Exploration and mining in the Coast Area, British Columbia

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1. Introduction

This report considers the Coast Area natural resource sector, comprising the South Coast and West Coast regions, including Haida Gwaii (Fig. 1). The area has one major metal mine (Myra Falls) one coal mine (Quinsam Mine), and numerous industrial minerals and aggregate operations. An informal survey of industrial minerals producers and the largest aggregate operations indicates most are producing at or above volumes reported in 2013. Quinsam Coal, a thermal coal producer, has reduced its workforce and output. Polymetallic producer Myra Falls appears less affected by lower commodity prices and continues to mine at a rate similar to 2013, although they report higher zinc grades. Exploration activities requiring significant capital were reduced in 2014 (Figs. 2-4); companies reported only one significant off-lease drill program and two smaller ones. The largest exploration program was the ongoing effort to replace reserves at Myra Falls.

2. Geological overview

Metallogeny in British Columbia is intimately linked to the tectonic evolution of the Canadian Cordillera, an accretionary orogen consisting of exotic and parauthoctonous terranes that were welded to ancestral North America during the last 180 million years (e.g. Nelson et al., 2013). The South and West Coast regions include parts of the Insular, Coast, and Intermontane morphogeological belts; most of the area is underlain by rocks of the Wrangell terrane and the Coast Plutonic complex (Fig. 1). Wrangellia is part of the Insular superterrane, a Paleozoic-Mesozoic allochtonous assemblage that docked with Intermontane terranes in the Early-Middle Jurassic as Panthalassic oceanic crust subducted beneath them (e.g. Nelson et al., 2013). A Middle-Late Jurassic magmatic arc resulted from this subduction, the roots of which are represented in the Coast Plutonic complex. Southeast-directed oblique convergence brought the Insular composite terrane southward with respect to the Intermontane terranes, trapping segments of oceanic crust and arc rocks that became the terranes of the southeastern Coast Mountains, and transecting and duplicating part of the Middle-Late Jurassic arc (Bustin et al 2013, Monger and Brown in press). From the Cretaceous onward, accretion continued outboard of Wrangellia. Today, oceanic crust of the Juan de Fuca plate slides eastward beneath previously accreted terranes on Vancouver Island (Pacific Rim, Crescent, and Wrangell, Fig. 1) along the Cascadia subduction zone (e.g., Hyndman, 1995). The principal deposit types in the South and West Coast regions are tied to Cordilleran terranes (Fig. 5).

2.1. Insular Superterrane

Wrangellia is the most prominent terrane of the Insular belt. The oldest rocks on Vancouver Island are Devonian volcanic arc andesites, basalts, breccias, tuffs and tuffaceous sediments of the Sicker Group and allied intrusive rocks. The Sicker Group is overlain by Mississippian-Permian limestones, argillites, and minor conglomerate of the Buttle Lake Group. This Paleozoic basement is exposed in two major uplifts on southern and central Vancouver Island. The Cowichan Anticlinorium and the Buttle Lake Anticlinorium have particular economic significance as they host past and present volcanogenic massive sulphide polymetallic producers at Mount Sicker and Myra Falls, probably emplaced in back-arc settings.

Unconformably overlying the Paleozoic rocks are Middle to Upper Triassic oceanic flood basalts and related sedimentary rocks of the Vancouver Group. The Vancouver Group consists of a thick (up to 6 km) sequence of flood basalts (Karmutsen Formation), and limestones (Quatsino Formation; on Haida Gwaii, Kunga Formation). The upper part of the Vancouver Group contains numerous skarn occurrences adjacent to Jurassic intrusions (Island Plutonic suite). Iron and iron-copper skarns are particularly abundant. The Tasu past producer (MINFILE 103C 003) on Haida Gwaii is one of the larger examples. Between 1914 and 1983, it produced 12 million tonnes of iron concentrate and copper, gold and silver.

The Vancouver Group is overlain by arc rocks of the Bonanza Group (Upper Triassic-Middle Jurassic), which includes a volcanosedimentary succession (Parson Bay Formation) and a unit of subaerial basaltic to rhyolitic flows and tuffs ('LeMare Lake volcanics'; Nixon and Orr, 2007). The LeMare rocks are of economic significance on northern Vancouver Island. North of Holberg Inlet, where intruded by Island Plutonic suite granodiorite and quartz diorite, the LeMare rocks host the past-producing Island Copper Cu-Mo-Au porphyry deposit (MINFILE 092L 158) and other undeveloped porphyry and epithermal prospects.

On the east coast of Vancouver Island, in the Straight of Georgia, and on the western mainland, Wrangellia is buried by rocks of the Nanaimo Group, an Upper Cretaceous continental

