Exploration and mining in the Southeast Region, British Columbia

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1. Introduction

The Southeast (Kootenay-Boundary) Region, in the southeast corner of the province (Fig. 1), offers a variety of mining and exploration opportunities accessible by well-developed infrastructure. Five operating metallurgical coal mines in the Elk Valley account for most of Canada's coal production, and exports. Several mines produce industrial minerals including silica, magnesite, gypsum, graphite, and phosphate. Placer mining occurs throughout the region, and several small operations produce aggregate, sand and gravel, and dimension stone. The region also hosts the historic lead-zinc-silver Sullivan mine, which operated from 1909 to 2001, and produced over 8 Mt of zinc, 8.5 Mt of lead, and 298 Moz of silver throughout its life. The Trail smelter (Teck Resources Ltd.) is still in operation, and expected volumes for 2016 are approximately 295,000 tonnes of refined zinc, 90,000 tonnes of refined lead, and up to 25 million ounces of silver. Exploration for both base metals and precious metals continues to be an exploration focus for the region.

As a pilot project, the Ministry of Energy and Mines partnered with the Association for Mineral Exploration and Ernst & Young LLP to develop a comprehensive online survey to collect expenditure data. For the Southeast Region, exploration expenditures are estimated at $37.4 million and exploration drilling is estimated at approximately 31,000 m (Clarke et al., this volume; Ernst & Young LLP (E&Y), 2017 in press).

Highlights for 2016 include

- the West Line Creek water treatment facility (Teck Coal Limited) was commissioned in February 2016
- conditional approval of the Elkview mine Baldy Ridge extension (BRE) (Teck Coal Limited) in September, 2016
- the Line Creek Burnt Ridge extension (BRX) (Teck Coal Limited) entered the pre-application stage of Environmental Assessment
- active programs at the Crown Mountain (NWP Coal Canada Ltd.) and Michel Creek/Loop Ridge (CanAus Coal Limited) coal projects, which are both in the pre-application stage of Environmental Assessment
- the Greenhills Cougar Pit extension (CPX) (Teck Coal Limited) working towards the pre-application stage of Environmental Assessment
- advancement of the Kootenay West gypsum mine (CertainTeed Gypsum Canada Inc.)
- the Driftwood Magnesite project (MGX Minerals Inc.) was granted a 20-year lease for quarry development
- plant construction at Moberly Silica (Heemskirk Canada Limited) to redesign operations for silica frac sand production
- the pending sale of the Lexington mine and mill to Golden Dawn Minerals Inc.

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 are evidence that the western margin of 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, with a complex history of deformation, intrusion, metamorphism, and mineralization.

The Southeast 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 and Colpron, 2007; 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 complexly structured accretionary wedge. Intrusive events superimposed on the region (Proterozoic, Devonian, Jurassic, Cretaceous, and Cenozoic) represent periods of enhanced

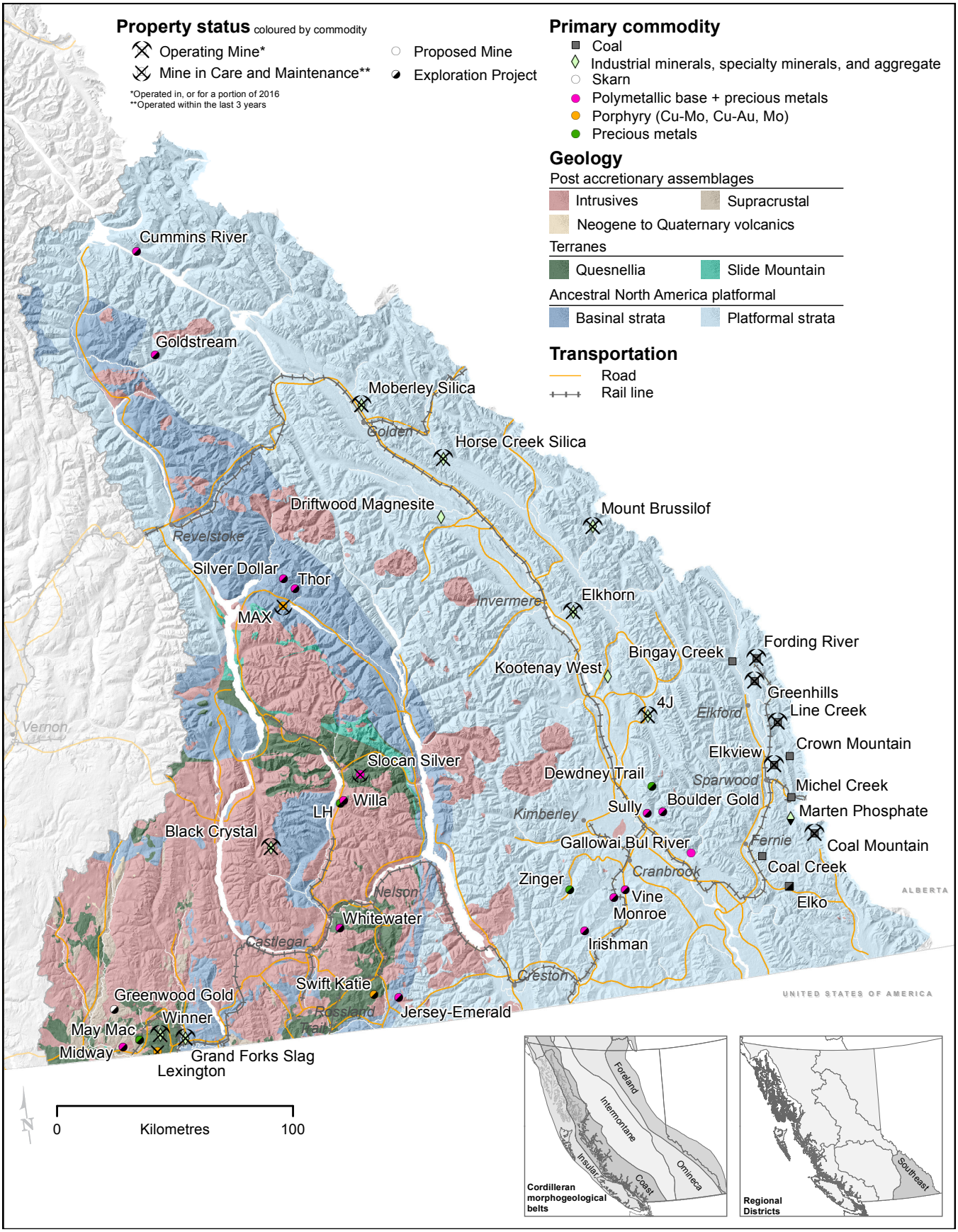

Fig. 1. Mines and selected exploration projects, Kootenay-Boundary Region, 2016. Terranes from the BC digital geology map (Cui et al., 2015).

tectonic activity, and deep tectonic structures along terrane boundaries and in Archean basement rocks show evidence of episodic reactivation thought time.

Historically, the Canadian Cordillera has been divided into five northwest-trending physiographic belts. The Southeast Region includes two of these belts (Fig. 2): 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 its eastern edge in southeastern BC, 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. The basement is an assemblage of microcontinents and magmatic arcs that formed through progressive accretion from the Archean to Mesoproterozoic. A structural grain was imparted on the basement by the successive orogenic events during its formation, and is seen on the regional aeromagnetic map of western Canada (Fig. 3). Northeast-trending basement structures later influenced both Cordilleran tectonism and metallogeny (e.g., Ross et al., 1991; McMechan, 2012; Nelson et al., 2013). For example, the Moyie-Dibble Creek (MDC) (Fig. 3) fault has been interpreted by Price (1981) and McMechan (2012) as the surface expression of the Vulcan Tectonic zone (Figs. 2, 3). Abrupt changes in thickness and facies in Proterozoic to early Paleozoic strata across these northeast-trending structures suggest periodic reactivation. In the West Kootenays, the southwestward shift in trend at the south end of the Kootenay Arc, and significant stratigraphic thickness and facies differences in strata of northeastern Washington also suggests a deep structural influence of the basement Vulcan Low.

Although generally deeply buried, crystalline basement rocks are locally exposed in structural culminations such as the Shuswap-Monashee complex (Figs. 3-4). Located west of the east-dipping Columbia River fault (Fig. 2), 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 (Fig. 2) forms a structural dome at the eastern exposed edge of the Shuswap metamorphic complex. Rock types include amphibolite-facies pelitic schist, marble, calc-silicate gneiss, psammitic gneiss, quartzite and metaconglomerate, amphibolite gneiss, and ultramafic 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), and flake graphite deposits (**Black Crystal**; Fig. 1).

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 Southeast Region, the Belt-Purcell basin (1.47-1.4 Ga) was a north-northwest trending intracratonic rift system that extended into what are now northern Idaho and Montana. 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; Fig. 4), 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 (Fig. 5). 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).

Intracratonic rift systems that have been infilled by marine sedimentary rocks, such as in the Belt-Purcell, have long been recognized as the most favorable environment for the formation of seafloor hydrothermal Zn-Pb-(Cu) sulphide, or SEDEX, deposits. These are prime exploration targets because of their large tonnage and grades (Paradis and Goodfellow, 2012; Paradis, 2015). The Sullivan deposit (MINFILE 082FNE052) was discovered near Kimberley in 1892. The mine operated from 1909 to 2001 and produced over 8 Mt of zinc, 8.5 Mt of lead, and 298 Moz of silver. Gold, tin, copper, cadmium, and small amounts of antimony, bismuth, and indium were also produced. SEDEX Pb-Zn-Ag mineralization similar to that of the historic Sullivan mine (Fig. 6) continues to be an exploration focus for the region. The contact between the lower and middle Aldridge members hosts the Sullivan ore body (Fig. 6) 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

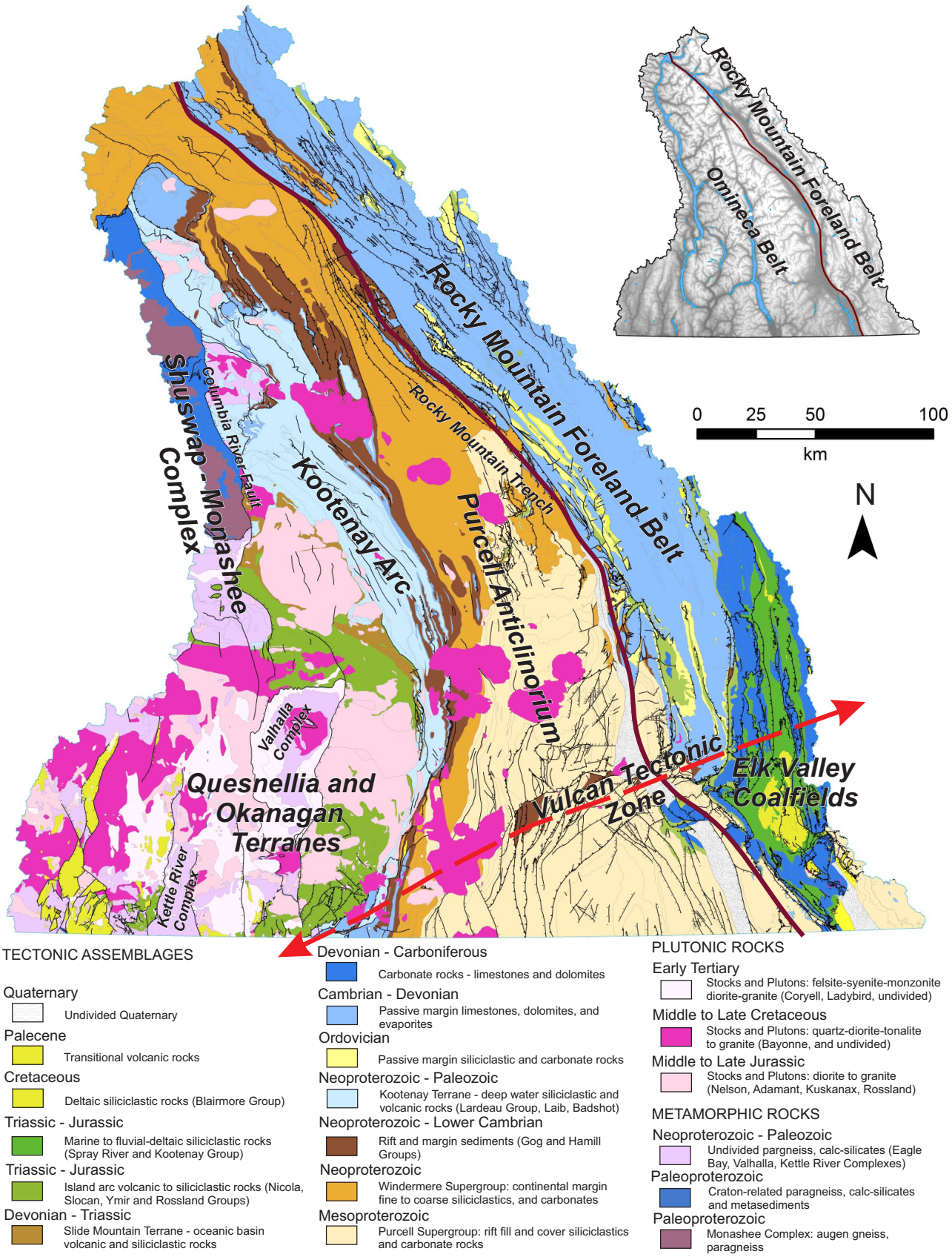

Fig. 2. Geology and physiographic belts of the Kootenay-Boundary region. Physiographic belts after Nelson et al. (2013). Bedrock units are after Cui et al. (2013) and Wheeler et al. (1991), and generalized to highlight temporal and lithological differences in the region for this report. Vulcan tectonic zone is after McMechan (2012).

