fig. 6; Price, 1981).

Following the breakup of Rodinia, continental margin successions were deposited on the western flank of ancestral North America. These rocks consist of the Cambrian through Devonian siliciclastic, carbonate, and evaporitic rocks that are now exposed in the Purcell and Rocky mountains (Fig. 7). Correlative deep-water equivalents of these successions, now exposed in the Selkirk Mountains, were deposited outboard of the ancestral North American platform (Colpron and Price, 1995). Though the rift-phase created a passive margin, block faulting and volcanism existed offshore, suggesting that eastward subduction existed beneath an overlying volcanic arc

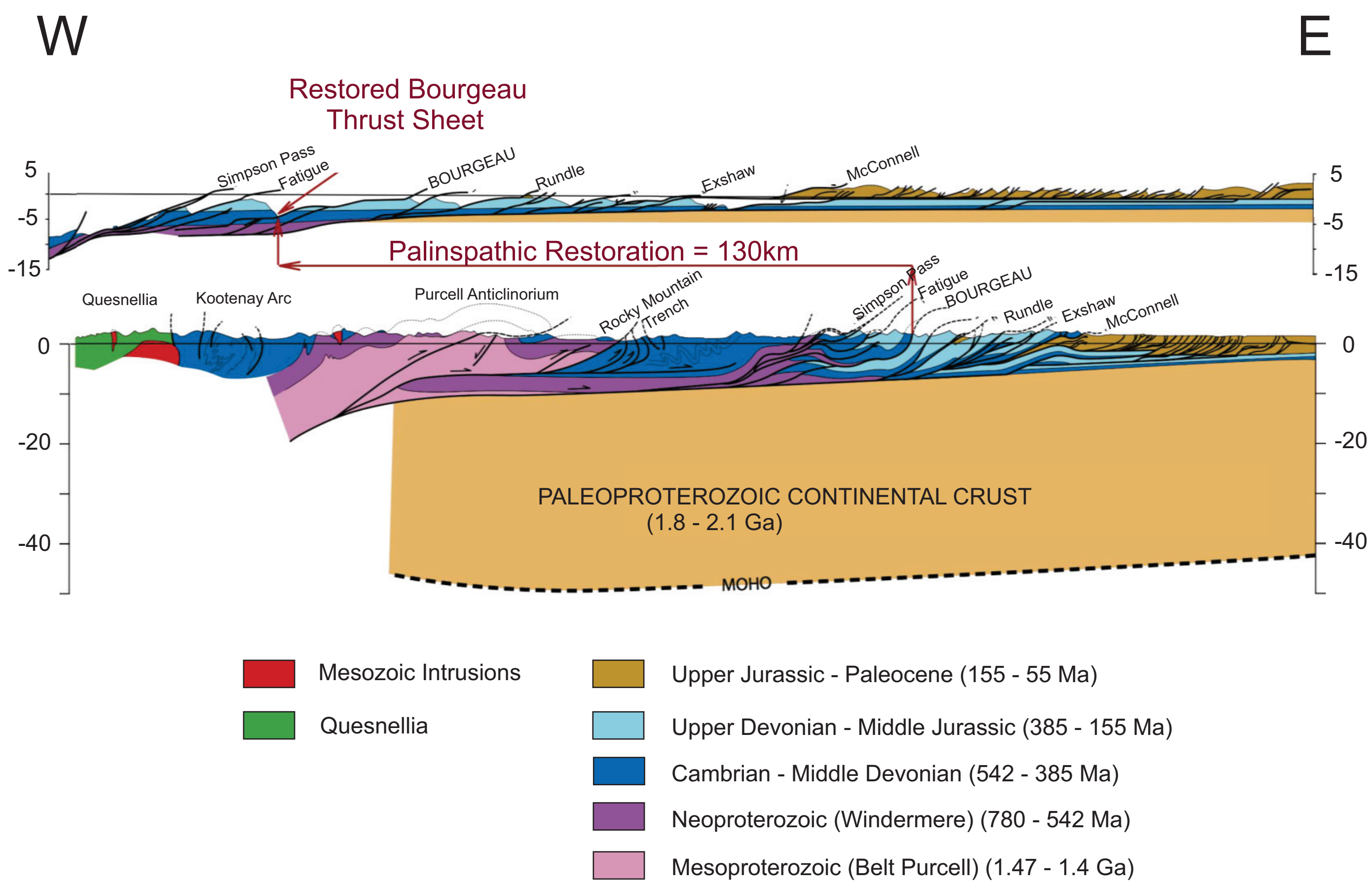

Fig. 9. Palinspathic restoration of the Rocky Mountain fold and thrust belt, southeastern British Columbia. Modified from Price and Fermor (1985).

that lay outboard of the miogeocline. During the Devonian, this eastward subduction also led to extension and bimodal arc magmatism in the outer continental margin (Piercy et al., 2006). Further evidence of this extensional regime is the stratigraphic relief in the Devonian successions across the Moyie-Dibble Creek fault.

This backarc extension caused the opening of the Slide mountain Ocean in Pennsylvanian to Early Permian time (285-300 Ma). The rocks of the Kootenay terrane (Fig. 1) represent the inactive remnants of the arc that remained on the continental side (Piercy et al., 2006; Nelson et al., 2006). The rocks consist of variably metamorphosed Neoproterozoic and Paleozoic strata, including the Badshot limestone (Lower Cambrian), and the clastics, carbonates, and volcanic rocks of the Lardeau Group (mid Cambrian-Mississippian) (Fig. 7; Logan and Colpron, 2006; Nelson et al., 2013). In the southern portion of the Arc, correlative sequences are the Reno, Laib, Nelway and Active Formations (Fyles, 1967). Early Paleozoic volcanism (Eagle Bay Assemblage), late Devonian granitic intrusions (Ice River Complex), bimodal arc magmatism in the outer continental margin, and early Mississippian deformation are characteristic of the Kootenay terrane (Price, 2012). Magmatism in these rocks slowed after ca. 360 Ma, and ceased altogether by ca. 350 Ma (Nelson et al., 2006).

By early to middle Permian, east-dipping subduction that was established beneath the western Laurentian margin was replaced by westward subduction, and the Slide mountain ocean, which may have been up to 3,000 km wide by the mid-Permian, closed by the Triassic. Remnant slivers of the Slide Mountain terrane, including: metamorphosed oceanic assemblages of inter-bedded MORB basalts; cherts, quartz sandstones and conglomerates; and serpentinites (Late Paleozoic; Milford and Kaslo Groups; Fig. 7), were accreted and imbricated between the rocks of Quesnellia and Ancestral North America.

Deposits that occur within the Kootenay Arc include stratiform, laminated, to massive sulphides, replacement-style Irish-type, Besshi-type, Cu-Zn-rich VMS, boron-enriched exhalites (Nelson et al., 2013), and Mesozoic precious-metal and skarn mineralization. Some Pb-Zn deposits are Ordovician to Devonian, which is consistent with an epigenetic Mississippi Valley-type rather than a syngenetic origin (Simandl and Paradis, 2009). The Badshot Formation, a thick Cambrian carbonate unit, and its southern equivalent, the Reeves member (Laib Formation; Fig. 7), host stratiform, laminated to massive sulphides, and replacement-style mineralization. The Laib Formation also hosts skarn mineralization in the Truman member. Overlying the Badshot limestone, the Lardeau Group (Middle Cambrian to Permian) comprises >3.5 km of graphitic phyllites, immature siliciclastic rocks, and mafic volcanic rocks, that are coeval with the shallow-water shelf deposits to the east (Logan and Colpron, 2006; Nelson et al., 2013). Within the Lardeau Group, rift-basin, MORB, and OIB rocks host Besshi-type, Cu-Zn-rich VMS deposits, and boron-enriched exhalative horizons in the upper Index and Jowett formations, and structurally hosted polymetallic breccias and veins. Latest Devonian to Early Mississippian (ca. 360-340 Ma) carbonatites and associated alkalic intrusions in the western Rockies and Omineca belt are also related to backarc extension, and include the Ice River and Fir showings in the Kootenay-Boundary Region (Nelson et al., 2013).

2.1.4. Quesnel terrane and Okanagan subterrane

Arc magmatism in the peri-Laurentian realm is recorded in the rocks of the Quesnellia terrane (Figs. 1, 7), where mafic to felsic arc-related volcanic rocks and carbonates are juxtaposed with Paleozoic strata. Volcanic island arcs, back-arc marginal basins, and their associated successions that once formed and lay outboard of the continent were accreted to the western margin during the Columbian-Laramide orogeny (220-70 Ma). The rocks consist of upper Devonian to Permian cherts, clastics, and basalts (Harper Ranch, Mount Roberts, and Attwood Groups; Fig. 7); coeval volcaniclastic rocks, pelites, and carbonates (Brooklyn Group); and Upper Triassic to Lower Jurassic volcanic arc rocks (Nicola Group). Synorogenic siliciclastics (Triassic; Slocan Group) disconformably overlap the Slide Mountain and Quesnellia terranes, and were likely derived from uplift during accretion.

In the southern portions of the region, Devonian and older units of Quesnellia differ significantly from coeval units to the north, and have been referred to as the Okanagan sub-terrane (Monger et al., 1991). They form a roughly east-west trending belt, and constitute basement to Late Devonian and younger sequences (Colpron and Nelson, 2009). Fragmentary evidence suggests these rocks may be an accreted remnant from the Arctic realm (Massey et al., 2013; Nelson et al., 2013). The Trail gneiss complex (paragneiss and orthogneiss), Knob Hill complex (chert, greenstone, and ultramafic ophiolitic rocks), and Anarchist Group (argillite-phyllite, chert, carbonate, and greenstones) rocks may represent a primitive arc to back-arc assemblage, with MORB, island arc tholeiites, and associated facies (Figs. 5, 7; Colpron and Nelson, 2009).

Mineralization occurs as Ag-Pb-Zn±Au,Cu polymetallic vein; shear-hosted, stockwork and breccia deposits; replacement-type base metals; Cu-Au-Ag and base metal skarns; porphyry Cu-Mo; alkalic porphyry Cu-Au-Ag; Au-Ag epithermal vein; Zn-Pb bearing mesothermal quartz veins; and precious and base metal massive sulphides.

2.1.5. Post accretionary plutons-Mesozoic to Tertiary magmatism

Metallogenic episodes in the Late Jurassic-Early Cretaceous, mid-Cretaceous, Late Cretaceous, and Paleocene-Eocene and Late Eocene can be related to changing convergence rates, subduction geometries, and convective heat transfer (Figs. 5, 7; Nelson et al., 2013). Shearing and deformation created pathways for pluton emplacement, and mineralization. Renewed eastward subduction and terrane accretion led to Late Triassic to Cretaceous magmatic intrusions, while in the Eocene, the tectonic framework was one of dextral transtension accompanied by extensional collapse. The metallogenic importance of this is found in the suite of epigenetic deposits with increasing influence of continental sources of metals (e.g., Mo, W), and increased precious metal enrichment (Nelson et al., 2013). Exhumation of the Shuswap-Monashee, Valhalla, and Kettle River metamorphic complexes (Fig. 5) is also related to the Eocene extension (Vanderhaeghe et al., 2003).