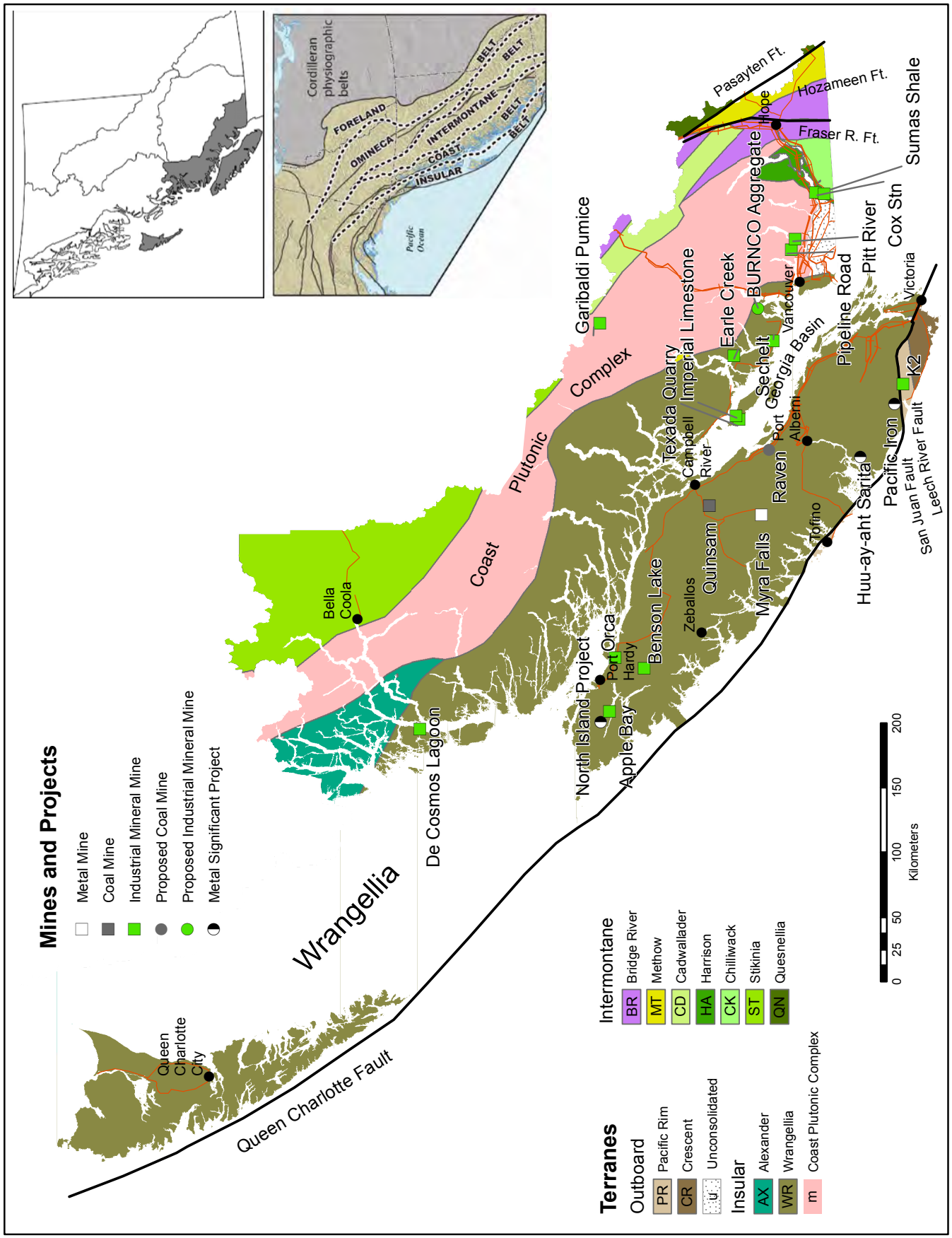

Fig. 1. Operating mines and selected major exploration projects, the Coast Area, 2014. Terranes from Nelson et al. (2013).

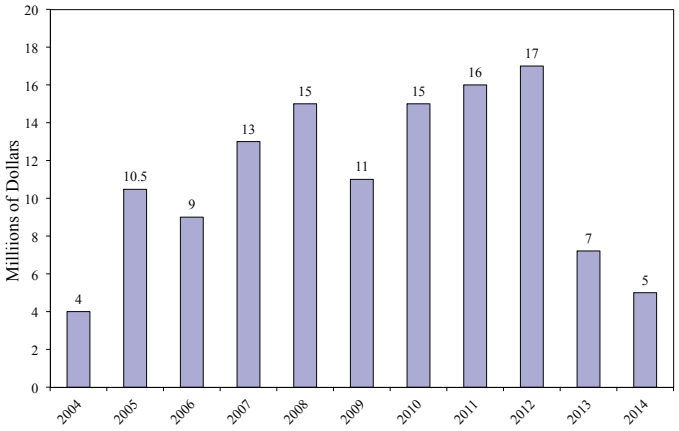

Fig. 2. Exploration spending estimates, Coast Area 2004-2014.

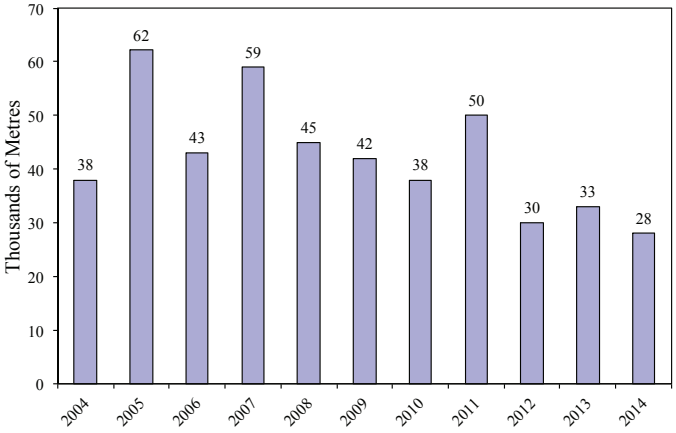

Fig. 3. Exploration drilling in the Coast Area, 2004-2014.

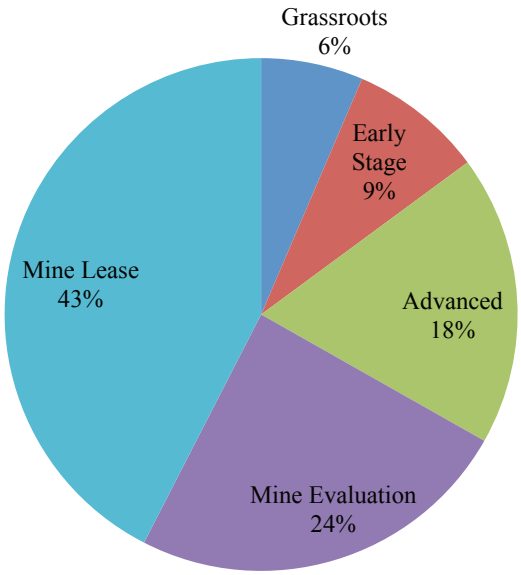

Fig. 4. Coast Area exploration spending by exploration stage, 2014.

to marine molassoid succession containing debris derived from unroofing of the Coast Belt and northern Cascades (Mustard, 1994). The Comox Formation, the basal unit of the Nanaimo Group, hosts economically important coal deposits that were mined historically in the Nanaimo area and are currently mined near Campbell River.

On Vancouver Island, the western flank of Wrangellia is bound by the Pacific Rim terrane, which consists of possible mélange deposits (Pandora Peak unit, Rusmore and Cowan, 1985; Pacific Rim complex, Brandon, 1989) and the Leech River complex, an assemblage of greenschist- to amphibolite-grade mudstones, sandstones, and mafic volcanic rocks cut by granitic bodies (Groome et al., 2003). Slate and siltstone is quarried for building stone in the Leech River complex. The Leech River complex has been an active placer gold camp since 1864. Gold quartz veins have been the subject of recent exploration near the Leech River Fault, along the southern margin of the terrane (Fig. 1).

The Crescent terrane represents Eocene accretion of Late Cretaceous or Paleocene to Early Eocene seamounts. The Leech River Fault marks the boundary of Pacific Rim and Crescent terranes. The Metchosin Igneous complex, a partial ophiolite and the northernmost extent of the Coast Range Basalt Province (Massey, 1986), contains three tholeiitic intrusion-hosted past producers of copper and precious metals, the most significant of which was the Sunro mine (MINFILE 092C 073).

2.2. Coast Plutonic complex

The Coast Mountain range is underlain by the Coast Plutonic complex, a large northwest-trending batholith consisting largely of diorite, quartz diorite, tonalite and granodiorite calc-alkaline rocks with less abundant high-grade metamorphic rocks. For the most part, uplift and erosion appear to have removed the levels at which epithermal and porphyry style mineralization form, however there are exceptions.