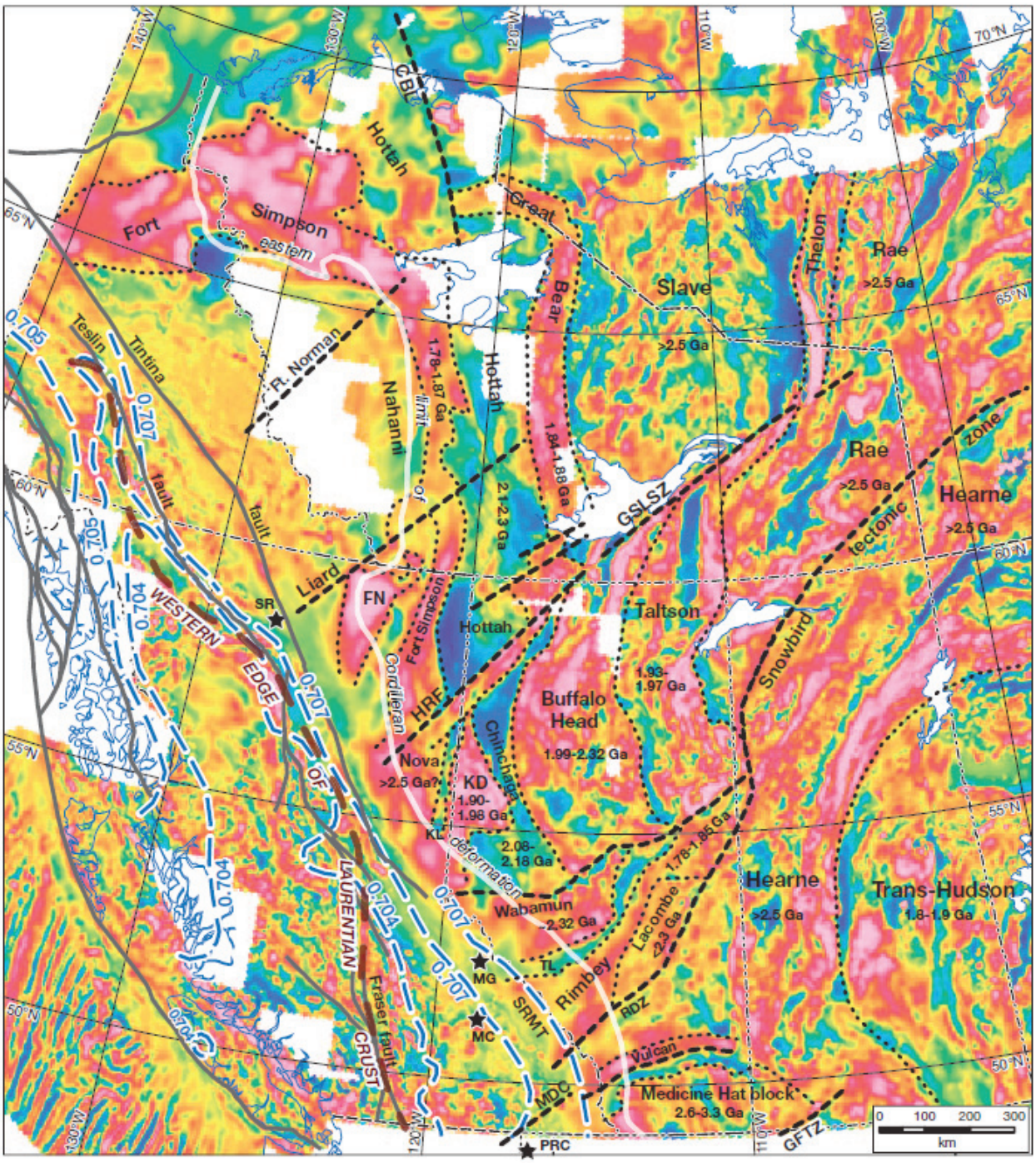

Fig. 3. Residual total field aeromagnetic map of western Canada, showing Precambrian basement domains of the western Laurentian craton with respect to the Cordilleran orogen (eastern limit of Cordilleran deformation indicated by white line). Precambrian basement domains are after Hoffman (1988), Ross 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).

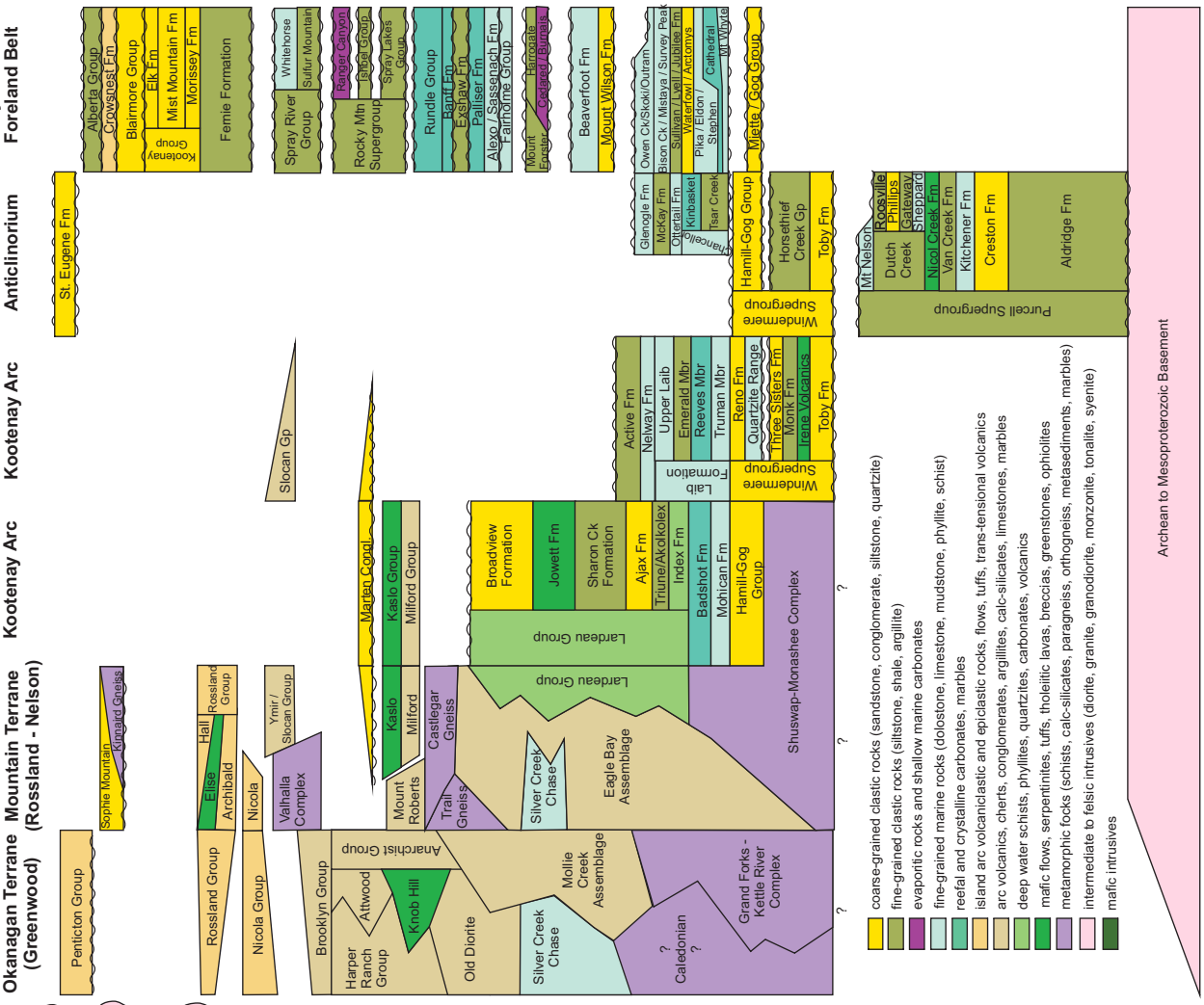

Fig. 4. Generalized stratigraphy, Kootenay-Boundary region. Tectono-stratigraphic events modified from Nelson et al. (2013). Selected stratigraphy and approximate ages derived from Poulton et al. (2012), Hein and McMechan (2012), Colpron and Nelson (2009), Grieve (1993), Fyles (1967 and 1990), Höy and Dunne (1997), Logan (2002), Norford (1981), McMechan (2012), Monger et al. (1991), Price (2012), Slind et al. (2014), Sevigny et al. (1993), Warren and Price (1992). Geological timescale from Walker and Geissman (compilers), Geological Society of America, (2009).

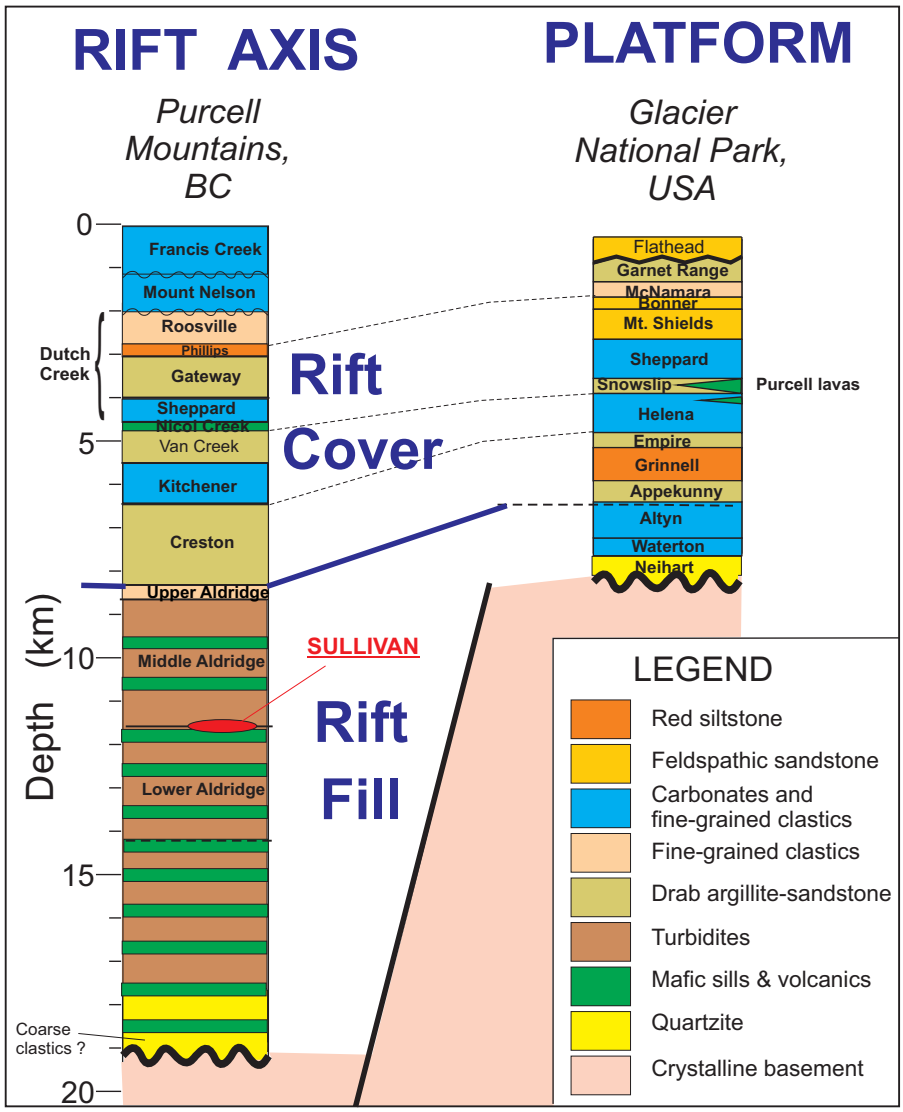

Fig. 5. Stratigraphic correlation and comparison of average thicknesses between formations of the rift-fill, rift-cover, and platform sedimentary sequences of the Belt-Purcell Supergroup. From Lydon (2007).

Fig. 6. Banded massive sulphide ore from the Sullivan mine.

the Purcell Supergroup contains carbonate-hosted, stratiform replacement-style sulphide mineralization in dolomites of the Mount Nelson Formation (Figs. 4, 6), and associated structurally related polymetallic Ag-Pb-Zn veins.

