

Exploration and mining in the South and West Coast regions, British Columbia



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1. Introduction

This report covers the Coast Area natural resource sector, comprising the South Coast and West Coast regions, including Haida Gwaii (Fig. 1). The area has one major polymetallic metal mine, **Myra Falls**, one coal mine, **Quinsam**, and numerous industrial minerals and aggregate operations. Industrial minerals and aggregate operations serving the construction industry have generally continued in steady production. Nyrstar N.V. suspended production at **Myra Falls** mid-year and halted further investment in the operation in the fall. Following a workforce reduction at the **Quinsam** coal mine in 2014, Hillsborough Resources Ltd. continues to produce below that operation's capacity. The **Raven** coal project's application for environmental assessment was withdrawn from the BC Environmental Assessment Office's screening process. In a more positive development, BURSCO Rock Products Ltd. submitted an environmental assessment application for its large aggregate project, **BURSCO Aggregate**, on Howe Sound. Exploration spending in 2015 is estimated at \$3.7 million (Fig. 2). Exploration projects were generally limited to surface surveys, with no significant off-lease exploration drilling programs reported during 2015. Total metres drilled were approximately 19,000 (Fig. 3). There were several trenching and bulk sample programs. Exploration spending by exploration stage is illustrated in Figure 4. Exploration spending in the region is at a 10 year low. A significant portion of spending and nearly all drilling is attributable to a largely successful on-lease exploration campaign that continued until October at **Myra Falls**.

2. Geological overview

Metallogeny in British Columbia is intimately linked to the tectonic evolution of the Canadian Cordillera, first as an accretionary orogen consisting of allochthonous terranes that were welded to and deformed with the western margin of ancestral North America primarily during the Jurassic and then as the site of post-accretionary tectonism and magmatism (e.g., Nelson et al., 2013, Clarke, this volume).

The South and West Coast regions include parts of the Insular, and Intermontane tectonic provinces; most of the area is underlain by rocks of the Wrangell terrane and the post-

accretionary Coast Plutonic complex (Fig. 1). Wrangellia is part of the Insular tectonic province, a Paleozoic-Mesozoic allochthonous assemblage that docked with Intermontane terranes in the Early-Middle Jurassic as Panthalassic oceanic crust subducted beneath them (e.g., Nelson et al., 2013). The Intermontane tectonic province is represented by a group of small terranes in the southern Coast Mountains. Subsequent to terrane accretion, a late Jurassic-Cretaceous-Eocene continent-margin arc was established in the area of the present Coast Mountains. Its roots are represented by the Coast Plutonic Complex. During the Early to mid-Cretaceous, southeast-directed oblique convergence brought the Insular terrane and western Coast Plutonic Complex 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 (Monger et al., 1994; Bustin et al., 2013; Monger and Brown in press). From the Cretaceous onward, accretion continued outboard of Wrangellia. Cenozoic ridge subduction converted much of the North America/Pacific plate margin to a transform fault (Queen Charlotte fault). Today, the small oceanic Juan de Fuca plate slides eastward beneath the previously accreted terranes of the Outboard tectonic province 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

2.1.1. Wrangellia

Wrangellia is a long-lived (Devonian to Jurassic) island arc terrane that underlies most of Vancouver Island and Haida Gwaii. 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