The middle Jurassic intrusive suite comprises syn- to late-tectonic plutons that were emplaced during the collapse of the outer margin and accretion of Quesnellia (Monger et al., 1982). The intrusions are predominantly granite and granodiorite in composition, but have local diorite, monzonite and syenite phases (Armstrong, 1988). Ag-Pb-Zn vein, polymetallic Ag-Pb-Zn±Au, breccia, shear-hosted, Cu-Au skarn, and replacement deposits are thought to be genetically related to the Kuskanax and Nelson intrusions (Middle to Late Jurassic; Fig. 7).

Cretaceous intrusions of the Bayonne magmatic belt (Figs. 5, 7) were emplaced inboard of the main magmatic arc in continental margin rocks. They are generally intermediate to felsic alkalic to calc-alkalic, including: peraluminous, subalkalic hornblende-biotite granodiorites, highly fractionated two-mica granites, aplites, and pegmatites. Mineralization related to the suite includes Mo-Au±W-quartz veins; W-Cu-Au skarns; Au-Ag-Bi-Cu-Pb fault-veins; and Pb-Zn-Au-As-Sb±W quartz-carbonate veins (Logan, 2002), with a low concentration of base metals and sulphides. At the southern end of the Bayonne magmatic belt, and along northeast-trending faults related to the Vulcan Tectonic zone (Fig. 5), are magmatic-hydrothermal mineral deposits (Fyles and Hewlett, 1959).

Intrusions emplaced during regional Tertiary extension include the Coryell suite of alkalic plutons (with local extrusive equivalents) and stocks of granite and augite-biotite syenite and monzonite (Figs. 5, 7). Tertiary biotite, feldspar, hornblende and augite lamprophyre dikes are commonly emplaced along fractures, faults, or prominent foliation planes (L. Caron, pers. comm., 2014). Some Tertiary faults expose Proterozoic crystalline basement (Kettle River and Valhalla metamorphic core complexes; Fig. 5) in their footwalls. Major deposit types include porphyry Cu-Mo±Au and Mo, intrusion-related gold, Ag-Pb-Zn, tungsten skarn, and structurally controlled epithermal and orogenic Au veins.

2.2. Rocky Mountain Foreland Belt

Following the breakup of Rodinia, passive margin successions were deposited on the western flank of ancestral North America (Figs. 5, 7). The Rocky Mountain Foreland Belt consists mainly of these mid-Proterozoic to Mesozoic sedimentary platformal and craton margin deposits, which were detached and thrust eastward during the Mesozoic to Tertiary terrane accretion.

Siliciclastic, carbonate, and evaporitic rocks were uplifted and displaced northeastward, to create a classical thin-skinned fold-thrust belt, with eastward-vergent, piggyback thrusts detaching along a basement-cover décollement (Fig. 9; Price and Fermor, 1985). These upturned thrust sheets host relatively easily mined industrial minerals such as gypsum, magnesite, silica, and phosphate.

Thrust loading on the western margin of the continent during the Mesozoic also led to foreland basin subsidence. Sediments were cannibalized from the emerging highs, and shed eastward into the basin (Cant and Stockmal, 1989). The Fernie Formation and Kootenay Group (Fig. 7) consist of a coarsening-upwards sequence of basinal to coastal plain sandstones, shales, and coals that were deposited in the foreland, adjacent to the uprising Canadian Cordillera in the Jurassic to early Cretaceous. They represent the first of a series of coarsening-upwards clastic wedges within the foreland basin that were derived from uplift (Poulton, 1988; Stott, 1984). The coal seams of the Kootenay Group were upturned and structurally thickened as thrusting continued, and the accretionary wedge propagated eastward. They are now exposed along strike for 175 km in the Rocky Mountain Front Ranges, and portions of the section permit open-pit mining (Fig. 5). Mineable coal seams make up 8-12% of the total thickness of the Mist Mountain Formation (Kootenay Group), and are typically medium-volatile bituminous in rank, generally with high volatile-A bituminous coals near the top of the section, and low-volatile bituminous coals near the base. The coal is mainly metallurgical, hard coking coal (Grieve, 1993).

The East Kootenay coalfields comprise three structurally separated fields, including the Elk Valley, Crowsnest, and Flathead (Fig. 10). The Elk Valley Coalfield is in the Alexander Creek and Greenhills synclines. The Crowsnest Coalfield coincides with Fernie Basin, a broad north-trending synclinorium, and the Flathead Coalfield consists of four relatively small, isolated exposures of Kootenay Group rocks in the extreme southeast corner of the region. Provincial legislation prohibits subsurface resource exploration and development in the Flathead River watershed (Fig. 10), and the Flathead Coalfield and portions of the Crowsnest Coalfield are excluded from coal mining activity.

3. Mines and quarries

The Kootenay-Boundary Region produces metallurgical coal from five mines in the Elk Valley, and continues to be an important source of industrial minerals such as gypsum, magnesite, silica sand, phosphate, mineral wool, dolomite, limestone, graphite, tufa, flagstone, railroad ballast, rip rap, smelter slag and aggregate (Fig. 1).

3.1. Coal mines

Southeastern British Columbia has a history of coal mining that dates back to the 1800s, with reports of coal discovered in the Elk Valley around 1845. Today, mining operations, coal production, and environmental assessment for expansion plans continue at four of the five mines in the Elk Valley operated by Teck Coal Ltd. (Table 1; Figs. 1, 10). The main product is metallurgical coal (85%), with some thermal and pulverized coal injection (PCI) coal (15% combined). The region accounts for approximately 70% of Canada's annual coal exports. Production from the Elk Valley in 2014 was 26.5 Mt of clean coal; however in 2015 Teck Coal Ltd. implemented rotating shutdowns in order to align production and inventory with weaker commodity prices. Expected production volumes for 2015 are around 25 Mt, and the company focused on implementing cost reductions and improved efficiencies at all operations.

In recent years, environmental assessment approval of major mine projects in the Elk Valley has been conditional on developing a regional watershed management plan. In November, 2014, Teck received approval from the British Columbia Ministry of Environment for the Elk Valley Water Quality Plan which addresses the management of selenium and other substances released by mining activities. It is a public policy document that will guide future regulatory decision making with respect to all water quality and mining in the Elk Valley. It includes water diversion and treatment, and establishes water quality targets for selenium, nitrate, sulphate, cadmium, and calcite.

The plan was developed with scientific advice from a Technical Advisory Committee chaired by the British Columbia Ministry of Environment, and included representatives from Teck, the Ktunaxa Nation, the US Environmental Protection Agency, the State of Montana, Environment Canada and other agencies. Public consultation was also part of the process. The West Line Creek water-treatment facility is a water treatment facility currently being commissioned at the **Line Creek** Mine (Fig. 10), and is the first of six that Teck plans for the Elk Valley. The second will be at the **Fording River** mine. Together they are part of a selenium management plan that will cost a projected $600 million over the next five years, and $40 million to operate annually.

3.1.1. Fording River (Teck Coal Ltd.)

Fording River (Fig. 10) produces mainly metallurgical coal from their Eagle Mountain, Turnbull, and Henretta pits. In 2015, exploration drilling was conducted mainly in active pits. Mine models indicate that relatively thick, low dipping seams extend into Turnbull Mountain, with potential for highwall pushback for both South Henretta and Turnbull pits. Mineable coal reserves east of the current Henretta pit also exist on the eastern limb of the Alexander Creek syncline down section from the current footwall limit. Proven and probable reserves are projected to support a 74-year mine life at the current production rate.

In September, 2015, the **Swift** expansion received conditional environmental assessment approval. The project will need to meet specifications outlined in the Elk Valley Watershed Management Plan, including the construction of a selenium water treatment facility. With an initial construction cost of

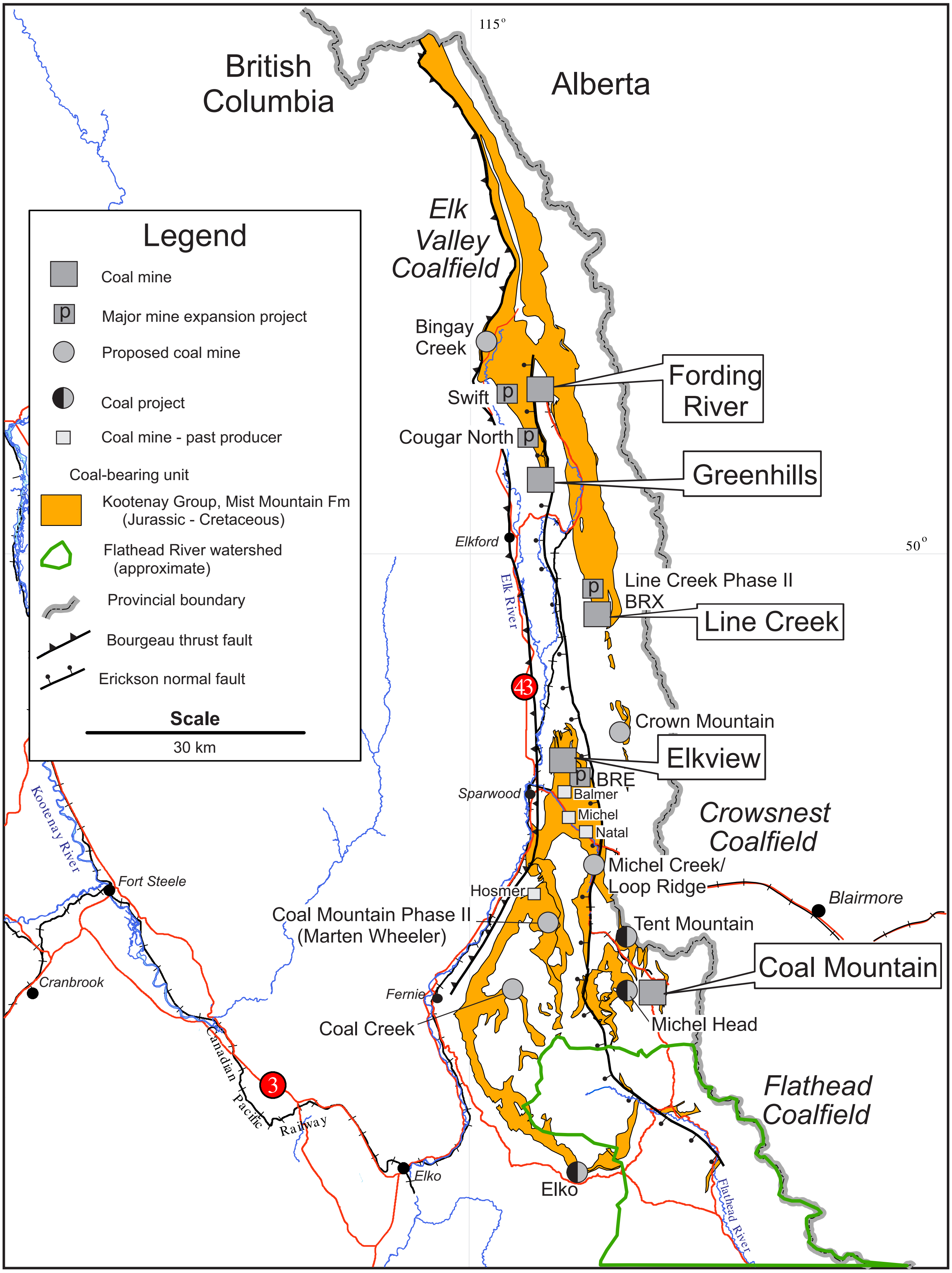

Fig. 10. Map of the Kootenay Group and East Kootenay coalfields, including the major coal mines and projects in southeastern British Columbia near Sparwood, BC.