The Purcell anticlinorium (Fig. 2) 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, 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. 4) 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. 4). 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). Sedimentary rocks of the Hamill-Gog Group are predominantly sandstones deposited on a 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), and the Vulcan Tectonic zone (Fig. 2). Thick sections of Hamill Group rocks are along Highway 3 near the Salmo-Creston pass but are absent to the south, suggesting that sediments were shed northward off a structural high. Facies changes in the overlying Paleozoic platformal carbonates south of the Canadian-USA border are also evidence that a high persisted into the Paleozoic. Though the Windermere Supergroup marks a major rifting episode, it hosts only 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. 7; 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. These transverse structures and basement structures related to the Vulcan Tectonic Zone (Figs. 2, 3) may also have influenced Mesozoic shear and vein gold, a trend that runs east-west through the historic gold rush town of Fort Steele (Kimberley Gold Trend; Seabrook, 2015). South of the Canada–USA border, significant production comes from seafloor copper-cobalt deposits (Blackbird mining district and Sheep Creek), and red-bed copper-silver deposits (Montana Copper Belt, i.e., Spar Lake), from the upper portions of the Belt-Purcell rift cover successions. Exploration for similar styles of mineralization in the Creston Formation (Fig. 6) is becoming another focus in the region. More recent work has also suggested potential for IOCG (iron oxide copper-gold; Olympic Dam) type deposits and PGE mineralization in mafic intrusions.

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); sediment-hosted copper deposits; IOCG epigenetic Cu-Au deposits; Mesoproterozoic intrusion and fault-related Ag-Pb-Zn and Cu-Ag veins; Mesozoic shear and vein gold, and associated placer 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. 2; Reesor, 1973). Deflection of the arc to a southwest trend near its southern end is coincident with the Vulcan low (Vulcan tectonic zone; Fig. 2), and may reflect reactivation this basement structure (Vulcan, Fig. 3; 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. 2). 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 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, and within the strata of the Rocky Mountains.

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 siliciclastic, carbonate, and volcanic rocks of the Lardeau Group (mid Cambrian-Mississippian; Fig. 4) (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 (Fig. 4; 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

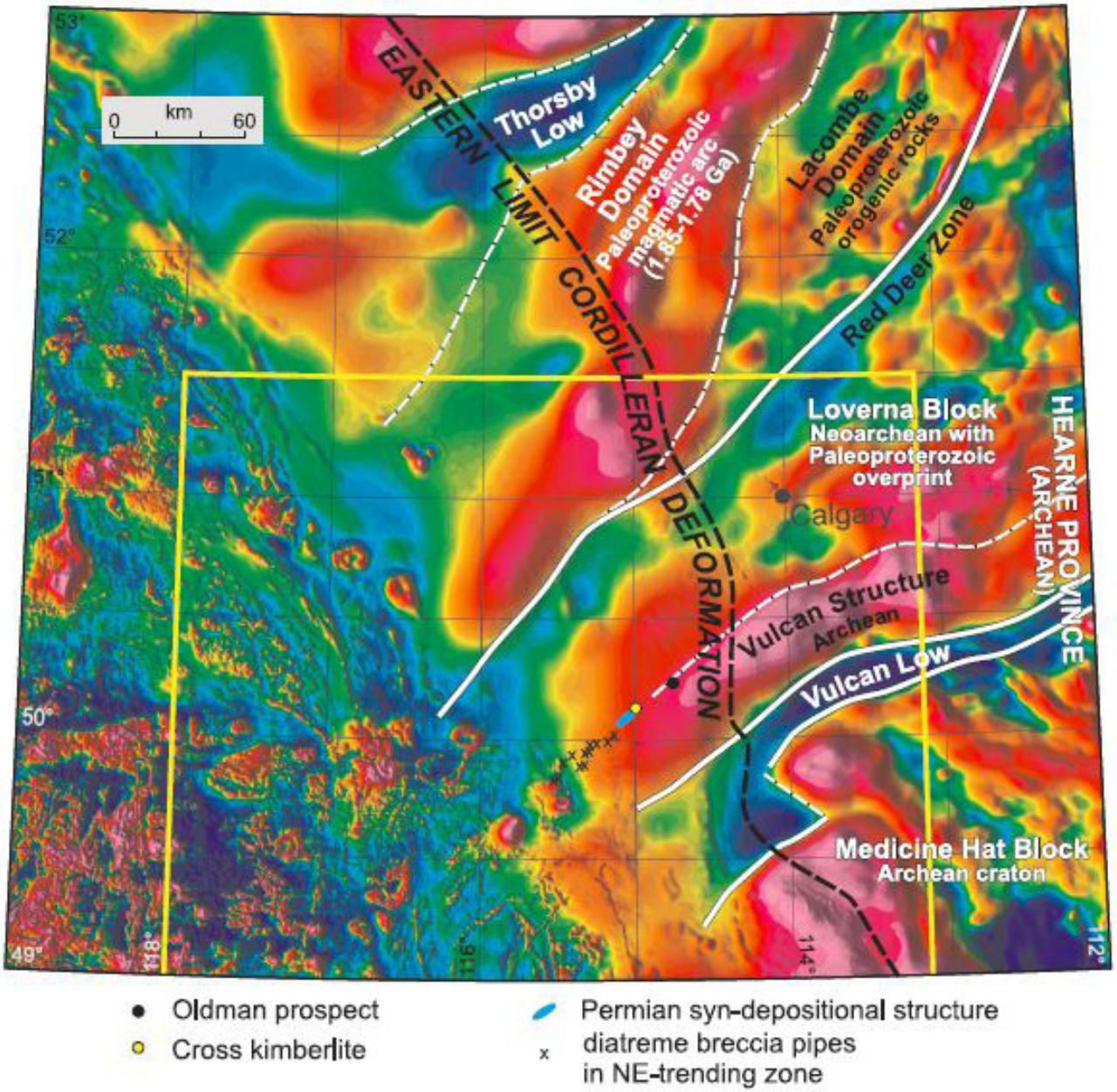

Fig. 7. Detailed aeromagnetic map of southeasten British Columbia, showing northeasterly-trending basement structures, and coincident diatreme pipes (marked by x's) and Permian syn-depositional structures. Basement structures also appear coincident with northeasterly-trending faults in the Purcell Anticlinorium, and Mesozoic intrusions within the region (see Figures 2 and 3). From McMechan (2012).

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. 4), were accreted and imbricated between the rocks of Quesnellia and ancestral North America.

Deposits in 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. 4), 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, as well as hydrothermal MVT mineralization in the western Rockies and Omineca belt are also related to backarc extension, and include the Ice River and Fir showings in the Southeast 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, 2, 4), where mafic to felsic arc-related volcanic rocks and carbonate rocks 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. 4); 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. 2, 4; 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. 2, 4; 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. 2) is also related to the Eocene extension (Reesor, 1965; Vanderhaeghe et al., 2003; Evenchick et al., 2007).

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, 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. 4).

Cretaceous intrusions of the Bayonne magmatic belt (Figs. 2, 4) 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 (Logan and Mihalynuk, 2014). 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. 2), 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. 2, 4). 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. 2) 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. 2, 4). Though the Paleozoic is represented mainly by a passive margin setting, rapid changes in stratigraphy and structural style within the succession indicate that basement

structures continued to be active. Structural elements that existed during the Paleozoic include: the Cathedral escarpment, the Kicking Horse Rim, and the White River trough, and were influenced by basement structures including the Vulcan low, and the Red Deer tectonic zone (McMechan, 2012; Fig. 7). A cluster of deep-sourced alkaline, ultrabasic, diatreme breccia pipes and dikes are evidence of extension during the Upper Ordovician to Middle Devonian (Mott, 1989). Hydrothermal alteration of Cambrian carbonate rocks created hydrothermal magnesite and Mississippi Valley-type (MVT) deposits (Paradis et al., 2011). Carbonatite-related rare earth element (REE) mineralization is also related to these deep structures, and most commonly found at the intersection of basin-parallel and transverse structures (McMechan, 2012). The restricted marine basins of the Devonian also contain mineable evaporitic deposits, including gypsum (Burnais Formation), and the well-sorted Ordovician quartz sandstones (Mount Wilson Formation; Fig. 4) which is mined for silica.

In the Mesozoic, terrane accretion along the western margin forced the Mesoproterozoic to Paleozoic continent margin successions to be uplifted, and displaced northeastward, into the Rocky Mountains (Price et al., 1972). The Rocky Mountain fold and thrust belt (Fig. 2) is a classical thin-skinned belt, with eastward-vergent, piggyback thrusts that detached along a basement-cover decollement (Fig. 8; Price and Fermor, 1985). These 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 in the west, and shed eastward into the basin (Cant and Stockmal, 1989). The Fernie Formation and Kootenay Group (Fig. 4) consist of a coarsening-upwards sequence of deep-water basin to coastal plain sandstones, shales, and coals that were deposited adjacent to the uprising Canadian Cordillera in the Jurassic to Early Cretaceous. They represent the first of a series of coarsening-upwards clastic wedges that were deposited in the foreland basin (Stott, 1984; Poulton, 1988). As thrusting continued, the accretionary wedge propagated eastward, and the coal seams of the Kootenay Group were also thrust upwards into the mountains. This faulting thickened and repeated the Mist Mountain sequence throughout the Elk Valley. The coal seams are now exposed along strike for about 175 km in the Rocky Mountain Front Ranges in north-south trending synclines, near horizontal to steep westerly dipping thrust faults, and a few high-angle normal faults. Some of the thickened sections permit open-pit mining.

Mineable coal seams make up 8-12% of the total thickness

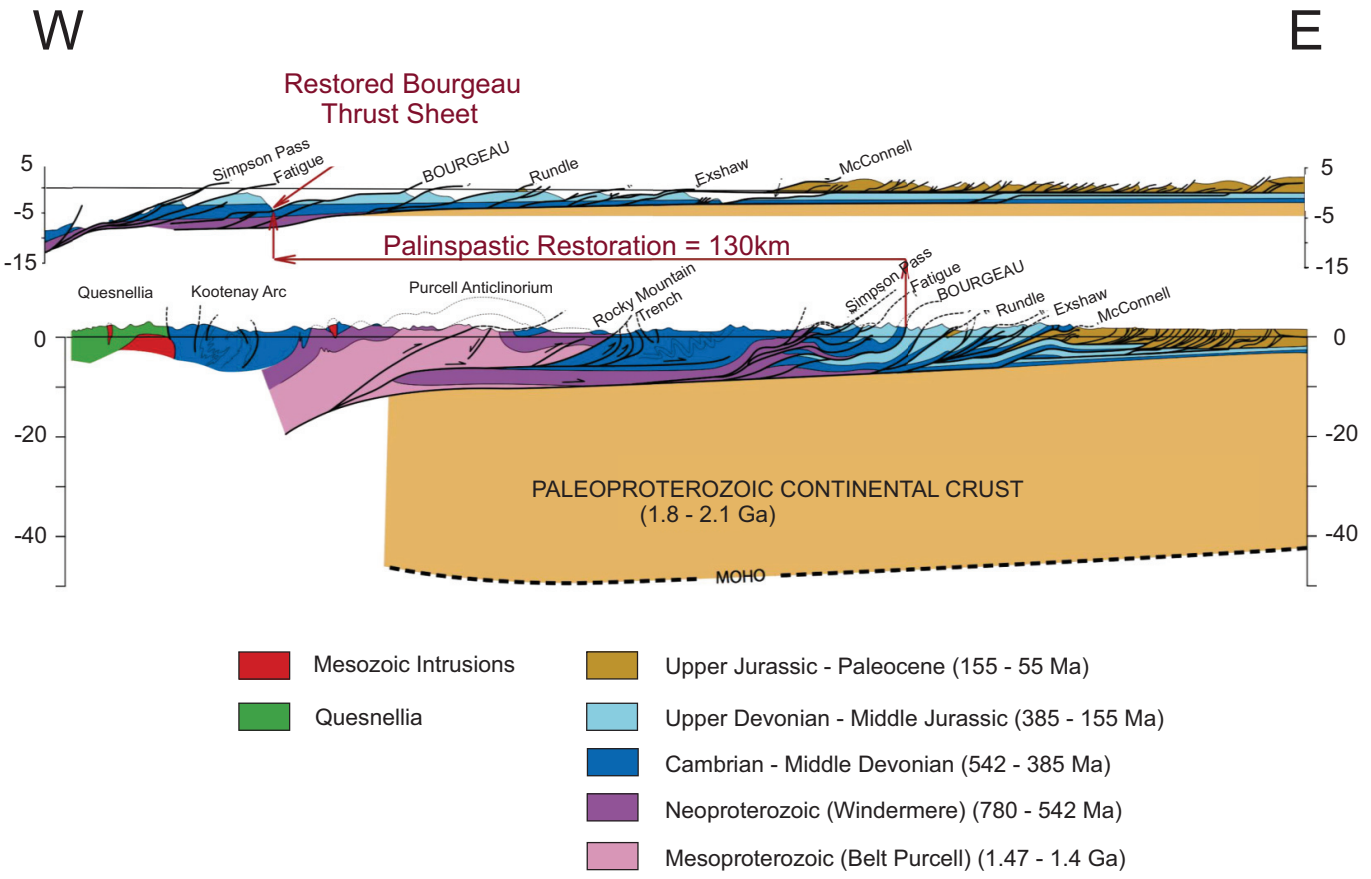

Fig. 8. Palinspastic restoration of the Rocky Mountain fold and thrust belt, southeastern British Columbia. Modified from Price and Fermor (1985).

of the Mist Mountain Formation (Kootenay Group; Fig. 9), 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 the 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.