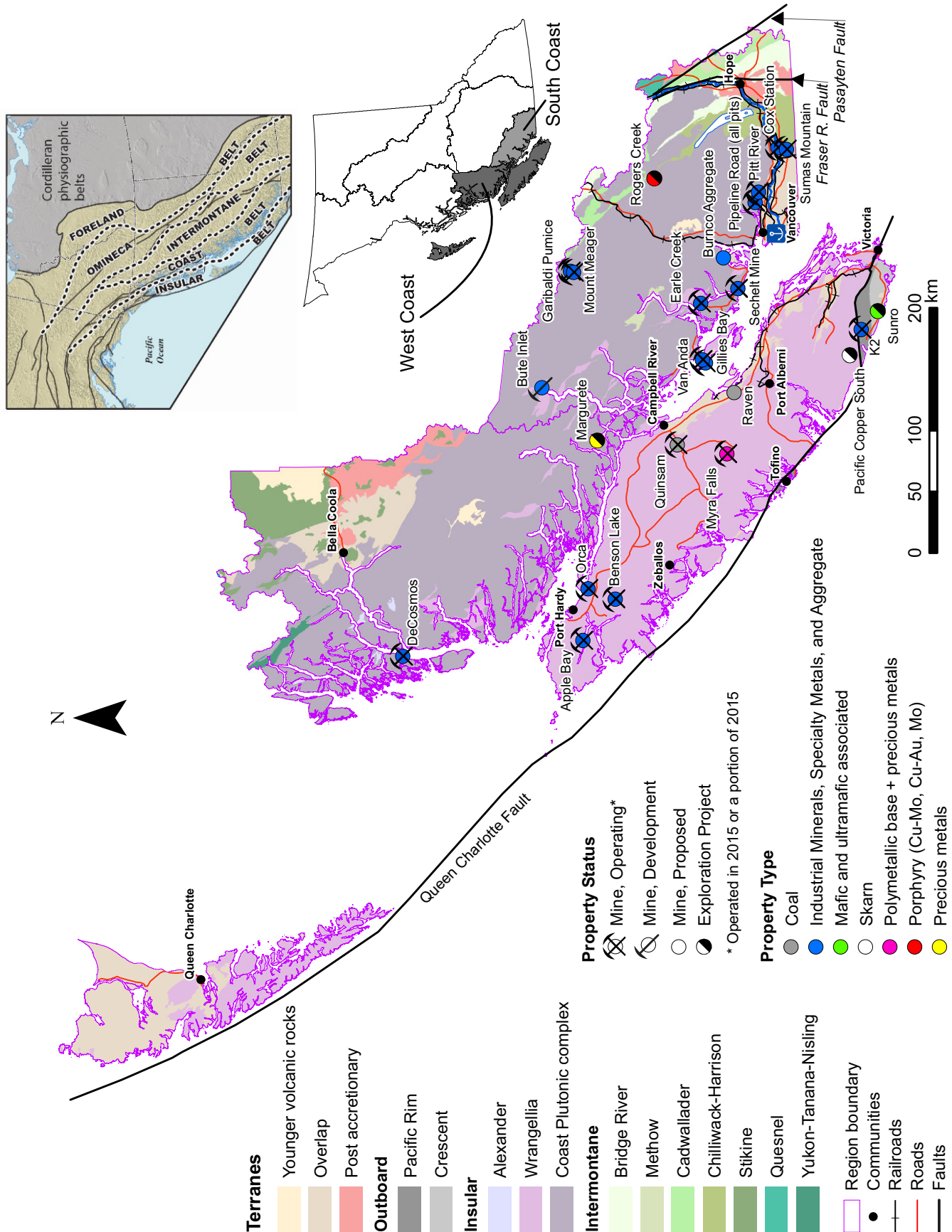


Fig. 1. Operating mines and selected exploration projects in the Coast Area, 2015. Terranes from BC digital geology map (Cui et al., 2015).

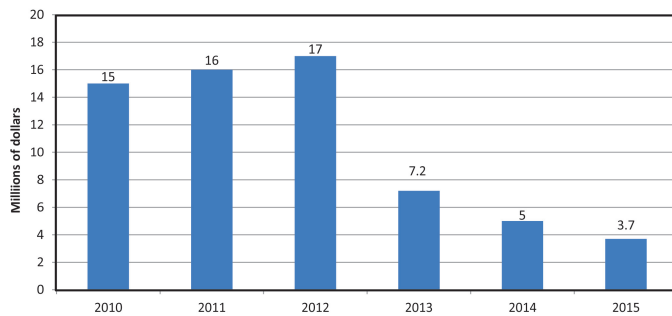


Fig. 2. Exploration spending estimates for the Coast Area, 2010-2015.

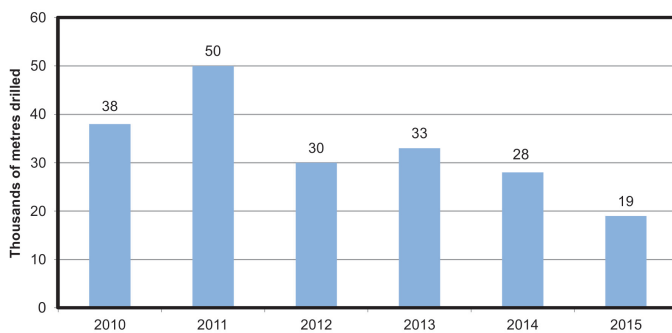


Fig. 3. Exploration drilling in the Coast Area, 2010-2015.

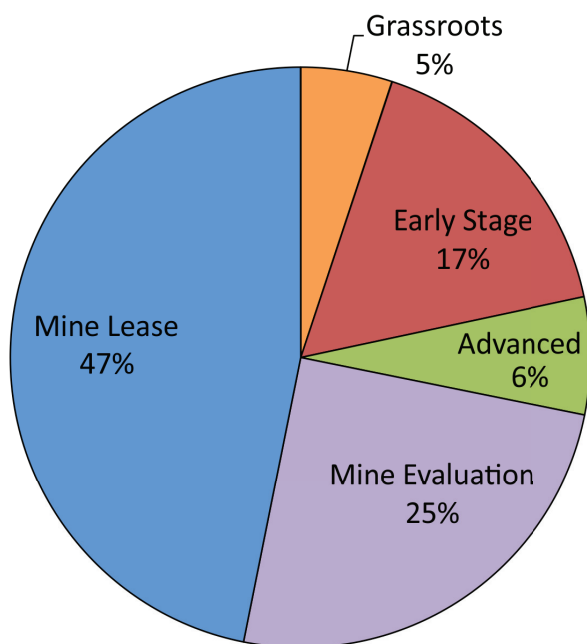


Fig. 4. Coast Area exploration spending by exploration stage, 2015.

present volcanogenic massive sulphide polymetallic producers at Mount Sicker (MINFILE 092B 001, 092B 002, 092B 003) 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 Mt of iron concentrate as well as copper, gold and silver.

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

2.2. Outboard tectonic province

On Vancouver Island, the western and southern margins of Wrangellia are structurally juxtaposed with the Pacific Rim terrane, which consists of possible mélangé 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 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).

2.3. Intermontane 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 is otherwise inaccessible. Exceptions include the Redbird, a molybdenum prospect west of Tweedsmuir Provincial park and east of the Kitlope Heritage Conservancy (MINFILE 093E 026).