Table 1. Operating coal mines, Kootenay-Boundary Region, 2015.

Mine	Operator	Commodity	Forecast 2015 Production (based on Q1-Q3)	Reserves (Proven + Probable)	Resource (Measured + Indicated)	Mine Expansion Plans and Comments
Fording River	Teck Coal Ltd. (100%)	HCC, TC	7.9 Mt	Proven + Probable: 620.4 Mt HCC + 4.5 Mt TC	Measured + Indicated: 1149 Mt HCC + 9 Mt TC; Inferred: 0.8 Mt HCC + 6 Mt TC	EA approval of Swift expansion (2015); exploration drilling in active pits
Greenhills	Teck Coal Ltd. (80%); POSCAN (20%)	HCC, PCI, TC	5.2 Mt	Proven + Probable: 60.6Mt HCC + 3.7 Mt PCI + 1.2 Mt TC	Measured + Indicated: 264.5 Mt HCC + 1.8 Mt PCI + 3.6 Mt TC	Cougar Pit Expansion (CPX) is preparing for pre-application of EA; environmental baseline
Line Creek	Teck Coal Ltd. (100%)	HCC, PCI, TC	3.1 Mt	Proven + Probable: 66.8Mt HCC + 3.1Mt PCI + 8.7Mt TC	Measured + Indicated: 712 Mt HCC + 0.7 Mt PCI + 9.1 Mt TC	Burnt Ridge Extension (BRX) in pre-application of EA (2014); pre-stripping at Line Creek Phase II (2013 EA approval)
Elkview	Teck Coal Ltd. (95%); Nippon Steel & Sumimoto Metal Corp. (2.5%), POSCO (2.5%)	HCC	6.3 Mt	Proven + Probable: 215.2Mt HCC	Measured + Indicated: 705.3 Mt HCC; Inferred: 176.2 Mt HCC	Baldy Ridge Extension (BRE) in pre-application of EA (2014); exploration drilling in active pits; development progressing in new approved mining areas
Coal Mountain	Teck Coal Ltd. (100%)	PCI, TC	2.3 Mt	1.6 Mt Proven + 5.6 Mt probable PCI	57.7 Mt Measured + 82.9 Mt Indicated + 9.6 Mt Inferred	Coal Mountain Phase II (CMO2; Marten Wheeler) entered pre-application of EA (2014) but withdrawn late 2015; Mineable resource at CMO is nearing depletion and expected mine shut down in late 2017

HCC = hard coking coal; PCI = pulverized coal injection; TC = thermal coal

approximately $88.5 million dollars and an annual operating cost of $16.9 billion, the open-pit project will use the existing Fording mine facilities and is expected to produce 175 Mt of clean coal over 25 years. Located west of the Fording River in the northern part of the Greenhills Range, the project will mine multiple coal seams on both limbs of the Greenhills Syncline, and include both previously mined and unmined zones (Fig. 11). The project is along strike and directly north of the **Greenhills Cougar North** project; and eventually the two will merge and collectively become the **Swift**.

3.1.2. Greenhills (Teck Coal Ltd.)

Greenhills is on the west limb of the Greenhills syncline (Figs. 10, 12). Coal seams generally grade in rank from medium-volatile bituminous in the lower parts of the section, to high-volatile-A bituminous at higher intervals. Proven and probable reserves are projected to support another 14 years of mining from current pits at the current rate. The **Cougar Pit Extension (CPX)** project is the proposed expansion area for Greenhills Operations, and lies immediately north of the existing operations, with similar coal characteristics. At full development, the **CPX** project will merge with the Fording River **Swift** expansion. In 2015, Teck conducted further baseline work and mine-planning to prepare to enter pre-application of Environmental Assessment. Exploration drilling in 2015 focused mainly on the active Cougar pit.

3.1.3. Line Creek (Teck Coal Ltd.)

Line Creek produces from the Burnt Ridge South, North Line Creek, and Horseshoe Pits (Figs. 10, 13). Expansion plans are well underway with the **Line Creek Phase II**, which received conditional Environmental Assessment approval in

Fig. 11. Previously mined seams of the Swift expansion area, looking westward from Fording River Operations, towards Cougar Ridge North.

Fig. 12. Greenhills mine (Cougar Pit), looking north towards Cougar Ridge North.

Fig. 13. Coal seams in the Alexander Creek syncline at the Line Creek mine. Photo courtesy of Teck Coal Ltd.

2013. This expansion will extend operations at Line Creek northward, and encompass the Mount Michael and Burnt Ridge North areas, adding approximately 59 Mt of clean coal, and 18 years of mine life to the mine. Coal seams are predominantly medium-volatile bituminous in rank, with some high volatile-A bituminous coals near the top of the section. In June, 2014, the **Burnt Ridge Extension (BRX)** project entered the pre-application stage of Environmental Assessment. The project will connect the current Phase I operating area at **Line Creek** to the recently approved (2013) **Phase II** area by pushing back the highwall of Burnt Ridge South pit to the north. It will add 8.3 Mt of clean coal to the mine. Drilling was focused on the Burnt Ridge and North Line Creek extension areas to update geological and geotechnical models.

3.1.4. Elkview (Teck Coal Ltd.)

The **Elkview** mine (Fig. 10) produces mainly high-quality mid-volatile hard coking coal from thrust repeats of mineable seams in a southwest plunging syncline. Teck estimates a remaining reserve life of approximately 32 years at the current production rate. Production is mainly from their Baldy Ridge BR1 and Natal PH1 Pit, and 2015 exploration drilling was focused mainly in the active pits. The mine received approval for their expansion at Baldy Ridge BR2 in 2012 and also for the Natal PH2 in 2013, and they have been also progressing towards development of these, along with environmental baseline work to satisfy permit conditions. The **Baldy Ridge Extension (BRE)** also entered pre-application of Environmental Assessment in June, 2014. The project will include expansion of their current permit boundary, mining of Baldy Ridge BR3, BR4, BR6, and BR7 pits, expansion of Adit Ridge AR1 and further expansion at Natal Ridge NP2 pit. New dump and tailings facility expansions are also included in the plan. The **BRE** expansion is expected to be brought on stream to maintain production at Elkview at around 6.8 Mt per year.

3.1.5. Coal Mountain (Teck Coal Ltd.)

Coal Mountain (Fig. 10) produces mainly PCI and thermal coal from seams at 37-Pit and 6-Pit, and 2015 activity was mainly focused on active pits. The **Coal Mountain Phase II (Marten Wheeler)** project, which entered the pre-application phase of environmental assessment in 2014, was designed to replace production after depletion of the resource at **Coal Mountain**. Late in 2015 however, Teck Coal Ltd. removed the proposal from the pre-application process as a result of lower commodity pricing. The **Coal Mountain** mine will remain active at current rates of production, and then is expected to shut down in late 2017. The company is evaluating opportunities for optimizing and expanding production at their other existing metallurgical coal mines in order to replace the 2.25 Mt of planned production from the cancelled **Coal Mountain Phase II** expansion after 2017.

3.2. Industrial mineral mines and quarries

The Kootenay-Boundary Region hosts several industrial mineral mines, the largest of which, are located in the Rocky Mountain foreland belt, where the upturned strata are easily mined. A variety of smaller mines and quarries exist throughout the region, and graphite is also mined from rocks of the metamorphic core complexes (Fig. 1; Table 2).

3.2.1. Mount Brussilof (Baymag Inc.; Magnesite)

Baymag Inc. produces high-quality magnesite year-round from their open-pit mine at **Mount Brussilof** (Fig. 14). The deposit was discovered in 1966, and the mine has been in production since 1982. The Mount Brussilof deposit is in Cambrian carbonates of the Cathedral Formation (Fig. 7) that were originally deposited on the edge of the Cathedral escarpment, which formed at the continental shelf edge. The deposit is a result of magnesium hydrothermal alteration, with characteristics similar to Mississippi Valley-type mineralization. Sulphides (mainly pyrite) are removed as impurities from the product. Magnesite ore is transported by truck to the company's processing facilities in Exshaw, Alberta for production of magnesium oxide (MgO) and magnesium hydroxide (MgOH). Production in 2015 was approximately 220 kt.

Fig. 14. Blast hole drilling at the Mount Brussilof mine, which produces magnesite from Cambrian carbonates of the Cathedral formation.

3.2.2. Moberly Silica (Heemskirk Canada Limited; Silica)

Silica is produced by Heemskirk Canada Limited at the **Moberly Silica** operation. The deposit is in regionally extensive orthoquartzites of the Mount Wilson Formation (middle to upper Ordovician; Fig. 7). The formation occurs over a 300 km length along the western portions of the Rocky Mountain Fold and Thrust Belt. Moberly Mountain is the northern extent of the unit, where it is terminated by a thrust fault. At Moberly, the unit is nearly vertical, about 200 m thick, extends along an 800 m strike length, and is de-cemented and friable. The deposit was mined from the early 1980s to 2008 for silica sand, glass-making, and other industrial uses. In 2011, the company completed feasibility and engineering studies to produce frac sand for the western Canadian oil and gas industry, and outlined a mine plan for a 400,000 t per year at a 35-year mine life. In 2014, the company updated the feasibility study and the resource estimate specific to producing 20 to 140-mesh frac sand (Fig. 15). In 2014, the company began redeveloping the current silica operations, redesigning and upgrading the haul roads, and constructing a new processing plant. Plant engineering is progressing, and plant commissioning is expected by late 2016 or early 2017.

Fig. 15. Stockpiled silica sand at the Moberly Silica mine, which produces silica for glass-making, and other industrial uses. Heemskirk Canada Limited is currently re-developing operations for production of 20 to 140-mesh frac sand for the oil and gas industry.