Fig 9. Coal seams of the Mist Mountain Formation, displayed in the pit wall at the Fording River mine. Photo courtesy of Teck Coal Ltd.

3. Mines and quarries

The Southeast 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. Metal mines

In 2016, no metal mines operated in the Southeast Region.

3.2. 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 Limited (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 over 70% of Canada's annual coal exports.

Over the past few years, the coal mines in the southeast have been reducing costs and optimizing operations in response to lower prices on the coal market. The average price of metallurgical coal in 2015 was $93USD/tonne, down from $115USD/tonne in 2014. Teck Coal Limited (Teck) implemented rotating shutdowns at the mines in the third quarter of 2015 in order to align production and inventory with the weaker commodity prices. In early 2016, prices had dropped further to around $80USD/tonne but have rebounded throughout the year. Teck received $92USD/tonne as a quarterly benchmark price in Q3 of 2016, negotiated in late June. Since the middle of the year prices on the spot market rose sharply and exceeded $200USD/tonne by mid-September. The Q4 quarterly benchmark price was negotiated at around $200-$205USD/tonne, and Teck ramped up production volumes in response. Record production was reported in Q3 and expected annual production volumes for 2016 are expected to be around 26 Mt. The recent price spike is due to a number of factors on the supply side, including: global production curtailments since 2014 resulting from the lower coal prices, reduced mine operation days in the Chinese domestic coal sector, and supply disruptions in China and Australia (Teck, 2016a).

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.

The selenium management plan will cost a projected $600 million over five years, and $40 million to operate annually. In 2015, Teck spent approximately $43 million on mitigative measures and construction of treatment facilities, and 2016 spending is estimated at $31 million. The West Line Creek water treatment facility (**Line Creek** mine; Fig. 10), the first of six facilities planned for the Elk Valley completed commissioning in February 2016. Construction has begun at the second water treatment facility at **Fording River** (Fig. 10; Teck, 2016b).

In May 2016, the Ktunaxa Nation Council and Teck also formally signed a comprehensive Impact Management and Benefits Agreement (IMBA) regarding the five mines in the Elk Valley. The IMBA sets out commitments for both parties that will support environmental and cultural stewardship

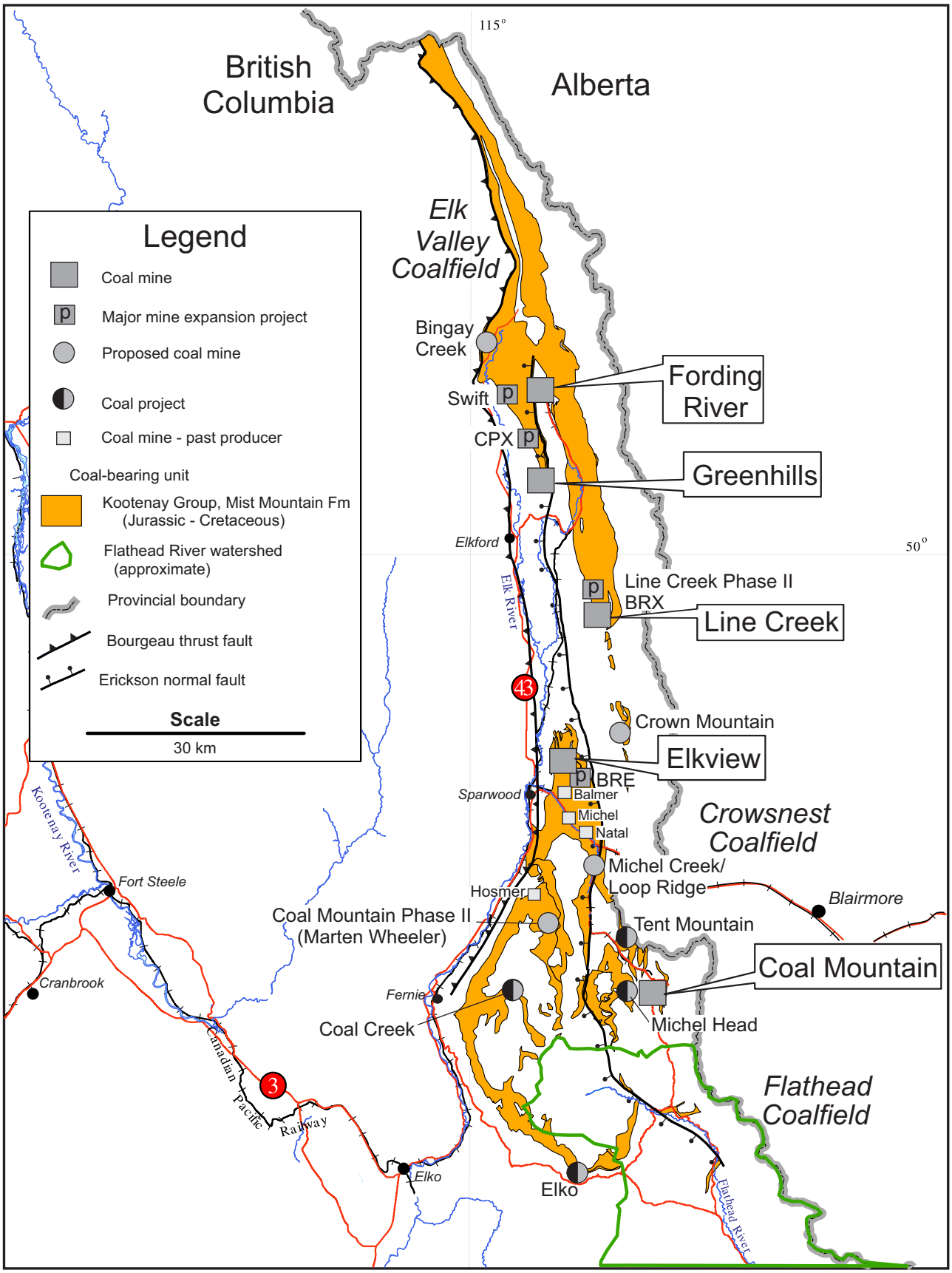

Fig. 10. Map of the Kootenay Group and East Kootenay Coalfields, including the major coal mines and projects in southeastern British Columbia near Sparwood, BC.

Table 1. Coal mines, Southeast Region, 2016.

Mine	Operator	Commodity	Forecast 2016 Production (based on Q1-Q3)	Reserves (Proven + Probable; Reported Dec. 31, 2015)	Resource (Measured and Indicated; Reported Dec. 31. 2015)	Comments
Fording River	Teck Coal Limited (100%)	HCC, TC	8.2 Mt	Proven + Probable: 434.9 Mt HCC + 5.0 Mt TC	Measured + Indicated: 1322.8 Mt HCC + 13.4 Mt TC; Inferred: 787.2 Mt HCC + 7.5 Mt TC	EA approval of Swift expansion (2015); permit amendments to align mine design with improved efficiencies; exploration drilling in active pits; construction of Fording River water treatment plant begun
Greenhills	Teck Coal Limited (80%); POSCAN (20%)	HCC, PCI, TC	5.2 Mt	Proven + Probable: 201.3Mt HCC + 5.0 Mt PCI + 2.7 Mt TC	Measured + Indicated: 304.5 Mt HCC + 7.9 Mt PCI + 1.1 Mt TC; Inferred 148.5 Mt HCC + 4.3 Mt PCI + 0.3 Mt TC	Cougar Pit Expansion (CPX) is preparing for pre-application of EA; environmental baseline
Line Creek	Teck Coal Limited (100%)	HCC, TC	3.3 Mt	Proven + Probable: 66.6 Mt HCC + 11.1Mt TC	Measured + Indicated: 756.1 Mt HCC + 19.3 Mt TC; Inferred 414.45 Mt HCC + 3.1 Mt TC	Burnt Ridge Extension (BRX) in pre-application of EA (2014); pre-stripping at Line Creek Phase II (2013 EA approval); Commissioning of West Line Creek water treatment facility in February, 2016
Elkview	Teck Coal Limited (95%); Nippon Steel & Sumimoto Metal Corp. (2.5%), POSCO (2.5%)	HCC	7.0 Mt	Proven + Probable: 273.2Mt HCC	Measured + Indicated: 580.1 Mt HCC; Inferred: 224.6 Mt HCC	Baldy Ridge Extension (BRE) received an Environmental Assessment Certificate in September, 2016; pre-stripping at BRE; exploration drilling in active pits; development progressing in new approved mining areas
Coal Mountain	Teck Coal Limited (100%)	PCI, TC	2.3 Mt	Proven+ Probable 4.5 Mt PCI	CMO: Measured + Indicated:78.4 Mt; Inferred: 4.7 Mt	Mineable resource at CMO is nearing depletion and expected mine shut down in late 2017; Coal Mountain Phase II (CMO2/Marten Wheeler) would utilize facilities from CMO, but currently remains on hold

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

within the Elk Valley. It sets out decision-making, dispute resolution and significant collaboration processes, and provides clarity on topics including: consultation and engagement, the environment and land stewardship, and employment and business opportunities for Ktunaxa citizens.

3.2.1. Fording River (Teck Coal Limited)

Fording River (Figs. 9, 10) consists of approximately 23,000 hectares of coal lands, and produces primarily metallurgical coal, and a small amount of thermal coal, from their Eagle Mountain, Turnbull, and Henretta pits. In 2016, 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. The current annual production capacities of the mine and preparation plant are approximately 8.5 million and 9.5 million tonnes of clean coal, respectively. 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 further 52 years from their Eagle Mountain, Greenhills Ridge, Turnbull, Henretta, and Castle Mountain areas.

In September 2015, the **Swift** expansion received conditional environmental assessment approval, and in 2016, the company received permit amendments for modifications of the initial phases of mine design in response to the recent lower commodity prices. Initial construction costs are approximately $88.5 million dollars and operating costs will be around $16.9 billion over the life of the project. The open-pit project will use the existing Fording mine facilities and is expected to produce 175 Mt of clean coal over 25 years. To meet specifications outlined in the Elk Valley Watershed Management Plan, the construction of a selenium water treatment facility on site is underway. Located west of the Fording River mine 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; eventually the two will merge and collectively become the **Swift**.

3.2.2. Greenhills (Teck Coal Limited)

Greenhills produces mainly metallurgical coal with a small amount of thermal coal, and consists of approximately 11,800 hectares of coal lands. In 2016, the mine set new record second quarter and first-half production from the Cougar pit area. The mine is on the west limb of the Greenhills syncline (Fig. 10). 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. The current annual production capacity of the mine and preparation plant (on a 100% basis) is 5.2 million tonnes of clean coal. Proven and Probable reserves are projected to support another 39 years of mining at the current rate.

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

The **Cougar Pit Extension (CPX)** project (Fig. 10) 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 2016, Teck conducted further baseline work and mine-planning to prepare for the pre-application phase of Environmental Assessment.

3.2.3. Line Creek (Teck Coal Limited)

Line Creek produces mainly metallurgical coal and small amounts of thermal coal from the Burnt Ridge South, North Line Creek, and Horseshoe pits (Figs. 10, 12). The mine consists of approximately 8,200 hectares of coal lands. Coal seams are predominantly medium-volatile bituminous in rank, with some high volatile-A bituminous coals near the top of the section. In 2016, record production levels were achieved at the mine by the second quarter. The current annual production capacity of the mine and preparation plant is approximately 3.5 million tonnes of clean coal. In 2016, exploration drilling was mainly focused in active pits. Expansion plans are well underway with the **Line Creek Phase II**, which received conditional Environmental Assessment approval in 2013. As part of the conditional approval, the West Line Creek water treatment facility was commissioned in February, 2016. 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 to the mine. Proven and probable reserves at Line Creek are now projected to support mining at planned production rates for a further 23 years.

In June, 2014, the **Burnt Ridge Extension (BRX)** project entered the pre-application stage of Environmental Assessment (Fig. 10). The project will connect the current Phase I operating area at **Line Creek** to the **Phase II** area by pushing back the highwall of the Burnt Ridge South pit to the north. It will add 8.3 Mt of clean coal reserves to the mine.

Fig. 12. Coal seams in the Alexander Creek syncline at the Line Creek mine. Photo courtesy of Teck Coal Ltd.

Fig. 13. Coal Mountain.