The southeastern Coast Belt, north of the international border is underlain by the Nooksack-Harrison and Chilliwack terranes (equivalent to Stikinia), and the Bridge River, Cadwallader

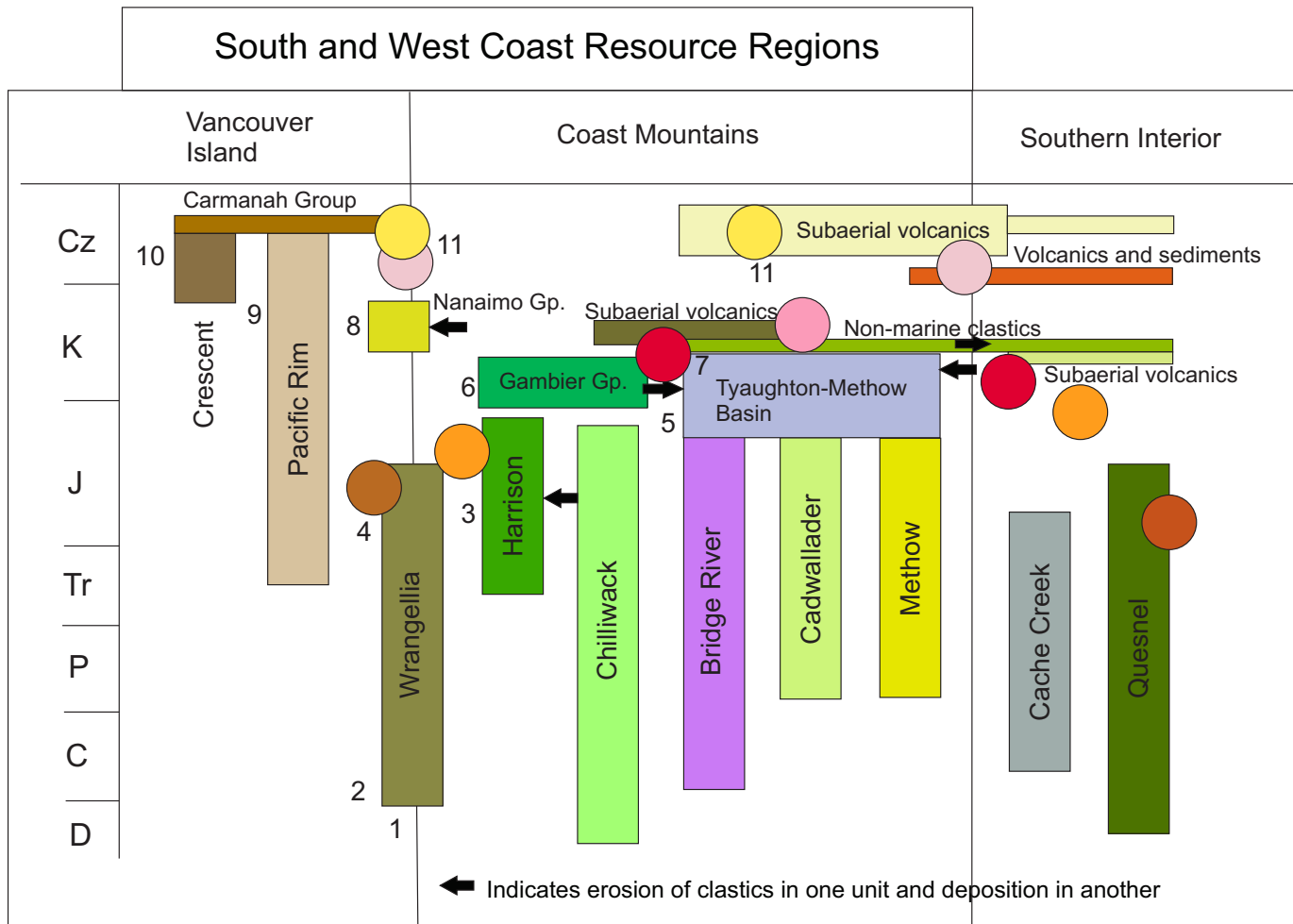


Fig. 5. Time-space diagram showing relations between terranes, basins, plutonic rocks (circles), and some significant mineralizing events in southwestern British Columbia. 1: Sicker Group volcanogenic massive sulphide; 2) orogenic gold veins in Sicker Group 3) Harrison Formation volcanogenic massive 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).

and Methow terranes, which are allied with the main Cache Creek terrane (Fig. 1). These represent 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, Monger and Brown, in press). 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 Nooksack-Harrison terrane are prospective for VMS mineralization. The Coquihalla Serpentine belt, along the Hozomeen 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 (MINFILE 092HNW007), which operated between 1981 and 1984.

2.4. Post-accretionary intrusions and overlap strata

2.4.1. 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 derived from the deep crust of the sutured Intermontane and Insular terranes. 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 the 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 t of copper along with zinc, silver, gold, lead and cadmium between 1905 and 1974.

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 (MINFILE

092HSW004, 092HSW093, 092HSW125), which operated between 1958 and 1974.

2.4.2. Nanaimo Group

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

2.5. 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 3,548 tonnes of copper, 131 kg gold and 7,235 kg silver. Catface Copper (Eocene; 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 (Fig. 1). 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.

2.6. Quaternary sediments

As a tectonically active region, southwestern British Columbia has undergone a high degree of uplift and high rates of erosion. Glaciation has influenced the nature of erosion and deposition. The Fraser Glaciation 25,000-12,000 years ago was the last major advance. Most sand and gravel deposits are products of its final, Pleistocene retreat, a period of high energy erosion and deposition as compared to the Holocene (Clague and Luternauer 1983).

Sediments derived from quartz diorite and granodiorite of the Coast Mountains, or volcanic, sedimentary and metasedimentary rocks of Cascades provenance, in clean glaciofluvial deposits, can produce strong, chemically inert, construction material suitable for a variety of applications.