3.2.3. Horse Creek Silica (HiTest Sand Inc.; Silica)

At the **Horse Creek Silica** mine, HiTest Sand Inc. operates a seasonal quarry in Mount Wilson quartzites (Fig. 7) for a variety of industrial use and aggregate products. The quarry is located further to the south and in an area where the formation is more consolidated than at Moberly (Fig. 1). The company is also evaluating processes for the production of alternate products, including silicon metal.

3.2.4. Elkhorn Mine (CertainTeed Gypsum Canada Inc.; Gypsum)

Gypsum is produced near the western edge of the Rocky

Table 2. Selected industrial mineral mines and quarries, Kootenay-Boundary Region, 2015.

Mine	Operator	Commodity; deposit type; MINFILE	Forecast 2015 Production (based on Q1-Q3)	Reserves (Proven + Probable)	Resource (Measured and Indicated)	Comments
Mount Brussilof	Baymag Inc.	Magnesite; Hydrothermal sparry magnesite; 082JNW001	220,000 t annually	50 Mt proven	-	MgO, and MgOH; sediment-hosted sparry magnesite
Moberly Silica	Heemskirk Canada Ltd.	Silica; Industrial use silica, frac sand; 082N001	-	20 to 140 mesh frac sand (dry): Proven 8.9 Mt of 64% frac sand + Probable 4.6 Mt of 64% frac sand; OR Silica for industrial (dry): 12.8 Mt Proven + 0.7 Mt Probable	20 to 140 mesh frac sand (dry): 32.4 Mt at 64% frac sand Measured and Indicated + 11.7 Mt silica as frac sand residues; OR Silica for industrial (dry): 43.2 Mt Measured + Indicated	$26M capital cost for plant construction and upgrades to existing facility (for frac sand operation); 300,000 tonne per year capacity; Construction started on frac sand processing plant in 2014, commissioning expected 2017
Horse Creek Silica	HiTest Sand Inc.	Silica; Industrial use, aggregate; 082N 043	-	-	Estimated: 3 Mt at 99.5% Silica (1987)	Variety of aggregate and industrial use products
Elkhorn	CertainTeed Gypsum Canada Inc.	Gypsum; Evaporitic bedded gypsum; 082JSW021	400,000 t annually	-	-	5 years mine-life remaining; the company will replace production by developing the Kootenay West mine (in EA)
4J	Georgia-Pacific Canada Limited	Gypsum; Evaporitic bedded gypsum; 082JSW009	n/a; Processing stockpiled ore	-	20 Mt	Processing stockpiles; updating mine expansion plans
Black Crystal	Eagle Graphite Corp.	Graphite; Metamorphic-hosted flake graphite; 082FNW260, 082FNW283	n/a; Quarry on care and maintenance; company focused on process optimization and exploration	-	Regolith: Measured + Indicated: 0.648 Mt at 1.83% fixed carbon; Calc-silicate: Indicated: 4.765 Mt at 1.21% fixed carbon	Exploration drilling to expand the resource; update geological model and pit design; process optimization at plant; produced sample of 99.995% pure spheronized graphite from flake graphite; product suitable for Li-Ion battery specifications
Winner; Friday Quarry	Roxul Inc.	Gabbro/basalt; Crushed rock for mineral wool; 082ESE265	Quarrying to supply feed stock for mineral wool plant	-	-	Crushing, screening, stockpiling; environmental
Grand Forks Slag	Granby River Mining Company Inc.	Slag/Silica; tailings from Grand Forks smelter dumps; 082ESE264	Quarrying for abrasives and roofing granules	-	-	Crushing, screening; environmental

Mountain Fold and Thrust belt from a thinly-bedded evaporite unit in the Burnais Formation (middle Devonian; Figs. 7, 16) that was deposited in a restricted shallow gulf. Gypsum-bearing strata are structurally disturbed, occurring as sections of steeply dipping, contorted rock gypsum, ranging in thickness from 30 to 180 m (Butrenchuk, 1991). CertainTeed Gypsum Canada Inc. operates the **Elkhorn** mine, which is expected to continue production for another 5 years.

3.2.5. 4J Mine (Georgia-Pacific Canada Limited; Gypsum)

Georgia-Pacific Canada Limited operates the **4J** gypsum mine and rail load-out facility southeast of Canal Flats. The deposit is

Fig. 16. Inter-bedded gypsum and finely laminated mudstones in the middle Devonian Burnais Formation. Gypsum is produced from the Burnais formation at the Elkhorn and 4J mines, with a new mine development proposal in EA for the Kootenay West mine.

within Burnais Formation evaporites (middle Devonian; Figs. 7, 16). The company re-evaluated their mine design for the next stages of pit expansion, and produced mainly from stockpiled material in 2015.

3.2.6. Black Crystal (Eagle Graphite Corp.; Graphite)

Eagle Graphite Corp. operates the **Black Crystal** flake graphite operation where graphite ore is mined from the open-pit quarry on Hodder Creek and processed at a pilot plant 10 km west of Passmore. The property is in the central part of the Valhalla complex (Fig. 5) in the Valhalla dome, a structural complex of upper amphibolite-grade gneisses in Paleozoic rocks of the Kootenay terrane that was exhumed during Tertiary extension. Disseminated fine- to coarse-flake graphite is distributed along foliation in organic-rich calc-silicates and marbles, across an area of about 500 m^2. The graphitic horizon is 80 to 100 m thick. Carbon grades up to 6.95% in two zones: a "hard rock" zone, and an overlying regolith zone. Most of the deposit, especially the regolith zone, is friable and blasting is not required. Sand and aggregate are produced as by-products during the mining and refining process. In 2015, the open-pit quarry was on care and maintenance, and efforts were focused on exploration drilling in order to update the geological models and more fully define and expand the resource on the property. The company also focused efforts on improving processing techniques at the plant, and enhancing purity and quality of the product. Process optimization enabled production of a sample of 99.995% pure spheronized graphite from fine flake graphite. Further electrochemical testing demonstrated that these particles met the specifications for lithium-ion batteries. The company also conducted a pilot project for pre-concentration of feed material without the need for flotation, on a variety of size fractions, which would allow for pre-processing of material at the quarry site and reduce transportation costs.

3.2.7. Winner and Friday Quarries (Roxul Inc.; mineral wool: Gabbro and basalt)

Roxul Inc. seasonally operates two small quarries near Grand Forks. Gabbro is quarried from the **Winner** quarry, and basalt is quarried from the nearby Friday Quarry (North Fork). The material is trucked to the Roxul Inc. manufacturing plant in Grand Forks, where it is blended with other mineral material necessary to make mineral wool insulation, construction board, blankets, and pipe covering.

3.2.8. Grand Forks Slag (Granby River Mining Company Inc.; Smelter slag)

North of Grand Forks, the Granby River Mining Company Inc. operates the **Grand Forks Slag** quarry, which produces abrasives and roofing granules from the smelter slag that was generated from the Granby Consolidated Mining and Smelting copper smelter. The smelter operated between 1900 and 1918, and generated slag from smelting copper-gold ore from the historic Phoenix mine, located west of Grand Forks.

4. Proposed mines

The proposed mine (or mine evaluation) stage, is concerned with the environmental, social, engineering and financial evaluation of a proposed mine. It includes application for an Environmental Assessment certificate and/or a Section 10 permit which states that a project is reviewable by the Environmental Assessment Office; or the submission of a Mines Act permit application for smaller scale projects not meeting the threshold criteria for review by the B.C. Environmental Assessment Office (Fig. 1; Table 3).

There are several proposed mines for the Kootenay-Boundary Region, including five proposed coal mines, several proposed industrial mineral mines and quarries of various scales, and two proposed metal mines. The five coal projects are **Crown Mountain**, **Michel Creek/Loop Ridge**, **Coal Mountain Phase II**, **Coal Creek** and **Bingay Creek**. Two of the industrial mineral projects include the **Kootenay West Mine** and the **Driftwood Magnesite** project, and the two metal mines are the **Gallowai Bul River** and **Slocan Silver** projects.

4.1. Proposed coal mines

4.1.1. Crown Mountain (NWP Coal Canada Ltd.)

The **Crown Mountain** property (NWP Coal Canada Ltd., a wholly owned subsidiary of Jameson Resources Ltd.) is along strike with Line Creek, and is considered an erosional outlier of the Mist Mountain Formation (Fig. 10). The property contains seven major coal seams, with combined average thicknesses of 15 to 35 m. In October 2014, the project advanced to the pre-application stage of Environmental Assessment. The project proposal is for an open pit mine with an estimated production capacity of 1.7 Mt per year of clean coal and a 16-year mine life. NWP Coal completed a prefeasibility study, with upside potential in a Southern Extension; and updated coal resource estimates at 74.9 Mt (measured + indicated categories). Coal

Table 3. Selected proposed mines, Kootenay-Boundary Region, 2015.

Project	Operator	Commodity; deposit type; MINFILE	Reserves (Proven + Probable)	Resource (Measured + Indicated)	Work Program
Crown Mountain	NWP Coal Canada Ltd. (Jameson Resources Ltd.)	Coal (HCC and PCI); open-pit; 082GNE018	HCC: 42.60 Mt Proven + 4.91 Mt Probable; PCI: 7.13 Mt Proven + 1.19 Mt Probable (2014)	HCC + PCI: 68.9 Mt Measured + 6.0 Mt Indicated (2014)	Prefeasibility studies; environmental and baseline work; mine design; permitting
Michel Creek (Loop Ridge)	CanAus Coal Ltd.	Coal (HCC and PCI); open-pit and underground; 082GSE050	-	HCC: 44.6 Mt Measured + 42.5 Mt Indicated; open-pit and underground (2015)	Drilling; trenching; environmental and baseline work; mine design; coal quality; permitting
Coal Mountain Phase II (Marten Wheeler)	Teck Coal Ltd.	Coal (PCI and TC); open-pit and underground; 082GNE006	-	PCI + Thermal: 114.3 Mt Measured + 97.3 Mt Indicated (2015)	Environmental and baseline work; mine design; permitting
Coal Creek	CrowsNest Pass Coal Mining Ltd.	Coal (HCC and PCI); underground; 082GSE035	-	HCC + PCI: 616 Mt in the upper 3 near-surface seams (2014)	Prefeasibility Study (PFS); geological modeling; resource evaluation; baseline studies
Bingay Creek	Centremount Coal Ltd.	Coal (HCC); open pit and underground; 082JSE011	-	42.43 Mt Measured + 52.9 t Indicated (2012)	Environmental baseline studies; Engineering and geotechnical evaluation for mine design; permitting
Kootenay West	CertainTeed Gypsum Canada Inc.	Gypsum; Evaporitic bedded gypsum; quarry; 082JSW005, 082JSW020	-	North and South Quarries: Total 18.7 Mt (at average quality of 83-85%)	Environmental baseline work; mine design
Driftwood Magnesite	MGX Minerals Inc.	Magnesite; Hydrothermal sparry magnesite; quarry; 082KNE068	-	-	Drilling; bulk sampling; environmental baseline work; metallurgical test work; lease application; mine design; preliminary plant design
Gallowai Bul River	Purcell Basin Minerals Inc.	Cu-Ag-Au+/-Pb-Zn; Cu-Ag veins; underground; 082GNW002	-	90,720 t at 1.3% Cu, 0.31g/t Au, 21.77g/t Ag	Draft project proposal submitted to EA; Permitting; environmental baseline; mine plan and mine design; ARD/ML
Slocan Silver (Silvana)	Klondike Silver Corp.	Ag-Pb-Zn+/-Au; Polymetallic veins; underground 082FNW050, 13, 082KSW006	-	-	Engineering reports: underground mining structure and tailings storage facilities; environmental monitoring

quality test work indicates coal quality characteristics that are similar to the Elk Valley coking coals.