3.2.4. Elkview (Teck Coal Limited)

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. The mine site consists of approximately 27,100 hectares of coal lands. The current annual production capacity of the mine and preparation plant (on a 100% basis) is approximately 7.0 million tonnes of clean coal. Teck estimates a remaining reserve life of approximately 41 years at the current production rate. Production is derived primarily from the Baldy Ridge and Natal Ridge pit areas. 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)** received an Environmental Assessment Certificate in September 2016, and the company began pre-stripping. 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. Capital cost estimates for the project have been reduced from $600 million (over 5 years) to approximately $60 million, primarily by re-sequencing the mine plan to defer movement of critical site infrastructure to a point later in the mine life. The **BRE** expansion is expected to be brought on stream by 2018 to maintain production at Elkview at around 6.8 Mt per year.

3.2.5. Coal Mountain (Teck Coal Limited)

Coal Mountain (Figs. 10, 13) produces mainly PCI (metallurgical) and thermal coal from seams at 37-Pit and 6-Pit. The mine site consists of approximately 3,000 hectares of coal lands. The current annual production capacities of the mine and preparation plant are approximately 2.7 million and 3.5 million tonnes of clean coal, respectively. The **Coal Mountain Phase II (Marten Wheeler)** project (Fig. 10), was designed to replace production after depletion of the resource at **Coal Mountain**. In November 2015, however, Teck Coal Limited removed the proposal from the pre-application process as a result of lower commodity pricing and placed the project on hold. The **Coal Mountain** mine will remain active at current rates of production until the 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 around 2.25 Mt of lost production after the shut-down.

3.3. Industrial mineral mines and quarries

The Southeast Region hosts several industrial mineral mines, the largest of which are 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).

3.3.1. Mount Brussilof (Baymag Inc.)

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 carbonate rocks of the Cathedral Formation (Figs. 4, 14) that were deposited on the edge of the Cathedral escarpment, 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). Annual magnesite production is approximately 220 kt.

3.3.2. Moberly Silica (Heemskirk Canada Limited)

Silica is produced by Heemskirk Canada Limited at the **Moberly Silica** operation. The deposit is in regionally extensive

Table 2. Selected industrial mineral mines and quarries, Southeast Region, 2016.

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; 082N 001	-	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	-	-	4 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	Process optimization at plant; produced sample of 99.995% pure spheronized graphite from flake graphite; product suitable for Li-Ion battery specifications; research and development
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

Fig. 14. Blast hole drilling at the Mount Brussilof mine, which produces magnesite from Cambrian carbonate rocks of the Cathedral Formation.

orthoquartzites of the Mount Wilson Formation (Middle to Upper Ordovician; Fig. 15). 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 operation with a 35-year mine life. 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 early 2017.

Fig. 15. Ripple marks on upturned bedding of the Mount Wilson quartzite (Ordovician), at the Moberly silica mine.

3.3.3. Horse Creek Silica (HiTest Sand Inc.)

At the **Horse Creek Silica** mine, HiTest Sand Inc. operates a seasonal quarry in Mount Wilson orthoquartzites (Figs. 4, 15), producing a variety of industrial use and aggregate products. The Mount Wilson orthoquartzites are more consolidated than at Moberly. The company is also evaluating processes for the production of alternate products, including silicon metal.

3.3.4. Elkhorn (CertainTeed Gypsum Canada Inc.)

Gypsum is produced near the western edge of the Rocky Mountains from a thinly bedded evaporite unit in the Burnais Formation (Middle Devonian; Figs. 4, 16) that was deposited in a restricted, shallow-marine embayment. Gypsum-bearing strata are structurally disturbed, occurring as steeply dipping and contorted sections 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 4 years.

3.3.5. 4J (Georgia-Pacific Canada Limited)

Georgia-Pacific Canada Limited operates the **4J** gypsum mine and rail load-out facility southeast of Canal Flats. The deposit is within Burnais Formation evaporites (middle Devonian; Figs. 4, 16). The company has been re-evaluating their mine design for the next stages of pit expansion as they wait for commodity prices to improve. In 2016, they produced mainly fines from stockpiled material for use in the agricultural industry.

3.3.6. Black Crystal (Eagle Graphite Corp.)

Eagle Graphite Corp. operates the **Black Crystal** flake graphite operation where graphite ore is mined from the open-

Fig. 16. Bedded gypsum 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.

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. 2) in the Valhalla dome, a structural culmination 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 2016, the open-pit quarry was on care and maintenance, and efforts were focused 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.

3.3.7. Winner and Friday quarries (Roxul Inc.)

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.

3.3.8. Grand Forks Slag (Granby River Mining Company Inc.)

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. Placer operations

Placer mining has occurred in southeastern British Columbia since the gold rush began in 1864. Currently there are still several placer streams in the region, though activities were not tracked in detail in 2016.

5. Mine development

A mine development project has financing in place and construction is underway with a targeted production start-up date. The project proponent must have all required government approvals and permits for constructing and operating a mine. With the exception of the coal mine expansion projects that are currently in construction phases and discussed above, no new mine development projects were under construction in the Southeast Region in 2016.

6. Proposed mines and quarries

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.

In the Southeast Region, there are currently four proposed coal mines, several proposed industrial mineral mines and quarries of various scales, and one proposed metal mines. The coal projects are **Michel Creek/Loop Ridge** (CanAus Coal Ltd.), **Crown Mountain** (NWP Coal Canada Ltd.), **Coal Mountain Phase II** (on hold; Teck Coal Limited), and **Bingay Creek** (Centermount Coal Ltd.). Two of the industrial mineral projects include the **Kootenay West** mine and the **Driftwood Magnesite** project (Fig. 1; Table 3).

6.1. Proposed metal mines

In 2016, there were no metal mine proposals yet with reviewable Environmental Assessment applications. However, several projects are working through stages with Mine Development Review Committees to ensure information requirements are being met.

6.2. Proposed coal mines

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

In October 2015, CanAus Coal Ltd., a wholly owned subsidiary of CoalMont Pty Ltd., entered the pre-application phase of environmental assessment for their **Michel Creek** project. The project consists of licenses at **Loop Ridge, Tent Mountain,** and **Michel Head** (Figs. 10, 17). 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. Drilling in 2016 focused on the **Loop Ridge** and **Michel Head** areas, with samples collected for coal quality testing. The project will use new techniques for the treatment of selenium in the construction and operational phases of the project to comply with environmental targets identified in the Elk Valley Water Quality Plan. Drill results have identified twenty coal seams from 5 to 20 m thick 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. The company

Table 3. Selected proposed mines, Southeast Region, 2016.

Project	Operator	Commodity; deposit type; MINFILE	Reserves (Proven + Probable)	Resource (Measured and Indicated)	Work Program	Comments
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	Pre-application of EA (2015); Coal quality testing; updated geological model; drilling has identified 20 coal seams with cumulative thickness of 70m (14% of a 504 m section in the Mist Mountain Fm); PEA model indicates potential production of 3.4Mt/y (~2.1 Mt/y saleable)
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	Pre-application of EA (2014); 16-year mine life; 1.7 Mt/yr; review of pre-feasibility study identified upside in lower capital costs for contract mining and additional resources in Southern Extension
Coal Mountain Phase II (Marten Wheeler)	Teck Coal Limited	Coal (PCI and TC); open-pit and underground; 082GNE006	-	Measured + Indicated: 173.9 Mt HCC + 6.5 Mt PCI; Inferred: 7.9 Mt HCC + 0.9 Mt PCI (2015)	On hold	Pre-application of EA (2014); Potential of 76.5 Mt; 34-year mine life; 2.25 Mt/yr; EA withdrawn in late 2015; project on hold
Bingay Creek	Centermount Coal Ltd.	Coal (HCC); open pit and underground; 082JSE011	-	42.43 Mt Measured + 52.9 Mt Indicated (2012)	Drilling; environmental baseline studies; engineering and geotechnical evaluation for mine design; permitting	Pre-application of EA (2012), on hold; 39 Mt; 20-year mine life; 2 Mt/yr
Driftwood Magnesite	MGX Minerals Inc.	Magnesite; hydrothermal sparry magnesite; quarry; 082KNE 068	-	Measured + Indicated: 8.028 Mt grading 43.3% MgO (2016; using cutoff grade of 42.5% MgO)	20 year mine lease acquired; drilling; 100 t bulk sample; metallurgical test work; acquisition of a pilot test mill; resource estimate	Preliminary test work indicates recovery rates of 93.4% reverse flotation and removal of up to 70% silica and 30% calcium oxides; bulk of resource is within 100m of surface; working on Preliminary Economic Assessment; drilling to extend the zone

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.

The site is considered a brownfields operation, with previous mining at the **Loop Ridge** area from the McGillvray pit. In 1969, the Crow's Nest Pass Mining Company mined 60,000-100,000 tonnes. A further 20,000 t was extracted in 1995 by McGillivray Mining Ltd., and then 30,000 t by Fording Coal Ltd. between 1996 and 2000. Fording dropped the asset in 2000 when the company was merged into Teck Coal Limited

6.2.2. 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

Fig. 17. Large diameter core hole drilling on the Loop Ridge property (CanAus Coal Ltd.), for coal quality testing. Looking north towards the Elkview mine.

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. In 2014, the company completed a resource estimate of 74.9 Mt (measured + indicated categories), with upside potential in a Southern Extension, and a preliminary prefeasibility study (PFS). In 2016, the PFS was updated with improved economics related to coal pricing, OPEX and CAPEX costs. Coal quality test work indicates that approximately 84% of the coal is hard coking coal, with remainder as PCI coal.

6.2.3. Coal Mountain Phase II (Teck Coal Limited)

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, the project was withdrawn from environmental assessment and put on hold a result of Teck Coal Limited implementing cost-saving measures. The project was proposed to replace production and use infrastructure from the **Coal Mountain** mine, which is scheduled to be shut down in 2017. 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. The project remains on hold.

6.2.4. 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. Work in 2016 consisted of drilling and environmental baseline studies. 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. The coal at Bingay Creek is medium-volatile to high volatile-A bituminous in rank.

6.3. Proposed industrial mineral mines

6.3.1. Kootenay West (CertainTeed Gypsum Canada Inc.)

CertainTeed Gypsum Canada Inc. continued to advance the proposed **Kootenay West** project, 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 in the Burnais Formation (Figs. 4, 16). 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 2016, the company focused on environmental work and mine design, with two pits (North and South). The projected start-up date for the mine is in 2018.

6.3.2. Driftwood Magnesite (MGX Minerals Inc.)

At the **Driftwood Magnesite** property, cliff-forming, upturned beds of sparry magnesite (Fig. 18) are interlayered with dolostones and dolomitic limestones of the Mount Nelson Formation (Proterozoic; Fig. 4). The coarse-grained textures in the magnesite zone suggest that hydrothermal alteration and recrystallization of magnesite occurred during regional metamorphism (Kikauka, 2000). The deposit varies from 100 to 300 m in thickness and has been traced along strike for 2,000 m, to a depth of approximately 110 m. In recent years, the company has been drilling and resampling both the East and West zones of the deposit. In 2016, they took a 100 tonne bulk sample from

Fig. 18. Drill core containing magnesite in the Mount Nelson Formation (Proterozoic) at the Driftwood Magnesite property (MGX Minerals Inc.).

a zone near surface (up to 15 m depth). They released a NI 43-101 compliant resource estimate in September, 2016 with updated results from their 2014 and 2015 drill programs, and are working on a preliminary economic assessment. Further step-out drilling was conducted in the fall, with nine holes drilled on the East zone, and seven holes on the West zone in order to test the depth and extend the known mineralization. They also acquired a pilot test mill, including a jaw crusher, ball mill, floatation cells, cyclone dewatering equipment, and tailings filtration system. The mill was used to process the bulk sample material to a high-purity magnesite ($MgCO_3$), and a silica by-product using reverse flotation techniques. The magnesite was shipped offsite to undergo further processing to produce magnesium oxide (MgO) as well as magnesium metal (Mg). The company received a 20-year mine lease for quarry operations and are evaluating mine and process design options. They are also conducting environmental baseline work for their quarry application.

Magnesium (Mg) is a non-metallic alkaline earth metal that is 75% lighter than steel and 33% lighter than aluminum, with comparable strength-to-weight ratios. Magnesium oxide (MgO) is also a widely used industrial mineral with end uses in fire-retardant wallboard, fertilizer, animal feed, environmental water treatment, and a refractory material in the steel industry.

7. Selected 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 Southeast Region in 2016 (Fig. 1; Table 4) for a variety of targets, including base and precious metals, industrial minerals, and coal.

7.1. Precious metal projects

Exploration for precious metals along fault and vein structures, and coincident with Mesozoic intrusions, is ongoing in the East Kootenays along the Kimberley Gold trend, which is interpreted as being associated with the Vulcan low (McMechan, 2012; Seabrook, 2015; Höy, 1982a). In the West Kootenays and Boundary regions, precious metal exploration dates back to the 1880s, and is also ongoing in vein (epithermal and mesothermal), associated with intrusives, and in skarn systems. Precious metals are explored for throughout the region, and are not limited to the projects discussed in this report.