At the southern end of the Coast Plutonic Complex, economically important deposits occur in pendants of Gambier Group, overlapping Late Jurassic to Mid-Cretaceous arc-related volcanic and sedimentary rocks. The most productive of these deposits was the Britannia mine (MINFILE 092GNW003), a Kuroko-type polymetallic volcanogenic massive sulphide deposit that produced 517,000 tonnes of copper with zinc, silver, gold, lead and cadmium between 1905 and 1974.

2.3. Terranes of the Southeastern Coast Belt

The Coast Area boundary transects small parts of the Quesnel Terrane and a larger area of Stikinia, however much is covered by parkland and is unavailable for mineral development or otherwise inaccessible. Exceptions include the Redbird, a molybdenum prospect west of Tweedsmuir Provincial park and east of Kitlope Heritage Conservancy (Fig. 1; MINFILE 093E 026).

The southeastern Coast Belt north of the international border is underlain by the Harrison, Chilliwack, Bridge River, Cadwallader and Methow terranes (Fig.1). These represent

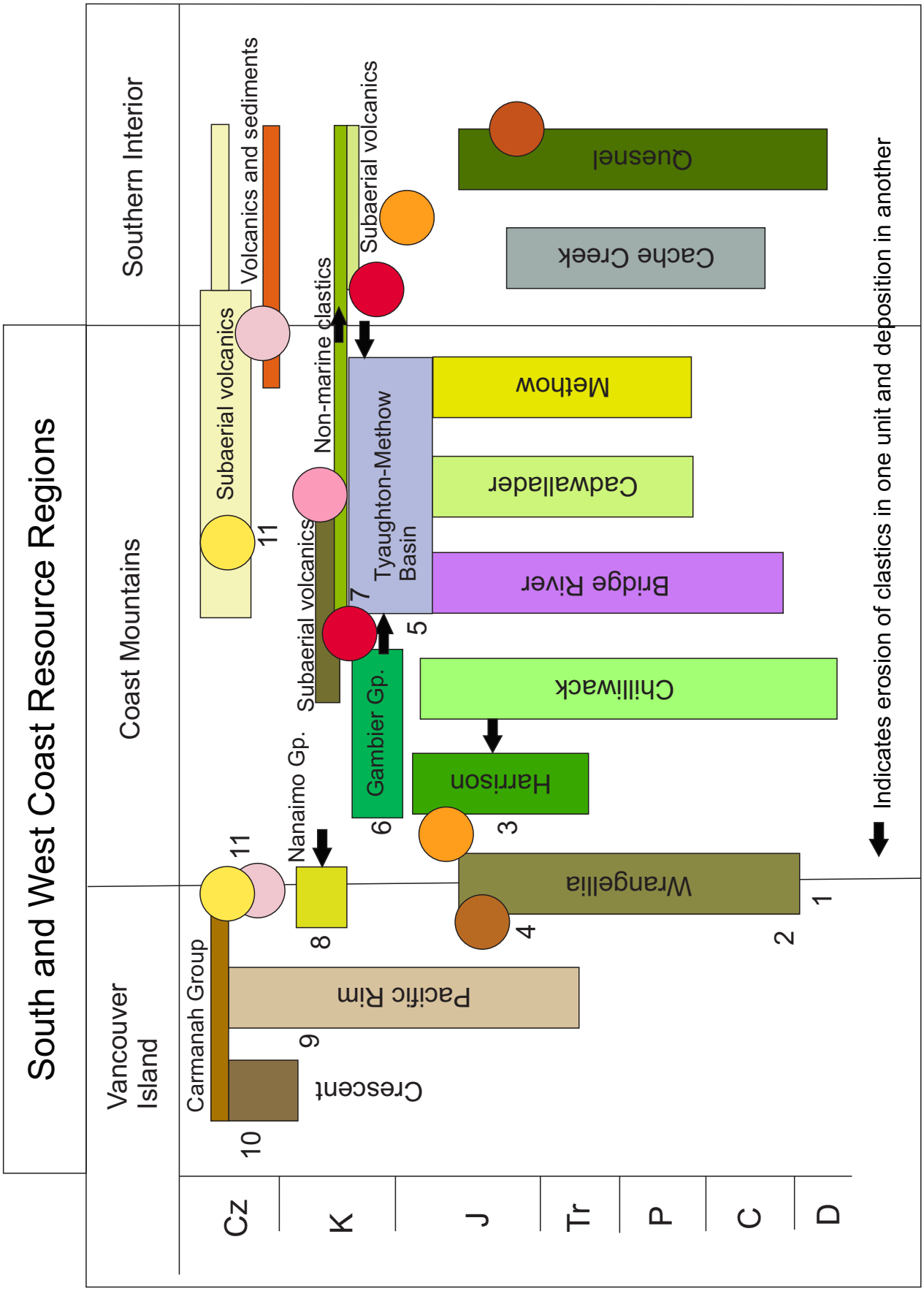

Fig. 5. Time-space diagram showing relations between terranes, basins, plutonic rocks (circles), and significant mineralizing events in southwestern British Columbia. 1) Sicker Group volcanogenic massive sulphide; 2) orogenic gold veins in Sicker Group; 3) Harrison Formation volcanogenic massive sulphide; 4) Island plutonic suite porphyry Cu-Mo, Fe, Cu skarn; 5) orogenic Au vein (Coquihalla serpentine belt); 6) Gambier Group volcanogenic massive sulphide; 7) tholeiitic intrusion hosted Cu-Ni (Cretaceous); 8) Nanaimo Group coal; 9) orogenic Au veins; 10) tholeiitic intrusion hosted Cu-Ni (Eocene?); 11) porphyry Cu, Mo, Epithermal Au (Eocene to Miocene). Modified from Bustin et al. (2013).

slices of oceanic and arc- related rocks enclosed between intermontane and insular terranes during Middle Jurassic to Middle Cretaceous regional sinistral faulting (Bustin et al., 2013). Historically, these terranes have not been shown to host large deposits, which may explain why the area has not been intensively explored despite its accessibility and proximity to infrastructure. Gambier Group equivalent overlap deposits and parts of the Harrison terrane are prospective for VMS mineralization. The Coquihalla Serpentine belt, along the Hozameen fault between the Bridge River terrane to the west and the Methow terrane to the east, hosts several gold prospects and five past producers including the Carolin Mine, which operated between 1981 and 1984. The Late Cretaceous Giant Mascot ultramafic-mafic intrusive suite (Manor et al., 2014) hosts the province's only past producing nickel mine, Giant Mascot Nickel, which operated between 1958 and 1974.