4.1.2. Michel Creek/Loop Ridge (CanAus Coal Ltd.)

In October 2015, CanAus Coal Ltd., a wholly owned subsidiary of CoalMont Pty Ltd., entered pre-application phase of environmental assessment for their **Michel Creek** project, which consists of licenses at **Loop Ridge, Tent Mountain,** and **Michel Head** (Fig. 10). The application has a current focus only on **Loop Ridge**, and a proposed production rate of 3.5 Mt/year (2.1 Mt/year clean coal), over a 10 year mine life. Future potential mine expansion to their other areas (**Tent Mountain** and **Michel Head**) could extend the project by an additional 10 years. The company began environmental baseline work for the project in 2013, and is hoping to begin construction in 2017. The project will comply with environmental targets identified in the Elk Valley Water Quality Plan in the design, construction and operational phases of the project. Drill results identified twenty Mist Mountain coal seams ranging from 5 to 20 m in thickness, west of the Erickson normal fault. Structure and spacing of the seams gives the project a low strip ratio of ~6:1, and testwork indicates coal quality is hard coking coal. Further bulk sample carbonization testwork is underway. The company released an updated NI 43-101 resource estimate with 44.6 Mt measured and 42.5 Mt indicated (open-pit and underground), and is working towards the pre-feasibility engineering and design phases for the project. Drilling in 2015 focused on the Loop Ridge project, with samples collected for coal quality testing from **Loop Ridge** and McGillvray pit. The company trenched on Loop Ridge South, with plans for follow up drilling in 2016 to extend the resource southward.

4.1.3. Coal Mountain Phase II (Teck Coal Ltd.)

At Teck Coal's **Coal Mountain Phase II** (Marten Wheeler) project, the Mist Mountain Formation contains up to 15 coal seams, 1-8 m thick, with a cumulative average thickness of 75 m on Marten and Wheeler Ridges (Fig. 10). The seams range in rank from medium- to high-volatile bituminous coal. The project entered pre-application stages of environmental assessment in September, 2014. In 2015, Teck focused on environmental baseline, geotechnical, and mine design work, however, the project was withdrawn from environmental assessment and put on hold late in the year as a result of Teck Coal Ltd. implementing cost-saving measures. The project was proposed to replace production and use infrastructure from the **Coal Mountain** mine. It has potential to produce 76.5 Mt of clean coal over an estimated 34-year mine life, at a production rate of approximately 2.25 Mt per year.

4.1.4. Coal Creek (CrowsNest Pass Coal Mining Ltd.)

CrowsNest Pass Coal Mining Ltd. continued geological modeling, engineering review, resource, and pre-feasibility work at their **Coal Creek** property (Fig. 10). The company has been testing the down-dip extensions of the uppermost coal seams at the historical underground Coal Creek and Elk River collieries, the former of which closed in 1958. The project is underlain by 11 coal zones 2 to 20 m thick. The company is evaluating three near-surface seams in the uppermost part of the Mist Mountain Formation that dip gently to the East for underground room-and-pillar mining potential. Drilling in 2012 indicated high-quality hard coking and PCI coal in the upper seams. Although the project remained on hold in 2015, environmental baseline studies, including water quality surveys are ongoing.

4.1.5. Bingay Creek (Centermount Coal Ltd.)

Centermount Coal Ltd.'s Bingay Main is a proposal for an open-pit and underground coal mine on the **Bingay Creek** property (Fig. 10). It entered pre-application of environmental assessment in early 2013, with further environmental work required. The mine would produce 2 Mt of coal annually, and have a mine life of approximately 20 years, with a total resource of approximately 39 Mt of clean coal. At **Bingay Creek**, the coal-bearing Mist Mountain Formation is preserved in a tight, asymmetric syncline in the immediate footwall of the west-dipping Bourgeau thrust fault. Based on previous exploration results, the coal at Bingay Creek is medium-volatile to high volatile-A bituminous in rank. Work in 2015 consisted of engineering and geological review and environmental baseline studies, with drilling planned for 2016.

4.2. Proposed industrial mineral mines

4.2.1. Kootenay West Mine (CertainTeed Gypsum Canada Inc.; Gypsum)

CertainTeed Gypsum Canada Inc. continued to advance the proposed **Kootenay West Mine**, which entered the pre-application stages of Environmental Assessment in 2014. The quarry will target gypsum from a deformed hydrated evaporite layer 20-25 m thick, with beds of 75-95% gypsum, within the Burnais Formation (Fig. 7). The mine will have an average production rate of 400,000 t per year, over a 42-year mine life. The total mineral reserve is estimated at 18.7 Mt, and product will be blended to a product specification of 83-85% gypsum for market. In 2015, the company focused on environmental work and mine design, with two pits (North and South). They hope to begin site preparation in 2016, with a projected start-up in 2018.

4.2.2. Driftwood Magnesite (MGX Minerals Inc.; Magnesite)

At the **Driftwood Magnesite** property, cliff-forming, upturned beds of sparry magnesite (Fig. 17) are interlayered with dolostones and dolomitic limestones of the Mount Nelson Formation (Proterozoic; Fig. 7). The coarse-grained textures in the magnesite zone suggest that hydrothermal alteration and recrystallization of magnesite occurred during regional metamorphism (Kikauka, 2000). In 2014, MGX Minerals Inc. drilled the East zone, and resampled cores from earlier drilling at the West zone. In 2015, the company focused drilling at the West zone, which varies from 100 to 200 m in thickness along a strike length of 400 m, to a depth of approximately 125 m. The company is currently working on completing a NI 43-101 compliant resource, and testwork was conducted to develop an optimized process design to remove silica and improve economic cut-off grades. They have applied for a mining lease for quarry operations, are conducting environmental baseline studies, and are evaluating mine design options. They began bulk sampling from the **East** zone late in 2015 for further metallurgical testwork, and are evaluating mineral processing options.

Fig. 17. Sparry magnesite of the Mount Nelson Formation (Proterozoic) at the Driftwood Magnesite property.

4.3. Proposed metal mines

4.3.1. Gallowai Bul River (Purcell Basin Minerals Inc.; Cu-Ag-Au±Pb-Zn)

Purcell Basin Minerals Inc. is working to restart the **Gallowai Bul River** mine, which has been on care and maintenance since 2009.The property is hosted in fault-bounded blocks of the Aldridge Formation (Fig. 7). Cu-Ag mineralization is in a network of east-west trending, near-vertical, sulphide-bearing quartz-carbonate veins, in sheared and brecciated host rocks. The main vein structure and stringer zones range from a few cm to 30 m wide. Mineralization occurs as pyrite, pyrrhotite, and chalcopyrite, with minor galena, sphalerite, arsenopyrite, cobalite, and traces of tetrahedrite and native gold. The historic Dalton mine operated between 1971 and 1974, and produced 7,260 t of Cu, 6,354 kg of Ag, and 126 kg of Au from 471,900 t milled (BC MINFILE) from open pits. The property has existing infrastructure, including a 750 t per day conventional mill, assay and metallurgical laboratories, tailings impoundment, waste dumps, and two open pits. The company has been completing environmental baseline work and updating mine plans, and is working towards fulfilling requirements for permit application.

4.3.2. Slocan Silver (Klondike Silver Corp; Ag-Pb-Zn±Au)

Klondike Silver Corp's **Slocan Silver** project consists of several past producers in a rich historic Ag-Pb-Zn mining area. The area is underlain by sheared and brecciated argillite and slates of the Slocan Group (Triassic) that are cut by Nelson granodiorite and quartz monzonite dikes (Middle Jurassic; Fig. 7). Shear-hosted polymetallic veins contain Ag-Pb-Zn mineralization. Klondike's holdings include the Sandon, Hewitt, Silverton Creek, Cody Creek, Payne, and Jackson Basin camps, and the Silvana, Wonderful and Hinckley past-producers. The main vein at Silvana is within an eight km long structure that yielded about 242 t Ag, 28,691 t Pb, 26,299 t Zn and 72 t Cd from 510,964 t mined between 1913 and 1993, mainly as argentiferous galena and sphalerite. The company's mill at Sandon is a 100 t per day concentrator that operated at an average rate of 40 t per day (Fig. 18). It was shut down in the latter half of 2013 as the company re-evaluated geological modeling and furthered exploration targets, and engineering studies in 2014. In 2015, the mine and mill remained on care and maintenance, and the company focused on environmental work, and engineering upgrades to the tailings facility and underground structures.

Fig. 18. Klondike Silver Corp's (Slocan Silver) mill at Sandon.

5. Exploration activities and highlights

Exploration projects can be categorized by exploration stages. The grassroots stage represents initial reconnaissance of a property and involves such activities as airborne geophysical surveys, geochemical sampling, mapping and prospecting. Early stage exploration consists of focused work on a target and typically includes ground geophysical surveys, trenching, drilling, and continued grassroots stage work. As well, First Nations consultation should begin at least by early stage exploration and continue throughout the remaining stages. Advanced stage exploration includes resource delineation, preliminary economic assessments and prefeasibility studies. Activity at the advanced stage typically includes infill drilling, bulk sampling and baseline environmental data collection. These activities continue into the mine evaluation stage. At the mine evaluation stage, detailed environmental, social, engineering and financial evaluation activities are carried out. As well, permit applications are submitted and it is proposed that the project become a mine.

Exploration continued in the Kootenay-Boundary Region in 2015 (Fig. 1; Table 4) for a variety of targets. Over last year, there was a decreased amount of exploration dollars spent on drilling and advanced stage projects, but increased spending on grassroots projects and assessment work (Fig. 4).