Peat bogs were once exploited for horticultural use in the Fraser delta. Mining of peat on the Fraser Delta ceased in the 1980s due to depletion of the resource.

3. Mines and quarries

This section covers significant metal and coals mines that operated within the past year, as well as selected industrial minerals and aggregate operations. See also Tables 1-3.

3.1. Metal mines

Myra Falls Operations is an underground polymetallic mine, owned and operated by Nyrstar N.V., which exploits a cluster of volcanogenic massive sulphide lenses. Nyrstar suspended mining activities at **Myra Falls Operations** at the beginning of the second quarter 2015. At that time the workforce was reduced, however work proceeded on the restoration and upgrading of power facilities and other infrastructure. Mine development planning focussed on the western orebodies with exploration and definition drilling directed at those targets (Fig. 6). Generally, exploration was successful, producing high grade intercepts as well as identifying untested targets.

In October 2015, Nyrstar halted investment at the mine, responding to a combination of low zinc prices, deficiencies in site infrastructure, planning, operation and maintenance practices and development of future mining areas. The suspension is part of a company-wide effort to preserve cash and mineral resources during a prolonged period of low commodity prices.

Nyrstar does not outline a long term plan for **Myra Falls**, but says evaluation of all of its mining assets is ongoing. Furthermore, it is considering an exit from the mining business entirely. Formed by a combination of smelting, alloying and materials technology companies in 2007, it expanded into mining in 2009.

Mining began at the **Myra Falls** site in 1966 and the operation mined its 30 millionth tonne of ore in 2013. Suspensions occurred previously; notably a 16 month suspension in 1993-1994. Since 2006, replacement of reserves and resources occurred at a rate approximately equal to that at which they were mined. In 2014 and 2015 there were after-mining increases to resources (Table 1). The mine employed approximately 350 during production. Currently there are 56 workers on site.

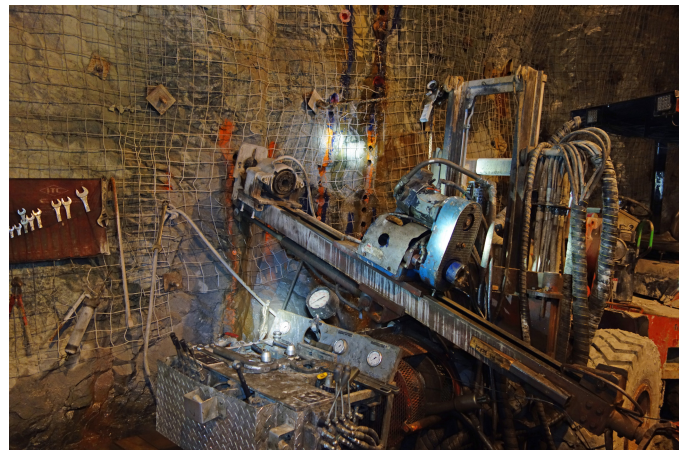


Fig. 6. A mobile drill rig underground at Myra Falls, part of a multi-year, near-infrastructure exploration effort.

Table 1. Metal mines, West and South Coast regions.

Mine	Operator	Commodity; deposit type; MINFILE	Forecast 2015 Production (based on Q1-Q3)	Reserves (Proven + Probable)	Resource (Measured and Indicated)	Comments
Myra Falls Operations	Nyrstar N.V.	Zn, Cu, Pb, Au, Ag; G06: Noranda/Kuroko Massive Sulphide Cu-Pb-Zn; 092F 330, 092F 073	145,000 t	5.87 Mt	7.36 Mt	Operations Suspended Q2. Resource inclusive of reserves
			6.91% Zn, 0.47% Pb, 0.69% Cu, 1.24 g/t Au, 51.94 g/t Ag	5.92% Zn	6.41% Zn	
				0.61% Pb	0.66% Pb	
			(9,000 t Zn, 200 t Pb, 600 t Cu, 4,000 oz Au, 209,000 oz Ag)	0.85% Cu	1.00% Cu	
				61.50 g/t Ag	66.31 g/t Ag	
				1.54 g/t Au	1.72 g/t Au	

Table 2. Coal mines, West and South Coast regions.

Mine	Operator	Commodity; deposit type; MINFILE	Forecast 2015 Production (based on Q1-Q3)	Reserves (Proven + Probable)	Resource (Measured and Indicated)	Comments
Quinsam	Hillsborough Resources Ltd.	TC; A04: Bituminous coal; 092F 319	130,000 t	n/a	n/a	Operating below capacity

HCC = hard coking coal; PCI = pulverized coal injection; TC = thermal coal; ULV = ultra low volatile

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 to have formed as Kuroko type, bimodal felsic volcanogenic massive sulphides.

3.2. Coal mines

Underground coal mining on Vancouver Island dates back to 1849. The **Quinsam** thermal coal mine near Campbell River (Figs. 1, 7) 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 currently part of the Vitol Group of companies. It is currently the only underground coal mine in the province. 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. Hillsborough is a private company that does not release reserve and resource figures. The mine has a significant potential resource, however sulphur content varies. Product is blended to meet customers' specifications. Currently they supply local cement plants. The mine can also serve international markets using a freighter loading facility on Texada Island.

Similar to other coal mines in the province, **Quinsam** has been affected by low thermal coal prices; 61 workers were



Fig. 7. A barge preparing to load coal in October 2015 at Quinsam's Middle Point facility near Campbell River.

laid off in 2014, leaving a workforce of 69. Production is accordingly lower (estimated 130,000 t clean coal, Table 2). Mining operations were suspended for eight weeks in the summer, resuming near the end of August. Neither mine site nor off site exploration activities are reported in 2015. There has been on site exploration and work at sites to the east and proposed to the south in recent years.