7.1.1. Dewdney Trail (PJX Resources Inc.)

PJX Resources Inc. identified a new target area at their Dewdney Trail property in 2016. The target is upstream from current and historic placer mining in the Wildhorse valley. Heavy mineral stream samples collected from two previously unexplored drainage areas contained sharply angular visible gold. Scanning electron microscope probe analysis found the grains to be fairly consistent in chemical composition with gold as the major element followed by silver and trace quantities of copper and iron, suggesting a single bedrock source. In addition, the chemistry of sample residue material suggests that the gold may be associated with felsic intrusive rocks and/or sericite alteration.

The property is underlain by Mesoproterozoic units (Fort Steele, Aldridge, Creston and Kitchener formations, Fig. 4). Stratabound between less permeable argillaceous units, a 75 to 100 m thick succession of immature quartz-wacke sandstone (Spirit quartzite) in the Upper Aldridge Formation is pervasively altered (sericite-quartz-pyrite-iron oxide-iron carbonate), veined, and fractured along the 7 kilometre length of an anticline fold axis. The fold axis is intruded by Cretaceous and possibly Tertiary felsic to mafic rocks. Fractures are typically filled with multi-episodic veins containing hematite/limonite, quartz, pyrite, ±copper oxides and magnetite. Locally, mineralization occurs near the contact of argillite and quartzite in brecciated quartzite, in syenite dikes and in fault gouge zones. The property contains several mineral showings, including: 1) large-tonnage sediment-hosted vein type gold prospects at the Spirit, Tac, and Lewis showings, 2) vein-type prospects at the Jack Leg, and 3) skarn and stockwork Cu-Au prospects at the Dew Drop showing. Past exploration efforts on the showing included prospecting, soil geochemistry, rock sampling, VLF-EM, ground magnetic surveys, ground IP surveys, airborne geophysics, hand trenching, and diamond drilling. The best sample to date was collected from a 4 to 5 metre wide, altered syenite dike, which returned 1,953 g/t Au, while other rock samples have yielded up to 18 g/t Au.

7.1.2. Zinger (PJX Resources Inc.)

In 2016, PJX Resources Inc. continued exploration on their **Zinger** property, which hosts numerous showings along an 8 km strike length. The property is adjacent to the Perry Creek fault, and hosts gold mineralization in multiple structures, veins, and shear zones. Host rocks are the Proterozoic Purcell Supergroup (Fig. 4), predominantly metasedimentary quartzites, argillites, and siltstones of the Creston Formation, argillites of the Kitchener Formation, and gabbro sills and dikes. Veins occur as quartz stockworks, veins, and stringers with iron carbonate, sericite, and minor sulphides. Sulphide

Table 4. Selected exploration projects, Southeast Region, 2016.

Project	Operator	MINFILE	Commodity; Deposit type	Resource (NI 43-101 compliant unless indicated otherwise)	Work Program	Comments
Dewdney Trail	PJX Resources Inc.	082GNW 094	Au; Au-veins	-	Heavy mineral stream sampling; mapping; sampling	Very angular gold grains, new target separate from previously identified gold mineralization on property
Zinger	PJX Resources Inc.	082FSE 122, 065	Ag-Pb-Zn+/-Au; polymetallic veins	-	Soil geochemistry	Soil anomaly approximately 100 m x 300 m, with Au ranging from 100 ppb to 4,941 ppb
Greenwood Gold	KG Exploration (Canada) Inc.	082ESW 022, 210, 034, 221	Au-Cu-Pb-Zn-Ag+/-Mo; Cu-Au-Ag skarn, polymetallic vein, Au-vein, porphyry	-	Mapping; sampling; remodelling airborne, ground EM and Magnetic data; geological evaluation	Option agreement with Grizzly Discoveries Inc. to gain 75% interest in 27,346 ha; rock samples yielded 29.8g/t Au near Au-Ag-Bi-Sb-Hg-Mo-Te geochemical anomalies in soil samples, and 9.27 g/t Au with elevated Ag, Cu, Hg, Sb and Te; anomalous precious metals and epithermal indicators in stream sediment samples
May Mac	Golden Dawn Minerals Inc.	082ESE 045, 116	Au-Ag-Pb-Zn+/-Cu; Cu-Au-Ag skarns, polymetallic veins, epithermal Au-veins	37,200 t grading 3.4 g/t Au, 342.8 g/t Ag, 2% Pb, 2% Zn (1981; non-compliant)	Drilling (17 DDH: 1,770 m); mapping; rock sampling	Drill intersections include: 4.4 m grading 218.6 g/t Ag, 2.49 g/t Au, 1.5% Pb, 2.9 % Zn; 2.1 m grading 185.9 g/t Ag, 3.50 g/t Au, 1.5% Pb, 1.8 % Zn; discovery of a new silver zone with 2.3 m grading 152.0 g/t Ag, 0.36 g/t Au, 1.9% Pb, 1.9 % Zn
LH	Magnum Goldcorp Inc.	082FNW 212	Cu-Ag-Au; subvolcanic, skarn, Au-veins	-	SP, magnetometer and EM surveys	Gold mineralization appears to be associated with pyrrhotite +/- arsenopyrite, providing conductive targets; identification of drill targets
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 (1990; non-compliant)	Drilling; geophysical and geological modeling	Infilled gravity survey grid; detailed geophysical and geological model
Monroe	Highway 50 Gold Corp.	082GSW 069, 035, 041	Pb-Zn-Ag+/-Au, Cu; SEDEX	-	Drilling (2 DDH; 1354 m); mapping	Drilling on UTEM anomaly; encountered fragmentals, bedded pyrrhotite-sphalerite, and indicators of distal-style mineralization in sedex system
Irishman-Panda	Teck Resources Limited	082FSE 110	Pb-Zn-Ag+/-Cu; SEDEX, polymetallic veins	-	Mapping, soil geochem; sampling; re-logging historic core	Initial stages of exploration on the property identified fragmental units, alteration assemblages, and indicators of sedex-style mineralization

Table 4. Continued.

Sully	Kootenay Zinc Corp.	-	Pb-Zn-Ag+/-Au; Gravity anomaly, sediment-hosted	-	Drilling; mapping; magnetic surveys; geophysical modeling	Mass models suggest two gravity anomalies may be stratiform sulphide mineralization; complex faulting on property
Boulder Gold	Classic Financial Corp.	082GNW 022, 036, 051	Ag-Pb-Zn+/-Au; polymetallic veins		Drilling (2 DDH); mapping; data compilation	Drilling on structure; encountered favorable mineralization
Gallowai Bul River	Purcell Basin Minerals Inc.	082GNW 002	Cu-Ag-Au+/-Pb-Zn; Cu-Ag veins; underground;	90,720 t at 1.3% Cu, 0.31g/t Au, 21.77g/t Ag (1984; non-compliant)	Permitting; environmental baseline; mine plan and mine design; ARD/ML	Proposed restart of Bul River Mine that is currently on care and maintenance
Cummins River	MMG Canada Exploration Inc.	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)	Drilling; 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
Goldstream	Barkerville Gold Mines Ltd.	082M 141	Cu-Ag-Au-Zn; Besshi type massive sulphides	-	Airborne VTEM geophysics	A number of conductive targets were identified over an area of 142 km^2
Thor	Taranis Resources Inc.	082KNW 030, 031, 060, 061	Ag-Pb-Zn+/-Au; polymetallic veins and breccia, stratiform volcangenic massive sulphide	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)	Drilling; data compilation and updating geological modeling; acquisition of a test mill, and moved on site; environmental baseline studies	9.15 m grading 143.9 g/t Ag, 1.05 g/t Au, 0.09% Cu, 1.83% Pb, 3.78 % Zn; 9.05 m grading 97.7 g/t Ag, 0.74 g/t Au, 0.16 % Cu, 3.32 % Pb, 5.83% Zn; 7.22 m grading 156.1 g/t Ag, 0.88 g/t Au, 0.09% Cu, 4.1% Pb, 2.39% Zn; 2.5 m grading 400.8 g/t Ag, 0.55 g/t Au, 0.13% Cu, 2.38% Pb, 3.19% 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
Slocan Silver (Silvana)	Klondike Silver Corp	082FNW 050, 013, 082KSW 006	Ag-Pb-Zn+/-Au; polymetallic veins; underground	-	Geological mapping and modeling; facility upgrades; environmental monitoring	Mill on care and maintenance; work focused on identifying exploration targets

Table 4. Continued.

Jersey-Emerald	Margaux Resources Inc.	082FSW 010, 009	Pb-Zn-Ag+/-W, Au, Mo, Bi; stratiform replacement, skarn	Emerald-Dodger Tungsten: Measured and Indicated: 3.071 Mt grading 0.34% WO_3, 0.028 Mt grading 0.1% Mo; Inferred 5.48 Mt grading 0.27% WO_3, 0.481 Mt grading 0.1% Mo(2006 - 2015) Jersey: Indicated: 1.9 Mt @ 4.1% Zn, 1.96% Pb; Inferred: 4.98 Mt @ 3.37% Zn, 1.95% Pb (2010)	Dewatering underground workings at Emerald; channel sampling in the underground; drilling (800m); surface sampling; LiDAR surveys; data compilation an 3D geological modeling	Undergound channel sampling included: 3.0 m grading 14.15% Zn, 9.30 Pb, 4.18 g/t Ag; 3.0 m grading 11.6% Zn, 23.21% Pb, 2.99 g/t Ag; 3.0 m 14.85% Zn, 10.55% Pb, 2.32 g/t Ag; 3.8 m grading 11.45% Zn, 20.45% Pb, 3.22 g/t Ag; 0.9 m grading 11.35% Zn, 13.60% Pb, 4.40 g/t Ag; 2.7 m grading 14.65% Zn, 0.91% Pb, 0.49 g/t Ag; Surface prospecting included: 7.9% zinc, 22.6% lead, 646 g/t (22.8 oz/t) silver; 11.6% zinc, 12.8% lead, 228 g/t (8.0 oz/t) silver
Swift Katie	Valterra Resource Corp.	082FSW 290	Cu-Au-+/-Pb-Zn-Ag-Mo	-	Drilling; geological modeling	Results pending
Willa	MX Gold Corp.	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	Plan to process ore from the Willa using the MAX mill and tailings facility; 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	-	Results on their bulk sample; Drilling (1500 m)	Bulk sample (354 kg) assayed 15.5 g/t Au; Drill core assays including: 1.25 m grading 7.8 g/t Au, 17.8 g/t Ag; 1.0 m grading 6.9 g/t Au, 7.6 g/t Ag; 2.48 m grading 3.29 g/t Au, 17.7 g/t Ag
Marten Phosphate	Fertoz Ltd.	082GNE 027	Phosphate; upwelling	-	Processing of stockpiled material (2015); extraction of an additional 2,000 tonne bulk sample	XRF of stockpiles: 24 – 27% P_2O_5; rock phosphate product was certified for use as an organic agriculture product in compliance with the requirements of the Canadian Organic Standards (COS) and the USDA National Organic Program; additional claims staked
Coal Creek	CrowsNest Pass Coal Mining Ltd.	082GSE035	Coal (HCC and PCI); underground	HCC + PCI: 616 Mt in the upper 3 near-surface seams (2014)	Prefeasibility studies; geological modeling; resource evaluation; baseline studies	Potential for an underground mine; review of the historical mine workings of Coal Creek colliery (operated from 1897 to 1958)

Table 4. Continued.

Elko	Pacific American Coal Limited	082GSE029	Coal (HCC, PCI)	Measured: 19.2 Mt + Indicated: 57 Mt + Inferred: 181.3 Mt (JORC 2015)	Mine design and CAPEX study	Mapping of 5 coal seams over the property; 3 seams have hard coking coal quality, 2 seams have PCI coal

mineralization is mainly pyrite (weathered to limonite near the surface), galena and chalcopyrite. Historic drilling intersected near-surface gold mineralization including 2.92 g/t Au over 2 m, within a broader interval of 0.50 g/t Au over 22.38 m. Soil sampling in 2016 identified an anomaly approximately 100 m wide and over 300 m long with gold in soil values ranging from 100 ppb to 4,941 ppb (or 4.941 g/t), and the company plans follow-up work including both trenching and drilling.