5.1. Precious metal projects

5.1.1. Gold Drop (Ximen Mining Corp.)

Ximen Mining Corp. continued work on their **Gold Drop** property. The company carried out mapping, trenching and sampling at the North Star and Gold Drop vein systems (Fig. 19), and over their surrounding claims, including the Amandy, Lakeview and Moonlight. One grab sample from trenching on the Northstar-Gold Drop vein assayed 159 g/t Au, 744 g/t Ag, 70 ppm Cu, and 17,000 ppm Pb. Most samples that were elevated in Au also had elevated Ag, Pb, and Cu.

The property is underlain by metamorphic rocks of the Knob Hill complex (Paleozoic) that have been intruded by granodiorite and diorite of the Nelson Plutonic suite and by biotite syenite and diorite/andesite dikes of the Coryell suite (Fig. 7). Gold-bearing veins in the area post-date the Nelson intrusives and pre-date the Coryell suite. The Gold Drop-North Star veins range in thickness from 10 cm to 2 m. North-trending, steeply-dipping strike-slip and normal faults, and low-angle detachment faults post-date mineralization (Caron, 2014). The property hosts at least 8 known low-sulphide, gold-bearing veins, and hundreds of metres of historic underground workings.

Fig. 19. Trenching at the Gold Drop-North Star vein system, near one of the historic adits on the property.

5.1.2. Greenwood Gold (Grizzly Discoveries Inc.)

Grizzly Discoveries Inc. continued working at their **Greenwood Gold** property, which consists of over 90,000 hectares in eight different claim groups that extend from east of Greenwood to west of Anarchist Summit. In 2015, the company conducted a field program to re-evaluate their claim group, and have outlined a variety of targets for further exploration. Exploration and reconnaissance target types identified for future exploration on the Dayton, Rock Creek (Ket 28), Motherlode, Sappho, Overlander, and Mount Attwood claim groups include; Cu-Au-Ag skarn, Au-Ag epithermal, Ag-Pb-Zn±Au shear-hosted, stockworks and breccias and Cu-Au-Ag alkalic porphyry targets. Drilling is planned for the Ket 28 target in 2016. The company also signed an option agreement with Kinross Gold Corporation's wholly owned subsidiary, KG Exploration (Canada) Inc., to earn 75% interest in approximately one third of the **Greenwood Gold** land holdings. The property hosts similar geology and mineralization to Kinross Gold Corporation's Kettle River-Buckhorn mine and mill (1,800 tonne per day capacity), which is located just to the south of the project area, across the border in Washington State, USA.

The area is underlain by rocks of the Paleozoic Knob Hill and Anarchist Groups, Brooklyn Formation (Triassic), and Penticton Group (Eocene; Fig. 7). Intrusions of Jurassic, Cretaceous, and Eocene age occur throughout the area.

5.1.3. May Mac (Golden Dawn Minerals Inc.)

Golden Dawn Minerals Inc. has been evaluating several historic mineralized areas on their Greenwood project, including the Deadwood, Wild Rose, Amigo, and **May Mac**. Golden Dawn's land holdings are adjacent to Grizzly Discovery Inc.'s properties near Greenwood, with similar geology hosting similar deposit types. In 2015, the company began sampling and mapping at the **May Mac** and Amigo, and then began drilling and bulk sampling late in the year. Channel samples collected from the historical underground workings showed elevated gold and silver values, and the initial drilling intersected similar quartz vein and/or stockwork zones with iron, lead, and zinc sulphides. Drill and assay results are pending, as the company continues their work program into 2016.

5.1.4. LH (Magnum Goldcorp Inc.)

Magnum Goldcorp Inc. continued work at the **LH** property as a follow up to their 2014 program. Drilling was carried out on anomalies identified from 2014 SP, IP and magnetometer surveys, and along alteration zones at the Ridge zone. Drilling also targeted extensions of high-grade zones from previous drilling and sampling in the historic underground workings.

Mineralization follows a zone of fracturing, faulting, and silicification in a roof pendant of what are interpreted as Slocan Group sedimentary rocks and Rossland Group metavolcanic rocks, within granodiorites of the Nelson batholith (Fig. 7). Gold mineralization occurs within a structural zone up to 13.7 m in width, in mesothermal quartz lenses and veins averaging 30 to 60 cm in thickness, and in silicified breccias and stockworks in hornfelsed volcanic rocks. Both styles of mineralization are associated with elevated sulphides, including pyrite, pyrrhotite, arsenopyrite, and chalcopyrite.

Table 4. Selected exploration projects, Kootenay-Boundary Region, 2015.

Project	Operator	MINFILE	Commodity; Deposit type	Resource (NI 43-101 compliant unless indicated otherwise)	Work Program	Comments
Gold Drop	Ximen Mining Corp.	082ESE 153, 152, 126	Au-Ag-Pb-Zn+/-Cu; Vein, alkalic intrusion-associated Au	-	Trenching; mapping; sampling	Chip sample results up to 0.60 m grading 43.6 g/t Au, 141 g/t Ag; and 0.55 m grading 56.2 g/t Au, 259 g/t Ag; grab sample grading 159 g/t Au, 744 g/t Ag, 70 ppm Cu, and 1.7% Pb
Greenwood Gold	Grizzly Discoveries Inc.	082ESW 022, 210, 034, 221	Au-Cu-Pb-Zn-Ag+/-Mo; Cu-Au-Ag skarn, polymetallic vein, Au-vein, porphyry	-	Mapping; sampling; geological evaluation	Option agreement with KG Exploration (Canada) Inc; extensive landholding with numerous targets
May Mac	Golden Dawn Minerals Inc.	082ESE 045, 116	Au-Ag-Pb-Zn+/-Cu; Cu-Au-Ag skarns, polymetallic veins, Au-veins	37,200 t grading 3.4 g/t Au, 342.8 g/t Ag, 2% Pb, 2% Zn (1981; non-compliant)	Drilling (2,000 m); mapping; rock and channel sampling;	Channel sampling: 0.87m grading 12.97 g/t Au, 34 g/t Ag; 0.2 m grading 36.37 g/t Au, 43 g/t Ag; 0.4 m grading 17.07 g/t Au, 11 g/t Ag; 0.4 m grading 4.46 g/t Au, 529 g/t Ag; Drilling intersected gold-bearing vein and stockwork system with lead and zinc sulphides, assays pending
LH	Magnum Goldcorp Inc.	082FNW 212	Cu-Ag-Au; subvolcanic, skarn, Au-veins	-	Drilling (11 DDH); SP and IP/ magnetometer survey	Phase I drilling: 16.9 m grading 13.58 g/t Au, including 10.9 m grading 20.61 g/t Au; 11m grading 20.66 g/t Au; results from Phase II drilling are pending
Vine	PJX Resources Inc.	082GSW 050, 049, 035	Pb-Zn-Ag+/-Au; polymetallic vein, SEDEX	1.3 Mt grading 2.2 g/t Au, 3.12% Pb, 36.3 g/t Ag, 3.12% Zn (2011; non-compliant)	Drilling (20 DDH; 5000 m); gravity survey; geophysical and geological modeling	Infilled gravity survey grid; detailed geophysical and geological model
Monroe	Sonoro Metals Corp.	082GSW 069, 035, 041	Pb-Zn-Ag+/-Au, Cu; SEDEX	-	Drilling (1114 m); petrographics; mapping	Drilling on UTEM anomaly; encountered tourmalinized breccia zones
Sully	Santa Fe Metals Corp.	-	Pb-Zn-Ag+/-Au; Gravity anomaly, sediment-hosted	-	Mapping; magnetic surveys; geophysical modeling	Mass models suggest two gravity anomalies may be stratiform sulphide mineralization; complex faulting on property
Cummins River	MMG Limited	083D 001, 002, 015	Pb-Zn-Ag+/-Cu; sediment-hosted	Indicated: 5 Mt grading 7g/t Ag, 0.6% Pb, 2.3% Zn (1987; non-compliant)	Heli-borne VTEM (623 line-km); soil and rock geochemistry; mapping	Stratiform sulphides; soil survey followed up on conductive and magnetic anomalies from VTEM; Zn-Pb-Mn anomaly in soil survey

Table 4. Continued.

River Jordan	Silver Phoenix Resources Inc.	082M 001, 002	Zn-Pb-Ag; Broken hill, SEDEX, Irish-type carbonate-hosted	-	Drilling (494 m); mapping; sampling	1.85 m grading 1.27% Pb, 6.04% Zn, 12.0 ppm Ag; 1.48 grading 4.01% Pb, 11.6% Zn, 33.8 ppm Ag
J & L	Huakan International Inc.	0825M 003	Ag-Pb-Zn+/-Au; SEDEX, Irish-type carbonate-hosted, polymetallic veins	Main Zone: 3.95 Mt grading 5.68 g/t Au, 56.5 g/t Ag, 1.94% Pb, 3.56% Zn (Measured +Indicated); Yellowjacket Zone: 1.0 Mt grading 64.1 g/t Ag, 2.77% Pb, 9.08% Zn, 0.21 g/t Au (Indicated) (2011)	Engineering and environmental baseline studies; metallurgical test work; preliminary economic assessment	Care and maintenance underground mine; process optimization; upgrades to facilities
Thor	Taranis Resources Inc.	082KNW 030, 031, 060, 061	Ag-Pb-Zn+/-Au; polymetallic veins and breccia, stratiform manto	Indicated: 640,000 t grading 0.88 g/t Au, 187 g/t Ag, 0.14% Cu, 2.51% Pb, and 3.51% Zn; Inferred: 424,000 t grading 0.98% Au, 176 g/t Ag, 0.14% Cu, 2.26% Pb, and 3.2% Zn (2013: potential open pit and underground)	Panel sampling; surveying and sampling stockpiles, environmental baseline studies	Panel sampling at SIF zone: 17.6 m grading 30.59 g/t Au; Panel sampling at Gold Pit: 2.04 m grading 52.4 g/t Au, 1,528 g/t Ag, 1.39% Pb, 0.08% Zn and 1.64 m grading 14.3 g/t Au, 254.9 g/t Ag, 0.99% Pb, 0.52% Zn
Teddy Glacier / Spider Mine	Jazz Resources Inc.	082KNW 069	Ag-Pb-Zn+/-Au; polymetallic veins	Inferred: 44,000 t grading 4.46 g/t Au, 7.94% Pb, 6.74% Zn (2007; non-compliant)	Metallurgical test work (flotation); ML/ARD; bulk sample permitting; environmental baseline studies	Pb flotation concentrate with 62% Pb, 83% Au and 92% Ag; Zn flotation concentrate with 48.7% Zn; Permitting pilot mill and tailings pond at Spider Mine
Jersey-Emerald	Margaux Resources Inc.	082FSW 010, 009	Pb-Zn-Ag+/-W, Au, Mo, Bi; stratiform replacement, skarn	Measured and Indicated: 3.071 Mt grading 0.36% WO_3 (2015)	Dewatering underground workings at Emerald; mapping; sampling; geological modeling	10.2 m grading 24.98 g/t Au with elevated bismuth; 2.75 m grading 0.49% WO_3; 4.5 m grading 0.5% WO_3; 3.35 m grading 0.52% WO_3; 2.65 m grading 0.59% WO_3; 4 m grading 0.35% WO_3; 6.45 m grading 0.33% WO_3, 0.65 g/t Au; 5.15m grading 0.47% WO_3

Table 4. Continued.