Hillsborough has been testing and researching underground waste and tailings disposal. The mine now disposes of coarse rock rejects underground in disused flooded workings.

Table 3. Industrial mineral mines and quarries, West and South Coast regions.

Mine	Operator	Commodity; deposit type; MINFILE	Forecast 2015 Production (based on Q1-Q3)	Reserves (Proven + Probable)	Resource (Measured and Indicated)	Comments
Apple Bay (PEM 100)	Electra Stone Ltd.	Silica+alumina; R12: Volcanic glass-perlite; 092L 150	70,000 t	n/a	n/a	Drilling, mapping sampling to assess resource. No results published. Drilling by Ashgrove Cement Company
Benson Lake	Imasco Minerals Inc.	High brightness carbonate; R09:Limestone; 092L 295	56,000 t	n/a	100+ years	Reserves and resources not formally stated
Blubber Bay	Ashgrove Cement Company	Limestone, dolostone; R09:Limestone; 092F 479	10,000 t+	n/a	100+ years	First of a multiple-barge dolomite shipment to continue into 2016
Garibaldi Pumice	Garibaldi Pumice Ltd.	Pumice; R11: volcanic ash; 092JW 039	18,000 m ³	n/a	14,396,000 m ³ pumice 4,990,000 m ³ pumicite (fines)	2014 resource estimate. Near-lease test pits and LIDAR survey in 2015
Imperial Limestone	Imperial Limestone Co. Ltd.	Limestone; R09:Limestone; 092F 394	250,000 t (high grade), 360,000 t (low grade)	n/a	50+ years	Forecast based on Jan-Nov production
K2	K2 Stone Quarries Inc.	Dimension stone, flagstone; R08:flagstone; 092C 159	22,000 t	n/a	n/a	Material extracted from quarry is cut to size
Sumas Shale	Sumas Shale Ltd. (Clayburn Industries Ltd., Lafarge Canada Inc.)	Shale, clay, sandstone; B05:Residual kaolin; 092GSE024	480,000 t	n/a	50+ years	Product for cement production
Texada Quarry	Texada Quarrying Ltd. (Lafarge Canada Inc.)	Limestone, aggregate; R09:Limestone; 092F 395	3,900,000 t	n/a	100+ years	Mostly limestone for cement production

Potentially acid generating tailings are currently disposed of subaqueously in an open pit. Underground tailings injection infrastructure is in place.

3.3. Industrial mineral mines and quarries

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 the **Texada Quarry** operation near Gillies Bay. Texada Quarrying Ltd. is a subsidiary of Lafarge Canada Inc. Most of its 2015 production (3.9 Mt) supplied 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 63 years and employs 69 people. 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 to 270,000 t annually and produced approximately 250,000 t of their high grade carbonate product in 2015. In addition they mined a larger quantity of lower quality limestone. 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 mostly 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 intermittently. It will barge dolomite to Ashgrove's Rivergate Limestone Plant in Oregon starting in December 2015 or January 2016.

On northern Vancouver Island, Electra Stone Ltd. continues to mine silica and alumina products from silicified and clay-altered rhyolitic flows and volcaniclastic rocks at the **PEM 100** or **Apple Bay** quarry (Figs. 8 and 9). The quarry ships raw product by barge to the Ash Grove Cement Company in Seattle. They had sales of 48,396 t in the first three quarters of 2015. If the fourth quarter is similar to the third they would have sales of approximately 70,000 t in 2015. Ash Grove and Electra conducted a mine site exploration program to better define its resources.

At the **Benson Lake** white carbonate deposit, also on northern Vancouver Island, Imasco Minerals Inc. reported 2015 shipments totalling approximately 56,000 t. The high-brightness product is used mainly as white filler.

The **Sumas Shale** quarry on Sumas Mountain is owned by Clayburn Industrial Group Ltd. and operated by contractor



Fig. 8. Electra Stone Ltd.'s PEM 100 quarry near Apple Bay, Northern Vancouver Island.



Fig. 9. Intensely altered rhyolite mined as a source of silica and alumina at Electra Stone Ltd.'s PEM 100 quarry.

Fraser Pacific Enterprises Inc. It delivers sandstone and shale product to the Lafarge and Lehigh cement plants in Richmond and Ash Grove in Seattle, a joint venture with Lafarge North America (Sumas Shale Ltd.). Production and shipments will be approximately 480,000 t in 2015. 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 on the central Coast. Until 2015, production had been from the **DeCosmos Lagoon** south of Bella Bella (Fig. 1). They have a new site at the head of **Bute Inlet**, which is likely to supply future raw material. They collected approximately 400 t there in 2015. Ironwood produces cosmetic products using the clay at its Richmond plant, a business that has continued for 27 years. Other individuals and companies supply the growing cosmetic clay market at smaller scales from locations on the central Coast and Vancouver Island. Glacial Bay Organic Clay Inc. is extracting material by hand, also near the head of Bute Inlet. They report increasing sales in 2015, particularly to Asia. Generally, Mines Act permits are not required where material is collected by hand, and therefore some glacial marine clay operations are unreported.

In the Mount Meager area, Garibaldi Pumice Ltd. produced 18,000 m³ of pumice from the **Garibaldi Pumice** quarry in 2015, an increase over 2014 and significantly more than 2013. Garibaldi Pumice Ltd. did some off lease exploration consisting of test pits and a LIDAR survey in the vicinity of its quarry.