7.1.3. Greenwood Gold (KG Exploration (Canada) Inc.)

KG Exploration (Canada) Inc. (a wholly owned subsidiary of Kinross Gold Corporation) continued working on the **Greenwood Gold** project. Exploration targets include epithermal and skarn related precious metal mineralization in Tertiary and pre-Tertiary rocks found in the northern extensions of the Republic and Toroda grabens. The property consists of approximately 27,346 hectares of land optioned from Grizzly Discoveries Inc. in 2015. Kinross can earn a 75% interest by incurring US$3 million over a 5-year period. The company focused on three key areas including Tertiary rocks in the northern portion of the Toroda Graben, pre-Tertiary rocks just northwest of Midway (the "Midway Window"), and pre-Tertiary rocks surrounding the historic Phoenix-Golden Crown-Lexington district (Attwood). Initial results identified previously unrecognized epithermal quartz veining and precious metal mineralization in the Attwood-Overlander area that are hosted in pre-Tertiary limestone and siltstone. Rock grab samples from exposed epithermal veins, from 0.75 to 2 m wide returned up to 29.8 g/t gold. A number of nearby geochemical anomalies with elevated Au-Ag-Bi-Sb-Hg-Mo-Te were outlined. Pre-Tertiary rocks of the "Midway Window" yielded a strong Au-Ag-As-Hg-Sb-Mo geochemical anomaly in the area of Ingram Creek that is spatially related to a northeast-trending structure, and potential precious metal epithermal and skarn mineralization. Rock samples from bands of sulphide mineralization within altered limestone yielded up to 9.27 g/t Au, with elevated Ag, Cu, Hg, Sb and Te. At March Creek, Bruce Creek, and Kerr Creek, stream-sediment samples were anomalous for precious metals and indicator minerals of a potential epithermal system. The company also remodelled airborne and ground electromagnetic and magnetic data, and conducted extensive mapping and sampling to further define drill targets for 2017.

The area is underlain by rocks of the Paleozoic Knob Hill and Anarchist Groups, Brooklyn Formation (Triassic), and Penticton Group (Eocene; Fig. 4). Intrusions of Jurassic, Cretaceous, and Eocene age occur throughout the area. Mineralization occurs as: Cu-Au-Ag skarn, Au-Ag epithermal, Ag-Pb-Zn±Au shear-hosted, stockworks and breccias and Cu-Au-Ag alkalic porphyry targets. The geology and mineralization are similar to Kinross Gold Corporation's Kettle River-Buckhorn mine and mill (1,800 tonne-per-day capacity), which is south of the project area, across the border in Washington State, USA.

7.1.4. May Mac (Golden Dawn Minerals Inc.)

Golden Dawn Minerals Inc. has been evaluating several historic mineralized areas on their **Boundary Falls** project, including the Deadwood, Wild Rose, Amigo, and **May Mac**. The company began drilling at the **May Mac** in 2015, and continued their drill program in 2016. Drilling tested downdip and step-out extensions of the main mineralized vein, and intersected similar zones with iron, lead, and zinc sulphides. Bulk sampling and further underground drilling is planned for 2017. They also entered into an agreement with Huakan International Mining Inc. to acquire the idle **Lexington** mill (200 ton-per-day gravity-flotation processing facility; Fig. 19) and the former **Lexington** and adjacent Golden Crown underground Cu-Au mines.

The area is underlain by rocks of the Paleozoic Knob Hill and Anarchist groups, Brooklyn Formation (Triassic), and Penticton Group (Eocene; Fig. 4), and intrusions of Jurassic, Cretaceous,

Fig. 19. The 200 ton-per-day Lexington mill (gravity-flotation) and tailings facility. Golden Dawn Minerals Inc. has entered into a purchase agreement with Huakan International Mining Inc. to acquire both the Lexington mine and mill, as well as the nearby Golden Crown mine. Both mines are underground Cu-Au mines.

and Eocene age occur throughout the area. Mineralization occurs as: Cu-Au-Ag skarn, Au-Ag epithermal, Ag-Pb-Zn±Au shear-hosted, stockworks and breccias and Cu-Au-Ag alkalic porphyry targets.

7.1.5. LH (Magnum Goldcorp Inc.)

In 2016, Magnum Goldcorp Inc. continued work on their **LH** property. Ground geophysical surveys including self-potential (SP), magnetometer and EM surveys were carried out. The company hopes to follow up with a drilling program in 2017 on anomalies that were identified by the surveys, and to extend mineralized zones from their 2015 drilling and sampling.

Mineralization appears to follow an east-west trending 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. 4). Gold occurs within a structural zone up to 13.7 m wide that contains 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. Gossan zones appear on surface near an old adit.

7.2. Polymetallic base and precious metal projects

Base metals are explored for throughout the region in the Omineca belt, and are found in SEDEX, MVT, VMS, manto and replacement deposits, and along structures in vein and fault systems. Only a few of the active projects in the region are discussed below.

7.2.1. Vine (PJX Resources Inc.)

PJX Resources Inc. continued drilling in 2016 at the **Vine** property, and updated their geological-geophysical model. Gravity geophysical surveys 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. 6). Recent drilling on these targets identified disseminated and replacement style sphalerite (zinc) along fractures and associated with carbonate-rich beds. The Western target lies parallel to the Vine vein, which is a shear-related vein system (Pb-Zn-Ag-Au) that was discovered in the late 1970s. Two holes drilled on the **Vine** vein in 1990 and 1994 encountered thin zones of massive sulphides at depth. Geophysical models of West target correspond to the depth of these intersections. The 2016 drill program is ongoing, and results are pending.

The property lies immediately north of the Moyie fault, a northeasterly-trending structure in the Vulacan tectonic zone (Fig. 2), and a small north-trending graben. The property is underlain by middle Aldridge Formation argillites and quartzites. Historic trenching and drilling at the Vine Vein 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.

7.2.2. Monroe (Highway 50 Gold Corp.)

Highway 50 Gold Corp. drilled at the **Monroe** property, targeting sulphide mineralization in the Aldridge Formation (Fig. 6). Drilling intersected abundant carbonate beds and pyrrhotite-biotite-chlorite-albite±chalcopyrite veins over a 150 m interval, with sericite and chlorite alteration above the Lower-Middle Aldridge contact. One hole also intersected a fragmental unit with pyrrhotite, and the second hole intersected a thin unit of bedded pyrrhotite- sphalerite. The drill program followed up on geochemical soil anomalies, geophysics and drilling that was conducted in 2015.

The property lies in a structural corridor at the intersection of two major fault zones, with numerous other showings, vent and breccia complexes, and abundant sericite, albite, chlorite, garnet and biotite alteration.

7.2.3. Irishman/Panda and DD (Teck Resources Ltd.)

Teck Resources conducted mapping and sampling at the **Irishman/Panda** in 2016, and re-logged historic drill core from the area. The company staked claims in the area in 2015 and has also optioned in on some of the other surrounding claims for SEDEX-style mineralization. Teck has the option to acquire 75% of the nearby **DD** property from PJX Resources Inc. by incurring $4M in exploration expenses by 2021, and a further $4M in expenses by 2026. The area is underlain by the Middle Aldridge (Fig. 6) siliciclastic rocks, with extensive stratabound and discordant fragmental units and widespread albite-tourmaline-chlorite-sericite alteration. The company plans to continue exploration in 2017.

7.2.4. Sully (Kootenay Zinc Corp.)

Kootenay Zinc Corp. expanded the ground magnetic survey on the **Sully** property and began drilling late in the year. Two subsurface gravity anomalies in the Purcell Supergroup (Fig. 4) have been identified on geophysical modeling. Mass models of the anomalies are consistent with contrasting specific gravities of sulphide mineralization, relative to the country rocks on the property. Previous mapping, drill-hole correlations, and interpretations suggest the anomalies may represent fault repetition of an upturned and rotated stratabound horizon in the Aldridge Formation. Previous drilling intersected traces of Pb-Zn-Cu sulphide mineralization and sericite alteration, and indicate that the property is underlain by complex fault structures.

7.2.5. Boulder Gold (Classic Financial Corp.)

Classic Financial Corp. drilled at their **Boulder Gold** property this year on targets that were identified by mapping and prospecting in 2015. A number of visible gold-bearing veins and structures have been identified on the property. Drilling encountered the downdip extension of surface structures and zones of alteration, including the Boulder fault zone. Mineralization at the property is best developed in quartz-iron carbonate-pyrite-sericite veins in north-northeast trending shears and breccias, and in the hinge zones of folds en echelon

with the Boulder Creek fault zone

The Boulder Creek area is underlain by siliciclastic, carbonate, and volcanic rocks of the Mesoproterozoic Purcell Supergroup, and Lower Cambrian quartzites, slates, and carbonate rocks. Gabbro-diorite Moyie sills intrude the area, as well as Cretaceous felsic (syenite/monzonite) intrusions and lamprophyre dikes.

7.2.6. Gallowai Bul River (Purcell Basin Minerals Inc.)

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. 6). 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.

7.2.7. Cummins River (MMG Canada Exploration Inc.)

MMG Canada Exploration Inc. continued work at the **Cummins River** property this year. The company drilled on low-moderate conductive, NW oriented targets that are coincident with magnetic anomalies and structures, as a follow up to their work in 2015. Targets, including a zinc-lead-manganese anomaly near the Bend North Road MINFILE showing, were identified on airborne VTEM, and soil sampling surveys.

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. 4) on the western limb of the Porcupine Creek anticlinorium. At the Cummins River Canyon, pyrite, pyrrhotite, sphalerite and galena are hosted in the Kinbasket limestones and Tsar Creek Formation metapelites (Chancellor Group) as intensely deformed, stratiform massive sulphides, siliceous sulphides, and mineralized manganiferous dolostone, 5 to 10 m thick (Reddy et al., 1986).

7.2.8. Goldstream (Barkerville Gold Mines Ltd.)

Barkerville Gold Mines Ltd. conducted 686 km of airborne geophysical (VTEM) surveys at the **Goldstream** property covering an area of 142 km^2. A number of moderate to high conductive targets were identified. Conductive targets coincide with magnetic anomalies, and are interpreted as sub-vertical tabular bodies, with depths to the top of the anomalies ranging from about 50-80 metres.

The property was acquired from International Bethlehem Mining Corp. in 2012 and contains the Goldstream mine and 1,000 tonne-per-day mill. Between 1983 and 1996, the mine produced 2,224,387 tonnes yielding 26,228,450 grams of silver, 42,363 grams of gold, 78,269,389 kilograms of copper and 7,988,112 kilograms of zinc (BC MINFILE). The deposit is classified as a stratiform Besshi-type Cu-Zn±Pb-Ag volcanogenic massive sulphide deposit. Mineralization consists of a thin sheet (1 to 3 metres thick) of pyrrhotite, chalcopyrite and sphalerite in sericitic quartzite and calcareous and chloritic phyllite, extending along a strike length of 400 metres.

The area is underlain by Lower Cambrian and younger metasedimentary and metavolcanic rocks of the Lardeau Group (Index Formation; Fig. 4). Massive greenstone units, chloritic phyllite, ultramafic pods and dark calcareous to pelitic schists host the Goldstream deposit.

7.2.9. Thor (Taranis Resources Inc.)

Taranis Resources continued drilling at the **Thor** property, which is composed of several targets and showings, including the **True Fissure**, **Great Northern**, **Broadview**, and **Blue Bell** past-producing mines (Figs. 20, 21). Their 2016 program included 2,100 m of drilling on several targets, and further sampling and mapping. The company acquired the property in 2006 and released a NI 43-101 resource estimate in 2013 based on 152 holes that were drilled between 2007 and 2008 at three main zones (**Broadview**, **Great Northern** and **True Fissure)**. The resource highlights both open-pit (62% of the property) and underground mining projects. Additional work since 2006 has identified other targets, which appear as VLF conductors and gossan features. In 2015, the company surveyed and sampled stockpiles at the **Broadview**, **Great Northern**, and **True Fissure** past-producers, and are updating the resource model on the property with the results. It is believed that historically, the galena ore was hand-picked while the chalcopyrite and sphalerite were left in the dumps. This year's drilling encountered stacked zones of mineralization beneath the **Great Northern**, and as step-out mineralization in previously undrilled areas. The company also acquired a portable test mill this year and have placed it on site. They plan to use it to process a 1,000 kg bulk sample. The company has updated their 3D model of the deposit to identify peripheral targets, and plans to update the resource after next year's drilling.