Willa	Discovery Ventures Inc.	082FNW 070, 071	Ag-Pb-Zn +/-Au-Cu-Mo; subvolcanic breccia, polymetallic veins, porphyry Mo, Au-skarn	Measured and Indicated: At a 3.5 g/t Au cut-off: 758,199 t grading 6.67 g/t Au, 0.85% Cu, 12.54 g/t Ag; Using a 2.5 g/t Au cut-off: 1,337,457 t grading 5.05 g/t Au, 0.74% Cu, 10.72 g/t Ag (2012)	Preliminary Economic Assessment; geological modeling; mine design; MAX facility upgrades; environmental baseline studies	Acquisition of the MAX Mine and mill facilities; plan to process ore from the Willa; estimated mine life of approximately 4.1 years at 500 t/day
Referendum/ Whitewater	Braveheart Resources Inc.	082FSW 222, 171	Au-Ag-Pb-Zn+/-Mo; polymetallic veins, Au-veins	-	Trenching; bulk sampling (1,000 t at Referendum; 100 kg at Whitewater); milling and flotation	Projected gold recoveries of 90% from preliminary flotation testing; further results pending
Record Ridge/ Midnight	West High Yield (W.H.Y) Resources Ltd.	082FSW 119, 116, 117	Au-Ag-Pb-Zn, Mg; polymetallic veins, ultramafic-hosted talc, magnesite	-	VLF-SP surveys; mapping; sampling; environmental baseline	Identified drill targets and plan on bulk sampling at the Midnight and Record Ridge properties
Marten Phosphate	Fertoz Ltd.	082GNE 027	Phosphate; upwelling	-	Mapping; sampling; XRF; environmental baseline; permitted bulk sample	XRF of stockpiles: 24- 27% P_2O_5; product shipped for direct spreading on agricultural area
Cro Phosphate	HighBrix Manufacturing Inc.	082GNE031, 035	Phosphate; upwelling	-	Drilling (7 DDH); trenching; bulk sampling	Product shipped for direct spreading on agricultural area
Elko	Pacific American Coal Limited	082GSE029	Coal (HCC, PCI)	Measured: 19.2 Mt + Indicated: 57 Mt + Inferred: 181.3 Mt (JORC 2015)	Mapping; sampling; geological modeling; field reconnaissance to locate historic adits and drilling; JORC compliant resource	Mapping of 5 coal seams over the property; 3 seams have hard coking coal quality, 2 seams have PCI coal

5.2. Polymetallic base and precious metal projects

5.2.1. Vine (PJX Resources Inc.)

PJX Resources Inc. continued drilling in 2015 at the **Vine** property, and updating their geological-geophysical model. Gravity geophysical surveys have identified two target areas (East and West) that are interpreted to have potential for massive sulphide mineralization (Pb-Zn-Ag±Au) in the Aldridge Formation (Fig. 7). Recent drilling on the east and west gravity targets has identified disseminated and replacement style sphalerite (zinc) along fractures and associated with carbonate-rich beds. At the East target, localized sericite, chlorite, albite, garnet, and biotite alteration, and complex structures suggest that the source of the gravity anomaly may be flat-lying and bedding parallel, or contorted within the hanging wall of the Moyie fault. Additional drilling is planned to attempt to explain anomaly sources in the target areas.

The property hosts the shear-related Vine Vein (Pb-Zn-Ag-Au) occurrence, which was discovered in the late 1970s, in middle Aldridge Formation argillites and quartzites. Historic trenching and drilling revealed vein-related and disseminated sulphides (pyrite, sphalerite, and galena) along a strike length of over 1000 m, and to a depth of over 700 m. Bedded massive sulphides were intersected in two historic drill holes at the Vine vein, and led to re-evaluation of the gravity and EM survey data.

5.2.2. Monroe (Sonoro Metals Corp.)

At the **Monroe** property, Sonoro Metals Corp. re-evaluated historic drilling, soil geochemistry, and geophysics, targeting sulphide mineralization in the Aldridge Formation (Fig. 7). Historic drilling on the property has encountered disseminated and stratiform sphalerite, pyrrhotite, pyrite and galena at the Sullivan time-horizon, and pervasive zones of hydrothermal alteration. The property lies in a favorable structural corridor at the intersection of two major fault zones, with numerous other showings, including vent and breccia complexes, and abundant sericite, albite, chlorite, garnet and biotite alteration. In 2015, the company and their partner Eagle Putt Ventures Inc., drilled on a UTEM anomaly offsetting a historic hole that had intersected distal-style mineralization at the lower-middle Aldridge contact. The 2015 hole encountered tourmalinized zones and pyrrhotite breccia-style mineralization.

5.2.3. Sully (Santa Fe Metals Corp.)

Santa Fe Metals Corp. expanded their magnetic surveys at the **Sully** property, with additional drilling planned to target two subsurface gravity anomalies in the Purcell Supergroup (Fig. 7). Mass models of the anomalies are consistent with contrasting specific gravities of sulphide mineralization, relative to the country rocks on the property. Recent mapping, drill-hole correlations, and interpretations suggest the anomalies may represent fault repetition of an upturned and rotated stratabound horizon in the Aldridge Formation. Drilling has intersected traces of Pb-Zn-Cu sulphide mineralization and sericite alteration, and correlations indicate complex fault structures on the property. The company intends to continue exploration in 2016.

5.2.4. Cummins River (MMG Limited)

MMG Limited worked at the **Cummins River** property this year on both their 100% owned claims, and their joint venture claims with Tsar Creek Holdings Ltd. In 2015, the company conducted geological mapping and an airborne VTEM survey, and followed up on conductive and magnetic anomalies with soil geochemical surveys and rock sampling. Results identified a large zinc-lead-manganese anomaly near the Bend North Road MINFILE showing.

The area is underlain by a thick sequence of amphibolite-grade lower to middle Cambrian quartzites, carbonates and pelites of the Miette, Gog, and Chancellor Groups (Fig. 7) on the western limb of the Porcupine Creek anticlinorium. At the Cummins River Canyon, pyrite, pyrrhotite, sphalerite and galena are hosted in the Tsar Creek Formation (Chancellor Group) as intensely deformed, stratiform massive sulphides, siliceous sulphides, and mineralized manganiferous dolomite, 5 to 10 m thick.

5.2.5. River Jordan (Silver Phoenix Resources Inc.)

Silver Phoenix Resources Inc. conducted a TDEM geophysical survey in 2013, and followed up with drilling in 2015 at the **River Jordan** property. The drilling targeted the down-dip extension of sulphide mineralization that extends over a two km strike length on surface. Two zones of sphalerite, galena, pyrite, and pyrrhotite mineralization were intersected and there are plans for further follow-up drilling. The property is within a series of gneissic domal structures along the eastern margin of the Shuswap Metamorphic Complex (Fig. 5). Replacement-style massive sulphides are hosted in calc-silicate gneisses of Proterozoic to Lower Paleozoic aged rocks on the southern flank of the Frenchman Cap Dome.

5.2.6. J&L (Huakan International Mining Inc.)

At the **J&L** gold-silver-zinc-lead property, Huakan International Mining Inc. continued pre-feasibility work, environmental baseline work, and engineering design work on tailings and mine facilities. The property is underlain by metasedimentary and metavolcanic rocks of the Hamill and Lardeau groups (Fig. 7). Mineralization is hosted by the Hamill Group (Badshot and Mohican formations), which consist of sheared and intensely folded impure quartzites, quartz sericite, sericite, and chlorite schists and phyllites, and grey banded to carbonaceous limestones. The main zone is a shear hosted, sheeted Au-Ag-Pb-Zn vein deposit that averages 2.5 m in thickness. Underground drilling and drifting has defined the zone over a 1.4 km strike length and for 850 m down dip; on surface the zone has been traced for 1.6 km. The Yellowjacket Zone sub-parallels, and is in the immediate hanging wall of the main Zone. Stratabound Ag-Pb-Zn is interpreted as a structurally controlled contact-related replacement deposit. A NI 43-101 resource estimate for the main zone that was released in 2012 reported 3.95 million tonnes combined in the measured and indicated categories, containing 722,000 ounces of gold and 7,179,000 ounces of silver at grades of 5.68 g/t Au and 56.2 g/t Ag, along with 1.94% Pb and 3.56% Zn.

5.2.7. Thor (Taranis Resources Inc.)

The **Thor** property is underlain by a thick succession of folded and faulted rocks of the Badshot Formation and Lardeau Group (Fig. 7), with potential for stratiform base metal sulphides (Ag-Pb-Zn-Au-Cu). In 2015, the company surveyed and sampled stockpiles at the Broadview, Great Northern, and True Fissure zones, and channel sampled at the Gold Pit zone, with results pending. Primary stratiform mineralization predates folding and faulting, and parallel horizons of galena, chalcopyrite, pyrite, and sphalerite extend along a 2 km strike length. High-grade gold is also found in late quartz veins that flank sulphide deposits (Fig. 20). A number of other targets have been identified on the property, which appear as VLF conductors and gossans. In 2014, Taranis Resources Inc. followed up on 2013 work with EW-sized core drilling at the SIF zone, where visible gold occurs in quartz-ankerite veins, and discovered mineralization at the SIF Carbon zone. An initial shaker table test from the

Fig. 20. Quartz veining and sulphide mineralization at the Thor property.

Fig. 21. Skarn mineralization in the underground at the Jersey-Emerald.

SIF Carbon zone yielded a sulphide concentrate that graded 512.4 g/t Au and 540 g/t Ag. The NI 43-101 resource estimate (2013; Table 4), based on drilling of 152 holes between 2007 and 2008, highlights both open-pit (62% of the property) and underground mining potential. Historic production on the property was from the Silvercup, Triune, Nettie L. and True Fissure mines.

5.2.8. Teddy Glacier/Spider Mine (Jazz Resources Inc.)

The **Teddy Glacier** property has been intermittently explored since the 1920s. In 2015, the company continued mapping and sampling, and conducted environmental baseline studies and mill upgrades to satisfy permit conditions. Jazz Resources Inc. plans to collect a bulk sample and process it at the **Spider Mine** mill.

The property is underlain by tightly folded and sheared limestones, carbonaceous phyllites, and grits of the Index and Jowett formations (Lardeau Group; Fig. 7). Mineralization occurs as a series of irregular Ag-Pb-Zn±Au polymetallic veins at the Big Showing, East Vein, Dunbar Vein, and West Vein. The Vimy Ridge stratabound zone exists as massive galena-pyrite-chalcopyrite in a silicified limestone at a schist-limestone contact (Shearer, 2007).