Neighbouring Great Pacific Pumice Inc. produced over 1000 m³ in 2015 at their **Mount Meager** quarry, partly from a new area on the site. They had been relying on stockpiles to satisfy orders the previous year.

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 five person crew. They quarried 22,000 t in 2015. 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. This quarry produced again in 2015 and the new owner plans to increase volumes in 2016. 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 Tlupana Blue Grey and Vancouver Island White marble 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 and their Cabin Group property which now has 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, 092L 146) 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). Haddington Island Stoneworks Ltd. did not quarry in 2015, but expects to return in 2016. Most of the product is used in restoration work on historic buildings.

Hardy Island Granite Quarries Ltd. 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 mined and shipped approximately 950 t in 2015, but sales were approximately 1800 t. Hardy Island has opened another quarry on Valdes Island which supplies sandstone (Nanaimo Group), another rock type that can be found on many older buildings in Vancouver and Victoria. Production in 2015 was 900 t.

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 Materials Ltd. 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 5 million tonne range in recent years. It is permitted for up to 7.5 Mt 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 Mt per year. Production and employment estimates for 2015 reported by Lafarge include: 3.9 Mt and 69 people at **Texada Quarry**; 1.3 Mt and 24 people at **Earle Creek**, 1.3 Mt and 27 people at **Pitt River Quarry**; 1.0 Mt and 18 people at **Central Agg**; and 0.75 Mt and 15 people at **Ward Road**. Remediation work continues at Lafarge's **Pipeline Road** site.

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 Jarvis Inlet at Treat Creek. They do not release yearly production figures.

Polaris Minerals Corporation operates the **Orca** quarry (Fig. 10) near Port McNeill, which produces sand and gravel mainly for export. Polaris Minerals Corporation reported sales of approximately 1.9 Mt for the first three quarters of 2015. Polaris reports some initial exploration off site near the quarry for limestone and igneous rock for possible use as crushed products.

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 have recently been 2-3 Mt per year. The quarry employs 45-50 people.

4. Mine development

Mine development projects are those for which there is a positive production decision, key government approvals and on-site construction has begun. There are no major mine development projects in the South or West Coast regions.

5. Proposed mines

Proposed mines are feasibility-stage projects for which proponents have begun the environmental certification process in the case of large projects, or have submitted applications for Mines Act permits in the case of projects below British Columbia Environmental Assessment Act thresholds (Table 4). Several small-scale as well as inactive larger projects are not covered.

5.1. Proposed metal mines

There are no proposed major metal mines in the South or West Coast regions considered to be active projects in 2015.

5.2. Proposed coal mines

Compliance Energy Corporation withdrew the **Raven Underground Coal** Project's application from the BC Environmental Assessment Office's screening process in March. Raven is a proposed mine south of Comox on Vancouver Island (Fig. 1). As contemplated in a 2011 feasibility



Fig. 10. Polaris Materials Corporation's Orca quarry. It has produced 18 Mt since 2007.

Table 4. Selected proposed mines, West and South Coast regions.

Project	Operator	Commodity; deposit type; MINFILE	Reserves (Proven + Probable)	Resource (Measured and Indicated)	Work Program	Comments
BURNCO Aggregate	BURNCO Rock Products Ltd.	Aggregate; B12: Sand and Gravel; N/A	-	Approx. 20 Mt	Permitting	Submitting applications for EA and Mines Act permit
Raven	Compliance Energy Corporation	SSCC+TC; A04: Bituminous coal; 092F 333	29.9 Mt	71.998 Mt	Permitting	Application for EA submitted for screening and withdrawn, 2015

SSCC = semisoft coking coal; TC = thermal coal

study, the main product would be a semi soft coking coal with a thermal by-product. Production would be approximately 830,000 t of clean coal per year, over 16 years. Compliance's original partners, LG International Investments (Canada) Ltd. and Itochu Corporation, have since withdrawn from the project. Compliance has not indicated plans for Raven but has expressed doubt that the Environmental Assessment Office would certify the project. It remains in pre-application status with the Environmental Assessment Office.

5.3. Proposed industrial minerals mines

The **BURNCO Aggregate** Project in the McNab Creek Valley submitted its application for Environmental Assessment with both provincial and federal agencies. The Ministry of Energy and Mines new Major Mines Permitting Office will process the Mines Act application. The proposed sand and gravel mine would ramp up to a 1.5 Mt 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.

6. Exploration activities and highlights

Exploration projects are categorized as grassroots, early-stage, advanced or mine evaluation, depending upon the nature of recent work. Work directed at discovery of new resources away from ore bodies in an existing mine plan can be considered mine-lease or on-site exploration. The South and West Coast had few large off lease exploration programs in 2015 (Table 5). The following are notes on smaller scale projects and updates on properties with significant defined deposits.

6.1. Precious metal projects

Aldever Resources Inc. (Formerly Glenmark Capital Corp.) conducted a reconnaissance program at the **Margurete** property, including 39 packsack drill holes. Results are not yet published. The property is in the Phillips Arm gold camp. Past producers in the area (Alexandria, Doratha Morton, Enid-Julie) mined gold in quartz veins.

Ashlu Mines Inc. is a private company that has assembled a land position around the former Ashlu Mine near Squamish (Ashlu property). In 2015, they reported continuing geophysics and geochemistry at the property (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 less than 90,000 t of 8.57 g/t Au and 12.31 g/t Ag. The property is largely underlain by the Clodburst pluton (Jurassic).