The **Thor** property lies at the northern end of the Kootenay arc (Fig. 2), and is underlain by a thick succession of folded and faulted sedimentary and volcanic rocks of the Badshot Formation and Lardeau Group (Fig. 4). The geology on the property is highly deformed, but it is interpreted that primary stratiform sulphide mineralization (Ag-Pb-Zn-Au-Cu) may be of volcanogenic massive sulphide origin, and predates folding and faulting. Parallel horizons of massive and disseminated galena, chalcopyrite, pyrite, and sphalerite extend along a 2 km strike length of a sheared, northwesterly trending anticline. The zone of mineralization is commonly intercalated with

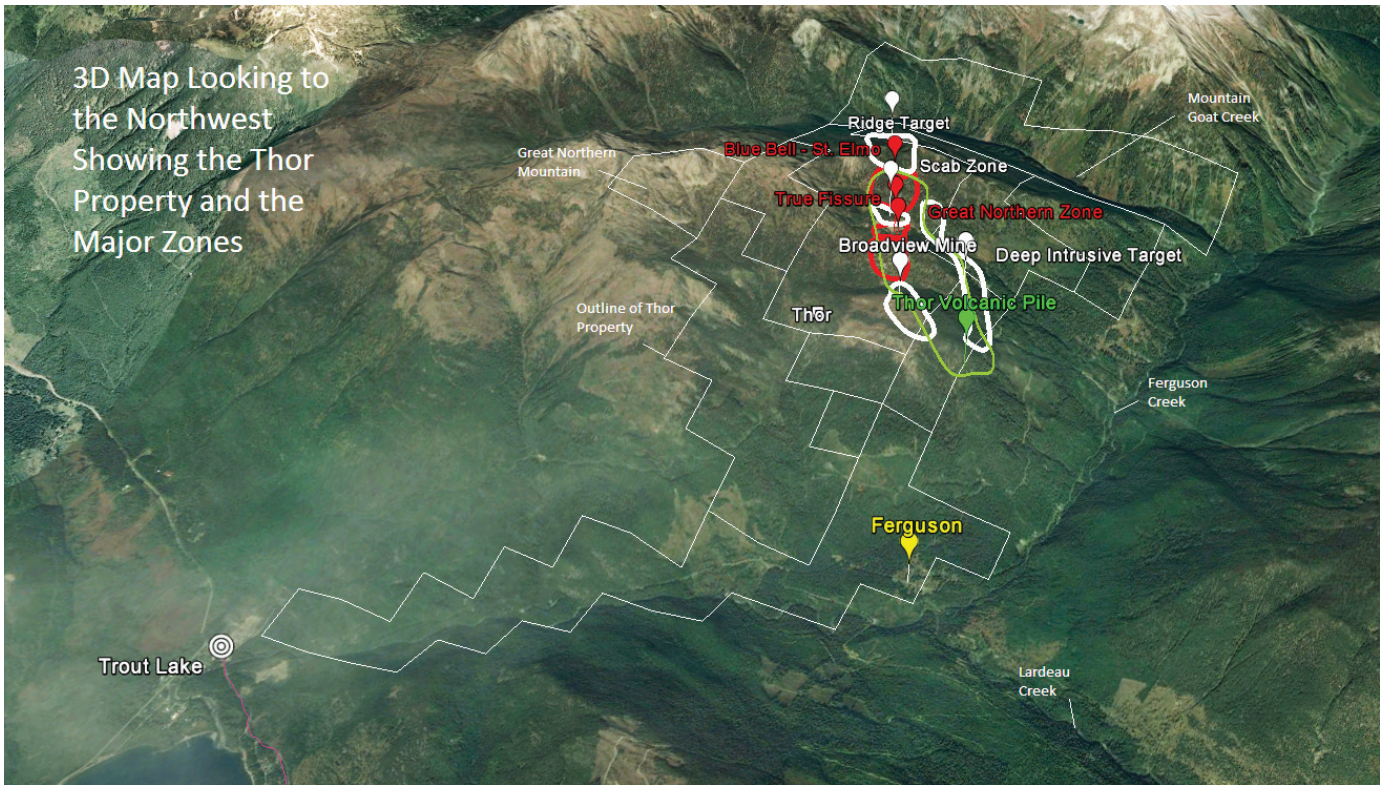

Fig. 20. Thor property historic producing mines, and exploration targets. Photo courtesy of Taranis Resources Inc.

Fig. 21. Massive sulphide mineralization (sphalerite) at True Fissure zone on the Thor property. Photo courtesy of Taranis Resources Inc.

pyroclastic tuffaceous sediments. Drilling has encountered foliated quartz-feldspar porphyry on the property, which is believed to pre-date structures and possibly be related to the mineralizing event. High-grade gold is also found in late quartz veins that flank sulphide deposits.

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

The **Teddy Glacier** property has been intermittently explored since the 1920s. In 2016, the company continued mapping and sampling, and conducted environmental baseline studies and mill upgrades. Jazz Resources Inc. plans to collect a bulk sample and process it at the **Spider Mine** mill, and have been working to obtain permits for this facility.

The property is underlain by tightly folded and sheared limestones, carbonaceous phyllites, and grits of the Index and Jowett formations (Lardeau Group; Fig. 4). 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).

7.2.11. Slocan Silver (Klondike Silver Corp.)

Klondike Silver Corp's **Slocan Silver** project consists of 25,000 hectares with several past producers from silver-rich veins in a historic Ag-Pb-Zn mining area. The area is underlain by sheared and brecciated argillites and slates of the Slocan Group (Triassic) that are cut by Nelson granodiorite and quartz monzonite dikes (Middle Jurassic; Fig. 4). 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 in 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 (BC MINFILE). The company's mill at Sandon is a 100 tonne-per-day concentrator

that operated at an average rate of 40 t per day (Fig. 22). In 2016, the mine and mill remained on care and maintenance, and the company focused on exploration work to identify new exploration targets and sources of mill feed for a re-start of the mill. Environmental work and engineering upgrades to the tailings facility and underground structures are ongoing.

Fig. 22. The Sandon mill, currently on care and maintenance. The mill has a capacity of 100 tonnes-per-day, and is owned and operated by Klondike Silver Corp.

7.2.12. Jersey-Emerald (Margaux Resources Ltd.)

Margaux Resources Ltd. continued work at **Jersey-Emerald**. Early in the year, the company focused on an historic drift (ca. 1905) that they discovered during their 2014 East **Emerald** tungsten drill program, and which is along strike with the Pb-Zn **Jersey** mine. In 2016, Margaux collected samples from this drift, and found it to be 12.8 metres long with continuous galena-rich mineralization along its length. After the initial underground sampling, the company conducted surface sampling and sampled several gossan zones and veins. They also completed LiDAR over the property, worked on dewatering the underground workings at the **Emerald**, and compiled all the available historical data (including surface and underground mapping and surveys, over 5,300 drill collars, logs, and assay data). They began expanding their 3D modelling of the property, and drilled late in the year with a focus on higher grade gold-bismuth targets and lead-zinc targets. The 2015 resource estimate for the **Emerald** is 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 2010 **Jersey** resource estimate included 1.9 Mt grading 4.1% Zn and 1.96% Pb (Indicated), and 4.98 Mt grading 3.37% Zn and 1.95% Pb (Inferred), using cutoff grades of 3.5%.

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. 4). Coarse-grained marble to garnet-pyroxene skarn occurs in the Truman and Reeves members at contacts with small Cretaceous biotite granite stocks, Jurassic Nelson intrusions, and pegmatitic stocks. The main structure is a NNE-trending anticline known locally as the Jersey anticline. The property contains: stratiform lead-zinc-silver mineralization; tungsten (with minor molybdenum and copper) skarn mineralization (Fig. 23); quartz veins, silicified limestone, and greisen-type alteration with gold, bismuth, cadmium and barium; and molybdenum porphyritic stocks. The **Emerald** Tungsten mine has stratabound Pb-Zn mineralization in the Reeves member, and a W-skarn zone in the Truman member. The **Jersey** mine has stratiform Pb-Zn mineralization at the base of the Reeves. The surrounding historic Dodger, Invicible, and Feeny mines also display tungsten mineralization.

Fig. 23. Skarn mineralization in the Truman Member (Cambrian) at the Jersey-Emerald.

7.2.13. Willa (MX Gold Corp.)

MX Gold Corp. continued work on the **Willa** property and are in the permitting stages and conducting environmental baseline studies for planned underground and bulk sampling. They have also been rehabilitating a historic portal and underground workings and upgrading the road. In addition to their work at the **Willa**, they have also begun repairs, maintenance, and modifications to the **MAX** mill and tailings facility, which they plan to use to process their bulk sample from the **Willa**. The **MAX** mine is 135 km to the west, near Trout Lake, and has been on care and maintenance since 2011.

The **Willa** deposit is in a roof pendant of the Nelson batholith, containing mafic volcanic rocks of the Rossland Group, intruded by felsic dikes (Fig. 4). Surrounding Slocan Group metasedimentary rocks contain silver-lead-zinc mineralization. Lamprophyre dikes and faults post-date and crosscut the metavolanic rocks 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).

7.2.14. Whitewater (Braveheart Resources Inc.)

Braveheart Resources Inc. continued exploration work at the **Whitewater** property. They began drilling in October 2016 with plans for additional drilling late in the year to test the extension and continuity of mineralization in quartz veins on the property. Results were also released early in the year from their 2015 bulk sampling program (354 kg).

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. 4). Mineralized quartz veins hosted by hornblende granodioritic rocks (Jurassic) and found in 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 in shear-hosted banded quartz veins that are up to 2 m wide and 400 m long.

7.2.15. Swift Katie (Valterra Resource Corporation)

Valterra Resource Corp. began drilling on their **Swift Katie** project late in the year, following up on drilling that was done in 2014 by Riverside Resources. One of the holes is offsetting a 2014 hole that initially assayed 3.5 m grading 13.3 g/t gold, 201 g/t silver and 0.33% copper. In 2016, drilling continued late in the year and results are pending.

The property is underlain by volcanic and synvolcanic intrusive rocks of the Elise Formation, Jurassic to Cretaceous (Nelson) intrusions, Eocene intrusive rocks (Coryell), and Tertiary felsic to mafic and lamprophyric dikes (Fig. 4). The property contains alkalic porphyry Cu-Au mineralization, with pyrite, chalcopyrite, bornite, pyrrhotite, sphalerite, tetrahedrite and chalcocite, and polymetallic (Pb-Zn-Ag±Au,Cu) shear-hosted quartz-calcite veins. In addition to a Cu-Au porphyry target, gold mineralization at the **Swift** also appears to be associated with pyrite-pyrrhotite-chalcopyrite veins at the contact between andesite and a diorite intrusion, and elevated copper and lead. The package at the **Swift** may reflect a transitional environment from a porphyry to an epithermal system. Drilling on the **Katie** has identified zones of copper-gold mineralization along a 1,800 m strike length, with numerous other untested soil anomalies, representing an alkali porphyry target.

7.3. Industrial mineral projects

Industrial minerals are explored for throughout the region, including graphite, gypsum, magnesite, silica, rip rap, dimension stone, sand and gravel, limestone, dolomite, tufa, smelter slag, basalt, gabbro, marble, and phosphate. Only one project of several in the region is described below.

7.3.1. 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. 4). Handheld XRF analysis of the phosphoritic beds indicates 24-27% P_2O_5, and the beds have been mapped for over 1,200 m. Fertoz is permitted for a 10,000 t bulk sample and in 2016, the company crushed and pulverized approximately 1,720 tonnes of previously stockpiled rock phosphate for direct application spreading as rock phosphate fertilizer. They extracted a further 2,000 tonnes this year, and staked additional claims to expand their land position. The company also received approval for use of their rock phosphate to process organic agriculture products in compliance with the requirements of the Canadian Organic Standards (COS) and the USDA National Organic Program

7.4. Coal projects

Coal exploration is ongoing in the Elk Valley, Crowsnest, and Flathead coalfields (Fig. 10), though with coal prices being depressed over the past few years, exploration on new projects has slowed. Two projects are discussed within this report.

7.4.1. 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). Although fieldwork remained on hold in 2016, environmental baseline studies, including water quality surveys are ongoing.

The company has been testing the downdip 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.

7.4.2. Elko (Pacific American Coal Limited)

In 2016, Pacific American Coal Limited conducted mine design and CAPEX studies on their **Elko** coal project property (Fig. 10), and updated their geological model. In 2015, they mapped and sampled, located old adits, and compiled historical drill, geological and sample data on the property. They have outlined locations for future drilling.

The project is in the Crowsnest coalfield, targeting Mist Mountain coal seams in 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.

8. Geological research

Geological research is being carried out in the region by the British Columbia Geological Survey, Geoscience BC, the Geological Survey of Canada, the National Institute of Advanced Industrial Science and Technology (AIST) at the Geological Survey of Japan, and by various students at the MSc and PhD levels.

8.1. Geoscience BC

Geoscience BC funds a variety of projects in the region. Over the past few years, several projects have also been funded as part of the SEEK (Stimulating Exploration in the East Kootenays) program, which is largely focused on gold and base metals mineral potential in the Belt-Purcell Basin (Purcell Anticlinorium; Fig. 2). One recent paper studies the links between fragmental rocks and mud volcanoes to massive sulphide Ag-Pb-Zn deposits in the Purcell Basin (Kennedy and Höy, 2016). 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. In the Boundary area, geological mapping is being conducted in NTS 083E/07 (Höy et al., 2016).

8.2. British Columbia Geological Survey and Geological Survey of Canada

The British Columbia Geological Survey has entered into a partnership agreement with National Institute of Advanced Industrial Science and Technology (AIST) at the Geological Survey of Japan, with technical support from the Geological Survey of Canada to study the rare earth element potential in the Rocky Mountain foreland belt. Preliminary field reconnaissance work was conducted in 2016 on the project, with further work planned for next year.

9. Summary

In 2016, exploration and mining continued in the region. Major mine development, expansion plans, and projects in the East Kootenay coalfields continue to advance. Several mine development projects for industrial minerals 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. Commodity prices were down and markets began the year at lower levels. However, prices and investment funding picked up later in Q3, and several late drill programs occurred throughout the region. Several drill programs are also planned for 2017.

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