2.4. Cenozoic Magmatism and Volcanism

Eocene to Miocene ancestral Cascades arc magmatism extended as far northward as southwestern British Columbia, as does present day Cascades magmatism. Evidence of forearc Paleocene to Miocene magmatism can be traced from southern Oregon through Alaska. Southwestern British Columbia was an active part of this semi-continuous belt (Madsen et al., 2006). Mineral deposits related to Cenozoic magmatism have not been particularly productive, but neither are they well explored. Between 1964 and 1967, Mount Washington Copper (Eocene; MINFILE 092F 117) produced 3548 tonnes of copper, 131 kg gold and 7235 kg silver. Catface Copper (MINFILE 092F 120) has a significant undeveloped resource. Other targets of presumed Cenozoic age include Giant Copper (MINFILE 092HSW001) and Okeover (MINFILE 092K 008). Harmony (MINFILE 103F 034) is a Miocene epithermal deposit with a significant undeveloped gold resource on Graham Island, Haida Gwaii (Figs. 1, 6). More recent Cascades magmatism has produced pumice and other volcanic rocks quarried for construction, landscaping and other applications. The Mount Meager area has also been investigated as a possible source of geothermal energy.

3. Mines

3.1. Metals

Myra Falls Operations (Fig. 7) is an underground polymetallic mine, owned and operated by Nyrstar N.V. The mine has operated for almost 50 years, despite being inside provincial park boundaries (Strathcona-Westmin), and its location on Buttle Lake, which is part of Campbell River's water supply. The deposits are hosted by the Sicker Group, a Middle Devonian volcano-sedimentary island-arc assemblage that forms basement to Wrangellia beneath much of Vancouver Island (Fig. 1). Ore bodies are in two horizons of the Myra Formation and are generally considered have formed as Kuroko type, bimodal (mafic-felsic) volcanogenic massive sulphides.

In the first three quarters of 2014, Myra Falls milled 377, 000 tonnes of ore, with higher zinc and gold grades and better recoveries than in 2013. Typical annual throughput in recent years has been approximately 500,000 tonnes (Table 1). The operation has a history of success in replacing reserves. In 2014, underground development, exploration and definition drilling continued to add new areas to the mine plan. Myra Falls increased their ongoing exploration program in 2014 with more drilling, including development of underground access and drill platforms. This work extended lenses in the west, which were discovered in 2013. A surface ramp was extended to regain access to the historic Lynx mine, providing additional western drill platforms. At the eastern end of operations, production began at the Price deposit after several years in exploration and development. The Price development provides additional exploration drill platforms in the east.

Fig. 6. Mineralized Miocene conglomerate (Skonun Formation) at the Harmony project, Graham Island. Harmony is an undeveloped low-sulphidation epithermal gold deposit.

Limited tailings storage capacity is perhaps more likely to limit mine life than is exhaustion of reserves. The mine employs 345 people.

3.2. Coal

Underground coal mining on Vancouver Island dates back to 1849. The **Quinsam** Thermal Coal Mine near Campbell River (Figs. 1, 8) has operated since 1986, and is currently the only active coal mine in the South and West Coast regions. The mine is operated by Quinsam Coal Corporation, a subsidiary of Hillsborough Resources Ltd., which is part of the Vitol Group. It is the only underground coal mine in the province, although others are proposed, including the Raven metallurgical coal

Table 1. Operating metal mines, South and West Coast regions.

Mine	Operator	Commodity; deposit type	Production Forecast 2014 (based on first 9 months)	Reserves (Proven + Probable, Dec 31, 2013)	Measured and Indicated Resources (inclusive of reserves)	Near-mine exploration	Website
Myra Falls	Nyrstar N.V.	Zn-Cu-Pb-Ag-Au; VMS	Approx. 0.5 Mt at head grades of 6.8% Zn, 0.77% Pb, 0.71% Cu, 2.12 g/t Au, 100.42 g/t Ag	5.49 Mt 5.69% Zn, 0.59% Pb, 0.88% Cu, 58.32 g/t Ag, 1.51 g/t Au	6.81 Mt 6.34% Zn, 0.67% Pb, 0.97% Cu, 66.53g/t Ag, 1.74g/t Au	Approx. 25,000 m diamond drilling + underground development	www.nyrstar.com

Table 2. Operating coal mines, South and West Coast regions.

Mine	Operator	Commodity	Production Forecast 2014	Reserves	Near-mine exploration	Website
Quinsam	Hillsborough Resources Limited	Thermal Coal	225,000 t clean coal	n/a	Drilling 14 holes (Percussion + core) 514.38 m; Trenching, 4 total length 100 m	hillsboroughresources.com

project near Comox. The Quinsam mine produces from coal seams in the upper part of the Comox Formation, the basal unit of the Nanaimo Group (Late Cretaceous). The mine is capable of producing over half a million tonnes a year. As a private company, Hillsborough does not release reserve and resource figures.

Similar to other coal mines in the province, Quinsam has been affected by recent low prices; 61 workers were laid off during the year, leaving a workforce of 69. Production was accordingly lower (225,000 tonnes clean coal, Table 2). Mine site exploration has continued, but a proposed exploration project south of the mine site is not yet permitted. Hillsborough has been testing and researching underground waste and tailings disposal. The mine now disposes of coarse rock rejects underground in disused flooded workings. Potentially acid generating tailings are currently disposed of subaqueously in an open pit. Underground tailings injection infrastructure is in place.

3.3. Industrial minerals

Large quarries on the coast serve the lower mainland, Vancouver Island, and US Pacific Northwest markets by barge. Those with access to freighter loadout facilities can also supply eastern Pacific international markets, and Hawaii. The largest industrial minerals producers in the region are listed in Table 3 (exclusive of aggregate-only quarries).

The largest limestone quarry on the coast is **Texada Quarrying** operation near Gillies Bay. Texada Quarrying Ltd. is a subsidiary of Lafarge North America. Most of its projected production for 2014 (3.8 million tonnes) will supply local cement plants. The quarry also produces aggregate, mainly from quartz monzonite to gabbro dikes and sills, which would otherwise be waste rock. The site also hosts a white carbonate quarry, one of only a few sources on the coast. The quarry has been in operation for 62 years and employs 65 people directly. The quarry has extensive reserves and, at current rates, is capable of producing for more than 100 years.

The Imperial Limestone Co. Ltd. quarry near **Van Anda** on Texada Island (Fig. 1) produces approximately 250,000 tonnes annually. They report approximately 272,000 tonnes produced and shipped in 2014. Quarrying at the Imperial site dates back to the 1930s, and the current owners have operated it since the early 1950s. They anticipate reserves will last more than 50 years.

Ashgrove Cement Company's **Blubber Bay** limestone quarry on Texada Island has remained on care and maintenance since 2010, after more than 100 years of operation. It reopens for sufficiently large contracts. It can still supply limestone aggregate and continues to supply dolomite to lower Mainland and northwest US markets. It shipped 56,000 tonnes of dolomite early in 2014.