Bear Mountain Gold Mines Ltd. repaired a portal at the Discovery zone at the Abo gold property where they propose a bulk sample. Abo has a 1989 (non-compliant) resource in two zones of 1.8 Mt in a "probable resource" category and 613,600 t in a "possible resource" category, with average grades of 2.79 g/t Au.

New Carolin Gold Corp. negotiated the purchase of a further 30% interest in the portion of the Ladner Gold project it optioned from Century Mining Corporation and now owns 40%. The company also filed a technical report with restated resource estimates intended to represent open pit and underground scenarios at the past-producing Carolin Mine:

- Inferred resource at 0.5 g/t cutoff of 12,352,000 t grading 1.53 g/t Au;
- Inferred resource at 2.0 g/t cutoff of 2,589,000 t grading 3.34 g/t Au.

The McMaster zone has an inferred resource of 3,375,000 t grading 0.69 g/t. The Carolin Mine tailings estimate remained unchanged from 2011 with 403,700 t at 1.83 g/t Au in the indicated category and 84,400 t grading 1.85 g/t in the inferred category.

A two week mapping and sampling program covered the McMaster zone in the fall. The past producing underground mine exploited a different area (Idaho zone). New Carolin has surrounding tenures covering much of the Coquihalla gold belt, a north-northwest trending series of gold occurrences between Sowaqua and Siwash Creeks which is generally not well explored by modern methods. Veins of economic interest are

Table 5. Selected Exploration projects, West and South Coast regions.

Project	Operator	MINFILE	Commodity; Deposit type	Resource (NI 43-101 compliant unless indicated otherwise)	Work Program	Comments
Margurete	Aldever Resources Inc.	092K 025, 092K 020, 092K 030	Au; I01: Au- quartz veins	n/a	Geology, rock geochemistry, packsack drilling	Reconnaissance program in historic gold camp
Pacific Copper South	Canadian Dehua International Mines Group Inc.	092C 022, 092C 091, 092C 023	Cu, Au, Fe; K03: Fe skarn; K01: Cu skarn	14.3 Mt 43.2% Fe (inferred, 2011)	Soil, stream and rock geochemistry	Formerly part of Pacific Iron property. Targets not limited to magnetite
Rogers Creek	Carube Copper Corp.	092JSE033, 092JSE034, 092JSE035	Cu, Mo, Ag; L04: Porphyry Cu±Mo±Au	n/a	IP survey; soil geochemistry	Chargeability anomaly reported

found in sediments and mafic volcanics northeast of the East Hozameen fault and Coquihalla serpentine belt.

Siwash Minerals Inc. began access and trenching in November at its Lucky D (also known as Monument) property near Yale. Targets are gold bearing quartz veins. Continuation of the work was deferred until spring. Siwash has an agreement with Nicola Mining Inc. to process material at Nicola's custom mill at the Craigmont mine site near Merritt. Monument lies at the northern end of the Coquihalla gold belt. Clibetre Exploration Inc. also has an agreement to process a stored bulk sample from Mount Washington at Nicola's mill.

6.2. Porphyry (Cu-Au, Cu-Mo, Mo) projects

6.2.1. Wrangellia, Island Plutonic Suite

Between 1971 and 1994, the Island Copper mine produced 345 Mt with average head grades of 0.41% Cu, 0.017% Mo, and 0.19 g/t Au. Several porphyry copper and epithermal gold targets extend 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 t of 0.21% Cu, 0.29 g/t Au, 0.010% Mo, and 0.56 ppm Re and Inferred 205,600 t of 0.18% Cu, 0.26 g/t Au, 0.008% Mo and 0.38 ppm Re.

NorthIsle Copper and Gold Inc. did not resume drilling on its large North Island project in 2015, but acquired an option on the Red Dog property, approximately 9 km west-northwest of the Hushamu deposit, last drilled in 2014. NorthIsle conducted reconnaissance mapping and sampling at Red Dog, testing for a northwestern extension of mineralization in the direction of a 2012 IP chargeability anomaly.

Red Dog has historical resource estimates of 25 Mt at grades of 0.35% copper, 0.44 g/t gold and 0.006% molybdenum or 20 Mt of 0.30% copper, 0.55 g/t gold and 0.012% molybdenum. Mineralization remains open to the west, where tenures are held by NorthIsle. There is an apparently separate mineralized zone

400 m east of the Red Dog zone, cut by post mineralization dikes. Since it was detected as a geochemical anomaly in 1962, Red Dog has seen approximately 9,000 m of reported drilling.

The Hushamu deposit, the most advanced of the porphyry prospects in the North Island project area has a 2012 resource estimate, with an indicated resource of 304,000 t of 0.21% Cu, 0.29 g/t Au, 0.010% Mo, and 0.56 ppm Re and an inferred resource of 205,600 t of 0.18% Cu, 0.26 g/t Au, 0.008 % Mo and 0.38 ppm Re. Hushamu, Hep, Red Dog and a 2005 discovery, NW Expo, form a roughly 10 km west-northwest trending series of porphyry occurrences. The former Island Copper mine is approximately 30 km east-southeast.

Western gateway Minerals Inc. conducted a geological mapping program at its Gooseneck Lake property. The target is porphyry copper mineralization. A report is filed for assessment.

Limited surface work was reported at Macktush in 2015. The property covers numerous vein and porphyry-type gold, copper-silver, and copper-molybdenum-gold occurrences. MINFILE documents 18 occurrences, many more are reported elsewhere. World Organics Inc., which has an option on the property held by Nahminto Resources Ltd., filed a technical report. Mapping and geochemical sampling work was filed for assessment. The property has a long history of exploration, but drilling has been limited.