5.2.9. Jersey-Emerald (Margaux Resources Ltd.)

Margaux Resources Ltd. continued work at **Jersey-Emerald** (Fig. 21) to follow-up on their 2014 drilling. 2015 work was focused on dewatering the underground workings at the **Emerald**, in preparation for further underground drilling and sampling. They also conducted mapping and sampling work at the **Jersey** with plans for drilling in 2016. The company released a new tungsten resource estimate for the **Emerald** of 3.071 Mt grading 0.34% WO_3 (measured and indicated) with 5.48 Mt grading 0.273% WO_3 (inferred) using a 0.15% WO_3 cut-off grade.

The property lies at the south end of the Kootenay Arc, and is underlain by interstratified carbonates and pelites of the Laib (Cambrian) and Active (Ordovician) Formations (Fig. 7). Coarse-grained marble to garnet-pyroxene skarn occurs in the Truman and Reeves members at contacts with small Cretaceous granitic stocks, and Nelson (Jurassic) intrusions. The property contains: stratiform lead-zinc mineralization; tungsten (with minor molybdenum) skarn mineralization; quartz veins, silicified limestone, and greisen-type alteration with Au, and Bi; and Mo porphyry. Exploration on the property dates back to the late 1800s, when gossanous outcrops were discovered by early prospectors. The **Emerald** Tungsten mine has stratabound Pb-Zn mineralization in the Reeves member, and a W-skarn zone in the Truman member, and operated from 1942 to 1943, then intermittently until 1973. The **Jersey** mine has stratiform Pb-Zn mineralization at the base of the Reeves, and the mine operated between 1949 and 1970.

5.2.10. Willa (Discovery Ventures Inc.)

Discovery Ventures Inc. continued work on the **Willa** property, and acquired the interest of Forty Two Metals Inc. in the **MAX** mine, mill, and tailings facilities. The resource was updated in 2012, and in 2015, the company updated their Preliminary Economic Assessment and continued mapping, sampling, and environmental baseline work. They have also begun repairs, maintenance, and modifications to the **MAX** facilities. The **MAX** mine is located 135 km to the west near Trout Lake, and has been on care and maintenance since 2011. The company plans to use the mill initially for bulk sample processing of ore from the **Willa**.

The **Willa** deposit is in a roof pendant of the Nelson batholith, containing mafic volcanic rocks of the Rossland Group, intruded by felsic dikes. To the north are Slocan Group metasedimentary rocks that contain silver-lead-zinc mineralization. Lamprophyre dikes and faults post-date and crosscut the metavolanics and intrusions. Mineralization (Pb-Zn-Ag-Au±Mo) is in structurally controlled silica-rich breccias, pipes and stockwork veins, with local massive- to disseminated, replacement zones. The main copper-gold mineralization is hosted in a sub-volcanic breccia pipe at the centre of a hypabyssal complex of quartz and feldspar porphyritic intrusions, and has an alkalic porphyry signature. Chalcopyrite, pyrite, and magnetite mineralization comprise three zones in, and peripheral to, the breccia pipe (Ash, 2014).

5.2.11. Whitewater/Referendum (Braveheart Resources Inc.)

Braveheart Resources Inc. continued their bulk sampling and trenching exploration work at the **Whitewater** and **Referendum** properties. Late in 2015, bulk samples were sent for crushing/milling and flotation testing, with results pending. Further work is planned for 2016.

The area is underlain by Middle to Late Jurassic Nelson Intrusions in contact with andesite tuffs, balsaltic tuffs, lapilli tuffs of the Lower Jurassic Elise Formation (Fig. 7). Mineralized quartz veins hosted by granitic rocks and northeasterly trending shear zones, contain galena, sphalerite, pyrite, chalcopyrite, and molybdenite mineralization. At **Whitewater**, banded veins are 0.5 to 2 m thick, and at the **Referendum**, visible gold is present in shear-hosted banded quartz veins that are up to 2 m in width and 400 m in length.

5.2.12. Record Ridge/Midnight (West High Yield Resources Ltd.)

In 2015, West High Yield (W.H.Y.) Resources Ltd. worked on their **Record Ridge** and **Midnight** properties. The property hosts gold mineralization in silicified zones, and magnesium and nickel in serpentinized ultramafic rocks. In 2015, the company conducted VLF and SP surveys, conducted mapping and sampling, generated drill targets, and conducted environmental baseline studies for the 2016 drill and bulk sampling programs for both the **Midnight** and **Record Ridge** projects. The company released a Preliminary Economic Assessment for their **Record Ridge** magnesium project in 2013, and sampled mainly on reject rock piles of several historic mines in 2014.

The IXL, **Midnight** and OK claims straddle the north-dipping contact between a Permian serpentinized ultramafic body to the south, and Rossland Group (Elise Formation) volcanic rocks and Mount Roberts Formation sedimentary rocks to the north (Fig. 7). The volcanic rocks are hornfelsed, with irregular zones of disseminated magnetite, pyrite, pyrrhotite, and local tungsten mineralization. Gold mineralization occurs in quartz veins near the ultramafic contacts. Veins are typically 0.1-0.6 m wide, extend along strike for up to 70 m, and consist of quartz with minor ankerite, pyrite, chalcopyrite and galena. Gold mineralization also occurs in local areas of pyrrhotite-pyrite bearing carbonate-talc-quartz alteration and carbonate veining (listwanite-type) in the serpentinites. Dikes and irregular bodies of Rossland monzonite, Coryell syenite and biotite lamprophyres cut both the ultramafic and the volcanic rocks.

5.3. Industrial mineral projects

5.3.1. Marten Phosphate (Fertoz Limited)

Fertoz Limited was active at their **Marten Phosphate** project, targeting phosphoritic beds of oolitic sandstone at the base of the Fernie Formation (Jurassic), immediately above the Spray River Group (Triassic; Fig. 7). Mapping and sampling on the property in 2015 followed up on 2014 work that included a drilling and trenching program and excavation of a small bulk sample that was sent for agricultural testing. The phosphoritic beds have been mapped for over 1,200 m from historical shafts. Initial handheld XRF analysis indicates 24-27% P_2O_5. The company also conducted environmental baseline work and has received approval for a 10,000 t bulk sample.

5.3.2. Cro Phosphate (High Brix Manufacturing Inc.)

Hi Brix Manufacturing Inc. is also targeting the basal Fernie phosphatic zone at the **Cro** project. In 2015, they carried out drilling, trenching, and bulk sampling. Material was shipped for agricultural testing, and results are pending.

5.4. Coal projects

5.4.1. Elko (Pacific American Coal Limited)

In 2015, Pacific American Coal Limited carried out mapping and sampling on their **Elko** coal project property to confirm the location of coal outcrops, and to locate and compile historical adits and drill data on the property. They also compiled geological data, and outlined locations for future drilling.

The project is located in the Crowsnest Coal field (Fig. 10), targeting Mist Mountain coal seams within the McEvoy Syncline. Five seams outcrop on the property, with thicknesses of 2.57 to 5.0 metres, and quality ranging from hard coking coal to PCI coal. Block modeling of the project indicates the potential for a small open cut operation, with potential development of a larger underground operation. The company released a JORC resource estimate of 181.3 Mt inferred + 57 Mt indicated + 19.2 Mt measured, and has plans for drilling in 2016.

6. Geological research

6.1. Geological Survey of Canada: TGI-4

The Geological Survey of Canada (GSC) has been working on a multi-year project that began in the area in 2010 as part of the **Targeted Geoscience Initiative (TGI-4).** A portion of the project was to develop geoscience knowledge and techniques to better understand and model SEDEX mineral systems, and mineral potential of the Purcell Anticlinorium (Fig. 5). Geological, geophysical, and geochemical data throughout the Purcell Basin were compiled into a database, in order to generate a regional 3D digital model and maps over a large area of the Purcell Anticlinorium, and give new perspectives and understanding on ore controls. In 2015, a compilation of papers was released on the processes and implications for exploration in Zn-Pb deposits (Open File 7838; Paradis (Ed.), 2015), as well as a 3D drillhole database (Open File 7817; Schetselaar et al., 2015).

In addition to the 2015 compilation and data release, preliminary releases since 2010 also include results of: magnetic susceptibility studies and geophysical perspectives of the Purcell Anticlinorium and Moyie anticline (Thomas, 2012; Thomas, 2013; Thomas, 2015; Thomas et al., 2013); the geology and geochemistry of Ag-Pb-Zn veins (Paiement et al., 2012), and carbonate-hosted non-sulphide Zn-Pb mineralization (Paradis et al., 2011); discussions of SEDEX concepts in the Cordillera (Paradis and Goodfellow, 2012); and zircon ages on the western margin of the Purcell Basin (Lydon and van Breeman, 2013). Preliminary interactive digital maps and data (Joseph et al., 2011) have been released, along with concepts on 3D modeling and interpolation of geological surfaces (Hillier et al., 2013b) and strike and dip observations (Hillier et al., 2013a).

6.2. Geoscience BC

Geoscience BC's **SEEK** project (Stimulating Exploration in the East Kootenays) is a partnership program with the East Kootenay Chamber of Mines focused on mineral potential in the Belt-Purcell Basin (Purcell Anticlinorium; Fig. 5). Ground geophysical data have been compiled for the region into a single database (Sanders, 2012; Hartlaub, 2013), and in 2013 new data were added in the St. Mary Valley area, near Kimberley and the historic Sullivan mine (Sanders, 2013). In 2014 and 2015, SEEK projects included a paleomagnetic study on structures in the Northern Hughes Range (Clifford, 2014; Ransom, 2015), geological mapping and compilation along the Kimberley Gold Trend (Seabrook, 2015), and mapping of vent systems and sub-basins in the middle Aldridge Formation near Cranbrook (Kennedy, 2015). Funding also supports the Fort Steele Drill Core Library Project, which is managed by the East Kootenay Chamber of Mines. The project aims to develop a secure repository to preserve some of the East Kootenay drill core, including core from the Sullivan mine and some of the other recent drilling in the area.

7. Summary

In 2015, exploration and mining continued in the region and development continued on several of the larger projects in environmental assessment process, but investment funding was lower than in the previous year for exploration-stage projects. Major mine development, expansion plans, and projects in the East Kootenay coalfields with long-term timelines will likely continue to advance in 2016. As coal companies scale back exploration in response to low coal prices however, they are seeking to reduce capital costs by optimizing efficiencies at their existing operations. Several mine development projects for industrial minerals and the Gallowai Bul River mine restart, continue to move forward. Exploration for SEDEX-style base metals in the Purcell Anticlinorium, and base and precious metal mining projects in the region remain active, but there has been an increased focus on grassroots exploration work due to a reduction in the availability of venture capital for larger projects. Despite this, several drill and bulk sampling programs are planned for 2016.

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