On northern Vancouver Island, Electra Gold Ltd. continued to mine silica and alumina products from silicified and clay-altered rhyolitic flows and volcaniclastic rocks at the **PEM 100** or **Apple Bay Quarry**. Similar to 2013, the company expects to ship approximately 70,000 tonnes in 2014. The quarry ships raw product by barge to Ash Grove Cement Company in Seattle.

Fig. 7. The HW headframe at Myra Falls, an underground Zn-Cu-Pb-Ag-Au producer on Vancouver Island. Exploration is ongoing at this Kuroko-type VMS camp.

Fig. 8. Operator's view from the back of a continuous miner at Quinsam Coal.

At the **Benson Lake** white carbonate deposit, also on northern Vancouver Island, Imasco Minerals Inc. reports 2014 shipments and sales similar to those of 2013, at over 45,000 tonnes.

The **Sumas Shale** quarry on Sumas Mountain is owned by Clayburn Industrial Group Ltd. and operated by contractor Fraser Pacific Enterprises Inc. It delivers sandstone and shale product to the Lafarge and Lehigh cement plants in Richmond and Ashgrove in Seattle, a joint venture with Lafarge North America (Sumas Shale Ltd.). Production and shipments will be approximately 500,000 tonnes in 2014. Because Clayburn's brick and refractory products plant in Abbotsford closed, fireclay is no longer produced separately.

Ironwood Clay Company Inc. mines glacial marine clay deposits on the central coast. Recent production has been from **DeCosmos Lagoon** south of Bella Bella (Fig. 1). They have a new proposed quarry at the head of Bute Inlet and a site at Hvidsten Point 15 km east of DeCosmos Lagoon. Ironwood reported continuing strong sales in 2014, and continued to process approximately 600 tonnes of material collected in 2013. They will quarry again in 2015. Ironwood produces cosmetic products at its Richmond plant. Other individuals and companies supply the growing cosmetic clay market at smaller scales from locations on the central coast and Vancouver Island. Generally, Mines Act permits are not required where material is collected by hand, and therefore some of these operations are unreported.

In the Mount Meager area, Garibaldi Pumice Ltd. shipped 14,000 cubic metres of pumice from the **Garibaldi Pumice** quarry in 2014, up considerably from 2013 as recent testing supported the product's suitability as a lightweight fill and road base. Neighbouring Great Pacific Pumice Inc. did not produce at their **Mount Meager** quarry in 2014, but continued to ship material from stockpiles. These stockpiles are now depleted and mining is planned for 2015.

K2 Stone is a natural stone product supplier with quarries near Port Renfrew on Vancouver Island, (**K2**). In 2014, K2 Stone mined and shipped over 17,000 t from Port Renfrew with a 5 person crew. The rock is trucked to Nanaimo for processing into masonry and landscaping products. Other smaller producers of slate quarry rocks of the Leech River complex. **Van Isle Slate** has been offering a line of hand-cut products. Island Stone Landscape Supply is another established producer and supplier of flagstone from the area. Matrix Marble and Stone Inc. continues to quarry marble on Vancouver Island and fabricate a line of products including countertops, sinks, tiles, and building products. They quarry their Carmanah Black near Port Renfrew (**Gordon River**) and Tlupana Blue Grey and Vancouver Island White near **Hisnit Inlet**.

Landscaping stone and dimension stone is quarried in the Squamish-Whistler corridor. The largest operator is Northwest Landscape and Stone Supply, with the **Spumoni Quarry**. In 2014 they upgraded their Cabin Group property to mining leases and obtained a Mines Act quarry permit. Others active in the area include Bedrock Granite Sales Ltd., Citadel Stone Ltd., Alpine Natural Stone Ltd.

Haddington Island and **Hardy Island** (MINFILE 092F 425) are two regular producers of dimension stone on the coast. The Haddington Island product (typically referred to as Haddington Island andesite) is a durable, resistant dacitic volcanic rock (70.5% silica), part of the Alert Bay volcanic belt (Neogene).

Table 3. Selected operating industrial mineral mines (excluding aggregate), South and West Coast regions.

Mine	Operator	Commodity; deposit type	Production Forecast 2014	Reserves (approx.)	Website
Apple Bay	Electra Gold Ltd.	Silica + alumina; hydrothermal clay-silica	70,000 t	Unreported	www.electragoldltd.com
Benson Lake	Imasco Minerals Inc.	High brightness carbonate; white marble	45,000 t	100+ years	www.imascominerals.com
Blubber Bay	Ashgrove Cement Company	Aggregate, dolomite; Limestone and dolostone	56,000 t (dolomite)	100+ years	www.ashgrove.com
Garibaldi Pumice	Garibaldi Pumice Ltd.	Pumice	14,000 cubic metres	Unreported	garibaldipumice.com
Imperial Limestone	Imperial Limestone Co. Ltd. (J.A. Jack & Sons Inc.)	Limestone	272,000 t	50+ years	www.jajack.com
K2	K2 Stone Quarries Inc.	Building stone	17,000 t	Unreported	www.k2stone.com
Sumas Mountain	Sumas Shale Ltd. (Clayburn Industries Ltd., Lafarge North America)	Silica -alumina; Shale and sandstone	500,000 t	60-70 years	www.clayburnrefractories.com
Texada Quarry	Texada Quarrying Ltd. (Lafarge North America)	Limestone, aggregate, high brightness carbonate	3,800,000 t	100+ years	www.lafarge-na.com

Haddington Island Stoneworks Ltd. shipped approximately 300 tonnes in 2014. They now use a diamond wire saw that causes less fracturing than traditional drilling and blasting. Most of the product is used in restoration work on historic buildings.

Hardy Island produces from a uniform grey Coast Plutonic complex granodiorite unit. Like Haddington Island, it is an historic quarry that has resumed regular annual production, mainly serving the local market. It shipped approximately 3,000 tonnes in 2014. Hardy Island Granite Quarries Ltd. is opening another quarry on Valdes Island which is to supply sandstone (Nanaimo Group), another rock type that can be found on many older buildings in Vancouver and Victoria.

Aggregates are an important part of the mining industry on the south coast, generating more jobs in the region than metal and coal mining. The area hosts some of the largest aggregate pits and quarries in Canada. Most quarries serve local markets, although a few of the largest also export. General sales and production trends follow those of the construction industry. Lafarge North America, Lehigh Hanson and, a local company Mainland Sand and Gravel Ltd., are the three largest participants in the Coast Area, although hundreds of pits and quarries produce in the region.

One of the largest aggregate-only mines is the **Sechelt Mine**, operated by Lehigh Hanson. The company no longer makes production figures public, but volumes have been in the 3-5 million tonne range in recent years. It is permitted for up to 7.5 million tonnes per year. A loading facility capable of accommodating Panamax class freighters handles most of the shipments.

In addition to the Texada Quarry, Lafarge North America operates two of the largest aggregate quarries in the region, **Earle Creek** and **Pitt River Quarries**, each of which typically produces more than 1 million tonnes per year. In 2014, Lafarge continued to make capital improvements to the Pitt River Quarry. Production and employment estimates for 2014 reported by Lafarge include: 3.8 million tonnes and 65 people (Texada Quarry); 1.3 million tonnes and 24 people (Earle Creek), 1.6 million tonnes and 30 people (Pitt River); 1.0 million tonnes and 25 people (Central Agg); and 0.9 million tonnes and 19 people (Ward Road). The Pipeline Road site employed 6 people for remediation work.

Also on Pipeline Road are large operations by Jack Cewe Ltd. and Allard Contractors Ltd. Together they produce in excess of one million tonnes per year most years. Cewe also operates a large quarry on Jervis Inlet. They do not release yearly production figures.

Polaris Minerals Corporation operates the **Orca Quarry** (Fig. 9) near Port McNeill, which produces sand and gravel mainly for export. Polaris Minerals Corporation reported production and sales of approximately 2.4 million tonnes is the first three

Fig. 9. Sign at the entrance of the Orca Sand and gravel mine, northern Vancouver Island. Photo taken September 18, 2014 indicates nearly 15 million tonnes produced since 2007, most of which was exported to California.

quarters of 2014. This represents an increase over the same period in 2013 and continues a multi-year trend. If production and sales hold steady in the last quarter, 2014 production and sales will be in the 3-3.5 million tonne range.

One of the largest operations in the area is the **Cox Station Quarry**. It is on the north side of Sumas Mountain, and is operated by Mainland Sand and Gravels Ltd. Over 95% of the crushed quartz diorite product goes to the lower mainland market via barge on the Fraser River. The quarry also has two CN Rail spur lines, which allow shipment by rail. Production and shipments are typically 2-3 million tonnes per year. The quarry employs 45-50 people.

4. Mine development and mine evaluation

Major new mining projects are not being developed in the South or West Coast regions, but significant exploration and development work continues at existing mines and quarries (see above). A proposed coal mine and a large aggregate operation are in the pre-application phase of Environmental Assessment (Table 4).

The **Raven Underground Coal Project** is a proposed mine south of Comox on Vancouver Island (Fig. 1). As projected in the feasibility study, the main product is to be a semi soft coking coal with a thermal byproduct. Forecast production is approximately 830,000 tonnes of clean coal per year, over 16 years. Compliance Energy Corporation is the majority partner in the Comox Joint Venture with LG International Corp. The company submitted its application for an Environmental Assessment Certificate in 2013, but the Environmental Assessment Office determined that the application did not contain all required information. Compliance has been working on a revised application in 2014.

The **BURNCO Aggregate Project** in the McNab Creek Valley (Fig. 1) is also in the pre-application stage of Environmental Assessment with both provincial and federal agencies. They submitted Draft Application Information Requirements in September 2013. The proposed mine would ramp up to a 1.5 million tonne-per-year operation, initially barging product to BURNCO Rock Products Ltd.'s ready-mix concrete plants in South Burnaby and Port Kells. BURNCO submitted revisions to the project in 2014 changing production rate, relocating some facilities and specifying a mine life of 16 years. The project now has approved Application Information Requirements and may proceed to an application for environmental certification.

5. Exploration projects

The largest off-lease exploration projects active in 2014 are listed in Table 5.

5.1. Haida Gwaii

Haida Gwaii saw little in the way of reported exploration activity in 2014, although several properties remain in good standing, notably grass roots to advanced stage gold properties such as Tasu Global (MINFILE 103B 076), More (MINFILE 103G 009), Sandspit Gold (MINFILE 103G 005) and Taseko Mines Limited's Harmony (MINFILE 103F 034), an epithermal gold property with a substantial undeveloped resource.

5.2. Central coast

Like Haida Gwaii, the central coast saw little exploration activity in 2014. A few mineral properties are in good standing, including glacial marine clay targets and a rhodonite prospect at Rivers Inlet (MINFILE 092M 015). Kisameet Glacial Clay Inc. worked their property, collecting material by hand. Along the interior coast, east of Vancouver Island, properties in good standing are more numerous, including skarn and gold vein targets but large exploration projects were not reported in 2014.

5.3. Northern Vancouver Island

Between 1971 and 1994, the Island Copper Mine produced 345 million tonnes with average head grades of 0.41% Cu, 0.017% Mo, and 0.19 g/t Au. NorthIsle Copper and Gold Inc.'s North Island Project includes several porphyry copper and epithermal gold targets extending along a 40 km west-north-west trend from Island Copper. **Hushamu** (MINFILE 092L 240), a copper-molybdenum-gold porphyry prospect, is the most advanced with Indicated 304,000 tonnes 0.21% Cu, 0.29 g/t Au, 0.010% Mo, and 0.56 ppm Re and Inferred 205,600 tonnes 0.18% Cu, 0.26 g/t Au, 0.008 % Mo and 0.38 ppm Re.

Northisle Copper and Gold Inc. returned to the Hushamu deposit in 2014 with a four-hole drill program designed to test an IP target northwest of the resource area (Fig. 10). The new drilling confirmed the presence of copper-molybdenum (+rhenium) mineralization, however it is unclear if it will augment the existing resource. A fifth drill hole was for metallurgical testing in the existing resource area. Other porphyry and epithermal targets in the area include the

Table 4. Proposed mines, South and West Coast regions.

Mine	Operator	Commodity; deposit type	Reserves	Work program	Website
BURNCO Aggregate	BURNCO Rock Products Ltd.	Aggregate	>24 million t	Engineering, environmental assessment application	www.burnco.com
Raven Underground Coal	Comox Joint Venture (Compliance Energy 75%, LG International Investments (Canada) Ltd.	Metallurgical coal	29.9 million t (Run of mine, Proven and Probable)	Environmental assessment application	www.complianceenergy.com

Table 5. Off lease exploration, South and West Coast regions.

Project	Operator	MINFILE	Commodity	Deposit type	Work program	Website
North Island Project (Hushamu)	NorthIsle Copper and Gold Inc.	092L 240	Copper, molybdenum, gold, rhenium	Porphyry	Diamond drilling, 1800 m, 5 holes, geochemistry, metallurgy	www.northisle.ca
Huu-ay-aht Sarita	Huu-ay-aht First Nation	092C 032	Gold	Skarn	Diamond drilling 300 m, 9 holes	huuayaht.org
Pacific Iron	Canadian Dehua International Mines Group Inc.	092C 022, 23, 25, 27 and others	Iron (magnetite)	Skarn	Ground magnetic survey (100 line km), rock geochemistry, geological mapping	www.dehua.ca

Fig. 10. Drill rig testing a target to the northwest of the Hushamu resource area, northern Vancouver Island.

Pemberton Hills, South MacIntosh, Hep, and NW Expo.

Guohua Furen Mining Inc. proposes to bulk sample and re-process crushed surface material at the **Nimpkish Iron** project near the former Iron Crown iron mine (MINFILE 092L 034), a skarn deposit. The project is in the permitting stage.

In addition to recent rock geochemistry, Canadian Dehua International Mines Group Inc. reported results of a ground magnetic survey conducted at **Iron Ross** (MINFILE 092K 043) in December 2013. Iron Ross is one of four magnetite skarn properties Canadian Dehua is exploring on Vancouver Island.

5.4. Central Vancouver Island

Near Campbell River, Canadian Dehua International Mines Group Inc. was active at the Argonaut (MINFILE 092F 075), a past producing magnetite skarn. The 2014 program consisted of a ground magnetic survey, geological mapping, and rock sampling. The property is underlain by Vancouver Group basalt and limestone and Bonanza Group volcanic rocks. All are intruded by Island Plutonic Suite granodiorite to quartz diorite.

Red Hut Metals Inc. reported a soil sampling program at its Conuma property in April. Targets include polymetallic VMS mineralization, as was discovered in the 1980s at nearby Dragon (MINFILE 092E 072) where Sicker Group rocks are exposed.

In 2012, Lu'an Canada Capital and Energy Investment Inc. purchased the **Mineral Creek** property near Port Alberni

(MINFILE 092F 079, 331) and, in 2103, optioned it to Sona Resources Corporation. The property was explored in the 1980s and test mined in the mid 1990s. Between 2005 and 2010, programs included drilling, geophysics and initiation of a bulk sample. Sona Resources Corporation carried out verification sampling at Ember and Linda Veins at Mineral Creek late in 2013 with results published in 2014. Surface grab samples returned up to 397 g/t Au, consistent with 2006 and 2009 drill results.

Prospectors reported grass roots discoveries in 2014. For example, Herb McMaster and Dan Bruner found a previously undocumented massive sulphide showing on the north side of Great Central Lake near Port Alberni and Joe Paquet indentified wollastonite in skarns near Campbell River (Fig. 11).

5.5. Western Vancouver Island

Canadian Dehua International Mines Group Inc. had a field program at **Head Bay** (MINFILE 092E 001, 5, 6, 15 and others), which included a ground magnetometer survey, geological mapping, and stream, moss, soil, and rock sampling. The property is underlain by Vancouver Group and Bonanza Group rocks and intruded by Island Plutonic suite granodiorites and Eocene to Oligocene quartz diorites. The property includes a past producer of magnetite (Glengarry). Iron and gold skarn and vein mineralization are exploration targets.

The Ministry of Energy and Mines issued a permit for drilling at the **Fandora** gold prospect in 2013 (MINFILE 092F 040, 41, 205). Imperial Metals Corporation has not announced plans for the property although they reported geochemical sampling for assessment in 2013 and again in 2014. Geochemical soil and stream sediment surveys in 2009-2013 identified previously unknown gold anomalies. Results for 2014 are not yet published.

The **Catface Copper** (MINFILE 092F 120) porphyry copper project north of Tofino (Fig. 1) is at an advanced stage of exploration, but was inactive in 2014. Imperial Metals Corporation published resource figures in 2009 and further defined the main resource area with drilling in 2010. Porphyry mineralization at Catface is related to the Tofino Intrusive suite (Eocene; Fig. 5).

Fig. 11. One of several previously undocumented occurrences of wollastonite on prospector Joe Paquet's properties near Campbell River.

The Huu-ay-aht First Nation conducted a 7-hole core drilling program at the **Huu-ay-aht Sarita** project, largely on treaty land. Skarn showings in the area have been explored for iron, copper, lead, zinc, silver and gold since 1895 (MINFILE 092C 032). Percussion drilling of shear zones north of the skarns on the Numukamis Indian Reserve returned gold and silver values in 1979 (Hunter and Roberts 1989). Results came under official scrutiny; although work commissioned by the Vancouver Stock Exchange and the RCMP was unable to verify the results, neither did it confirm errors or sample salting. Subsequent workers documented traces of visible gold in siliceous skarn (Pollmer, 2013). In what may be a first, the Huu-ay-aht First Nation is investigating on its own treaty lands and on adjacent mineral tenures it owns. The objective goes beyond a typical exploration venture to address uncertainty about previous work by using modern best practices. The property is underlain by granodiorite, probably part of the Island Plutonic suite, in intrusive contact with Quatsino Formation limestone and Bonanza Group rocks. To the north is a fault contact with the Karmutsen Formation.

5.6. Southern Vancouver Island

The **Pacific Iron** project (formerly the Pearson project) was the largest of Canadian Dehua's iron skarn projects in 2014, in terms of area under tenure and amount of fieldwork completed. Work consisted of ground magnetic surveys, geological mapping and geochemical sampling. The previous operator of the property outlined an inferred resource at the Bugaboo (MINFILE 092C 022, 23, 25, 27) area. The new work identified additional targets on this large property (Figs. 12, 13).

The Sunro Copper Group has been conducting preliminary engineering studies on the past-producing **Sunro** mine (MINFILE 092C 073) for several years. Work in 2014 included re-entry and inspection of the existing workings. Sunro was an underground copper mine with byproduct gold and silver. Full-scale production ceased in 1974. In June of 1973 ore reserves were estimated at 1,030,465 tonnes grading 1.47% Cu in proven category and 423,782 tonnes 1.33% Cu in probable category (historical estimates). Mineralization is mainly hosted by basalts of the Metchosin Igneous complex, concentrated near contacts with intruding the Sooke gabbro.

5.7. Texada Island

Texada Quarrying Ltd. filed part of its 2013 work for assessment in 2014, but did not report new work in 2014.

South of the quarries, a large holding by Coast Minerals Corporation and Northstar Mining Ltd., the **Texada** property remains in good standing, with work filed for assessment including a spectral analysis study in 2013 followed by prospecting and geochemical sampling in 2014. Vein and porphyry style copper, gold, and molybdenum occurrences were reported.

Fig. 12. Massive magnetite at the Pacific Iron Project, southern Vancouver Island.

Fig. 13. A forge blower at abandoned workings on the Pacific Iron property, probably dating to 1916.

5.8. Squamish-Pemberton (Sea to Sky area)

In 2014, Ashlu Mines Inc., a private company that has assembled a land position around the former Ashlu Mine near Squamish, reported continuing geophysics and geochemistry at its **Ashlu** property (Fig. 1; MINFILE 092GNW045, 47, 55, 62; MINFILE 092GNW013). A five-year rock, soil, and silt sampling program has relocated showings around the former mine. The Ashlu Mine is a past producer that exploited a narrow (<1 to 4.6 metre) gold-bearing quartz vein over a strike length of 90 metres and extending 85 metres down dip. In 1981, reserves were just under 90,000 tonnes of 8.57 g/t Au and 12.31 g/t Ag. The property is largely underlain by the Cloudburst pluton (Jurassic).

5.9. Sunshine Coast

Eastfield Resources reports further geochemical sampling on the **Okeover** (MINFILE 092K 008, 57, 168) or **OK** property in 2014, following small programs in 2011-2013 which identified chargeability and soil geochemical anomalies, representing Cu-Mo targets beyond the existing North Lake Zone resource area. The property is under option to Prophecy Coal Corp. (60%).

5.10. Lower Mainland-Coquihalla-Northern Cascades

NSS Resources Inc. acquired tenures surrounding the **Seneca** (MINFILE 092HSW013) and Vent (MINFILE 092HSW139) VMS occurrences, last active in 2007. The new land package includes the Fleetwood zone (MINFILE 092HSW165). NSS filed a technical report recommending further work. The Vent and Seneca prospects themselves are held by Goldsource Mines Inc. To the east, Pacific Bay Minerals Ltd. proposes a small drill program near the **LD** showing (MINFILE 092HSW070). To the south, Abram Reimer prospected a property with VMS and polymetallic vein showings (e.g. MINFILE 092HSW072). All of these occurrences are within the Harrison terrane (Fig.1).

At the **Krof** property, a soil geochemical survey by Mystic Capital Corporation identified a zinc-copper-barium anomaly approximately 1.5 km south-southeast of the Krof massive sulphide occurrence (MINFILE 092HNW070). Together with results of a 2008 electromagnetic survey, it suggests a new exploration target. To the southeast, prospecting at the **Lekcin** (MINFILE 092HSW168, 82) property in 2014 resulted in discovery of a sulphide showing in bedrock near the edge of a magnetic high identified by a previous airborne magnetic survey (Fig.14).

New Carolin Gold Corp did not report fieldwork at the **Ladner Gold Project** (MINFILE 092HNW007, 18, 3 and others) however they did report reaching an agreement with the receiver for the property vendor to acquire the remaining interest in the Carolin Mine. The average recovery from 1982-1984 production was slightly better than 50%. Consequently, tailings reprocessing is being considered. The Carolin Mine (Idaho Zone) is in the Coquihalla gold belt (McMaster Zone, Montana), which has not been well explored by modern

Fig. 14. Nickel bloom field test for nickel sulphide at a discovery on the Lekcin property north of Hope. Photo by Chris Paul.

methods.

To the northwest, Alexandra Resources Inc. reported a small geological program on its **Alexandra** property (MINFILE 092HNW031).To the southeast along the same trend, Savoy Ventures Inc. followed up an airborne survey with a program of prospecting, geology, and rock, soil, and silt geochemistry at the **Big Range** property. Targets include both porphyry Cu-Mo and gold quartz veins (MINFILE 092HSW144, 145). The Hozameen fault, which runs through the property, hosts serpentine similar to the Carolin Mine. Spatially associated with the fault, a felsic stock with arsenic, molybdenum, and copper in quartz veins has been reported. Other mineralization occurs as orogenic gold, and porphyry Cu-Mo or Mo.

Homegold Resources Ltd. conducted a limited (90 metre) drill program at **Silver Peak**, which includes the Eureka-Victoria past producer (MINFILE 092HSW011).

6. Outlook

Several years of difficult venture markets are having a clear impact on exploration and other pre-development activities in southwestern British Columbia. Exploration continued at the Myra Falls and Quinsam mines, but lower thermal coal prices had a direct impact on Quinsam's operations. Regardless, Quinsam is looking to the future as it continues to expand reserves. Industrial minerals and aggregate producers are generally holding steady.

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References cited

Brandon, M.T., 1989. Deformational styles in a sequence of olistostromal mélanges, Pacific Rim Complex, western Vancouver Island. Geological Society of America Bulletin, 101, 1520-1542.

Bustin, A.M.M., Clowes, R.M., Monger, J.W.H., and Journeay, J.M., 2013. The southern Coast Mountains, British Columbia: New interpretations from geological, seismic reflection, and gravity data. Canadian Journal of Earth Sciences, 50, 1033-1050.

Groome, W.G., Thorkelson, D.J., Friedman, R.M., Mortensen, J.K., Massey, N.W.D., Marshall, D.D., and Layer, P.W., 2003. Magmatic and tectonic history of the Leech River Complex, Vancouver Island, British Columbia: Evidence for ridge-trench intersection and accretion of the Crescent Terrane. In: Sisson, V.B., Roeske, S.M., and Pavlis, T.L. (Eds.), Geology of a transpressional orogen developed during ridge-trench interaction along the North Pacific margin. Geological Society of America Special Paper 371, pp. 327-353.

Hunter, A.E, and Roberts, P.S., 1989. Geological, Geochemical and Geophysical Report on the Sarita River Group. British Columbia Ministry of Energy and Mines Assessment Report 18662.

Hyndman, R.D., 1995. The Lithoprobe corridor across the Vancouver Island continental margin: the structural and tectonic consequences of subduction. Canadian Journal of Earth Sciences, 32, 1777-1802.

Manor, M.J., Wall, C.J., Nixon, G.T., Scoates, J.S., Pinsent, R.H., and Ames, D.E., 2014. Preliminary geology and geochemistry of the Giant Mascot ultramafic-mafic intrusion, Hope, southwestern British Columbia. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Open File 2014-03. Scale 1:10 000.

Massey, N.W.D., 1986. Metchosin Igneous Complex, southern Vancouver Island: Ophiolite stratigraphy developed in an emergent island setting. Geology, 14, 7, 602-605

Monger, J.W.H., and Brown, E.H., In press. Tectonic Evolution of the southern Coast-Cascade orogen, northwestern Washington and southwestern British Columbia. In: Rocks, Fire and Ice: The Geology of Washington. Edited by E.S. Cheney. University of Washington Press.

Nelson, J.L., Colpron, M., Israel, S., 2013. The Cordillera of British Columbia, Yukon and Alaska: Tectonics and Metallogeny. In: Colpron, M., Bissig, T., Rusk, B., and Thompson, J.F.H., (Editors), Tectonics, Metallogeny, and Discovery - the North American Cordillera and similar accretionary settings. Society of Economic Geologists, Special Publication 17, 53-109.

Nixon, G.T., and Orr, A.J., 2007. Recent Revisions to the Early Mesozoic Stratigraphy of Northern Vancouver Island (NTS 102I; 092L) and Metallogenic Implications, British Columbia. In: Geological Fieldwork, 2006. British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Paper, 2007-1, pp. 163-177.

Pollmer, A.R., 2013. Huu-ay-aht Sarita Property Geological Assessment Report. BC Ministry of Energy and Mines Assessment Report 34731.

Rusmore, M.E., and Cowan, D.S., 1985. Jurassic-Cretaceous rock units along the southern end of the Wrangellia terrane on Vancouver Island. Canadian Journal of Earth Sciences, 22, 1223-1232.