6.2.2. Cenozoic intrusions

There are several advanced Eocene to Miocene porphyry copper targets in southwestern British Columbia. Those in the South and West Coast regions saw modest levels of exploration in 2015. Imperial Metals Corporation did not report new work at Catface, a copper-molybdenum prospect on the west coast of Vancouver Island. There was a limited surface program in 2014. They last drilled the deposit in 2010, subsequent to a 2009 resource estimate. Eastfield Resources Ltd. and Prophecy Resource Corp.'s OK copper-molybdenum prospect north of

Powell River had a 2014 geochemical survey, but no new work reported in 2015. Carube Copper Corp. reports a chargeability anomaly following an IP survey at its **Rogers Creek** porphyry copper project north of Harrison Lake. It may represent a new target as previous drilling intersected anomalous Cu-Mo-Ag mineralization at the edge of the anomaly. Imperial's Giant Copper, with copper-gold porphyry targets southeast of Hope had a modest soil sampling and mapping program in 2015. Mineralization intersected at depth in 2007 has not been followed up with additional drilling.

6.3. Polymetallic base and precious metal projects

6.3.1. Wrangellia

Nitinat Minerals Corporation mapped and sampled its Jasper property in July. They discovered quartz-sulphide mineralization and reported high zinc values (up to 24.7% Zn) in surface sampling. The Jasper property currently covers eight MINFILE occurrences, and Nitinat Minerals documents additional occurrences. Among these are skarn, vein and VMS style mineralization.

Treasury Metals Inc. has not reported new work at their Lara property near Chemainus, but they reported a late 2014 geological mapping and geochemical sampling program in 2015.

6.3.2. Nooksack-Harrison

In 2014, NSS Resources Inc. acquired tenures surrounding the Seneca (MINFILE 092HSW013) and Vent (MINFILE 092HSW139) VMS occurrences, last active in 2007. The new land package, the Seneca Property includes the Fleetwood zone (MINFILE 092HSW165). NSS filed geochemical and geological work for assessment. The Vent and Seneca prospects themselves are held by Goldsource Mines Inc.

6.4. Iron, copper and gold skarn projects

6.4.1. Wrangellia

Canadian Dehua International Mines Group Inc. has done geochemical surveys on three of its Vancouver Island properties. Its large land holding on southern Vancouver Island is divided into two blocks, the southernmost one surrounding the most advanced prospects, the Bugaboo and Reko iron skarns (**Bugaboo-Reko**, or **Pacific Copper South** property). The new property to the north is currently called Pacific Copper North. There was also work at the Head Bay project near Tahsis on Northern Vancouver Island. The three programs consisted mainly of soil, stream and rock geochemistry. These were reconnaissance level surveys on large properties and not restricted to magnetite targets. Canadian Dehua has not yet reported results.

6.5. Mafic and ultramafic associated projects

6.5.1. Pacific Rim, Metchosin Complex

New Sunro Copper Ltd., a private company, carried out underground rehabilitation and an airborne magnetic and radiometric survey on the New Sunro property (Fig. 11),



Fig. 11. The Olympic Mountains and the southward continuation of the Crescent terrane, viewed from the Sunro property of New Sunro Copper Ltd. Sunro is near the northernmost extent of the Coast Range Basalt Province.

including the **Sunro** past producer.

Classed as a magmatic deposit (BC deposit model M02 or USGS mafic and ultramafic dike-sill complex related), sulphide mineralization is reported mainly in shear zones, fractures, shatter zones in Metchosin basalt, close to gabbroic sills. Some mineralized samples from the site were anomalous in nickel, cobalt and palladium, among other elements, but copper gold and silver are the commodities found in economic concentrations to date. Two orebodies were mined intermittently from 1962 to 1974. Between 1962 and 1978 the mine produced 13,754 t Cu, 203,101 g Au and 2,262,651 g Ag from 1.3 Mt of ore. Exploration has been modest and limited to surface surveys since mining ceased in 1974. The last reported historical resource estimate was in 1973. At that time 1,030,465 t grading 1.47% Cu were in proven and 423,782 t grading 1.33% Cu in probable categories. There are exploration targets in addition to historical ore zones.

6.5.2. Giant Mascot ultramafic intrusion

Ridgeline Exploration Services Inc. reported soil and biogeochemical surveys at the Lekcin property. These covered the Big Nic area and a 2014 discovery named the RP showing. Lekcin is adjacent to the Giant Mascot past Ni-Cu producer. Targets at Lekcin are magmatic sulphide Ni-Cu +/-PGE concentrations similar to those exploited at Giant Mascot. The property is owned by Mike Blady, Chris Paul, John Chapman and Gerry Carlson.

6.6. Industrial mineral and aggregate projects

Exploration for industrial minerals and aggregates is often carried out by individuals and private companies and typically goes unreported; in some cases it remains private as they must compete in limited local markets.

6.6.1. Wrangellia

Cataract Enterprises Ltd. is permitted to extract a bulk sample from the T&S Mine marble project near Skull Lake on the west coast of Vancouver Island. Vancouver Stone Quarries Inc. is also

permitted to trench and sample a marble prospect near Tahsis. Both hope to proceed in December. White Rose Holdings Ltd. reported mapping at its Leo D'Or marble prospect.

As noted above, Polaris Materials Corporation conducted exploration near its **Orca** sand and gravel quarry for sources of crushed aggregate and is testing bulk samples. Electra Stone Ltd. conducted a drilling and mapping program to define resources at its **Apple Bay** quarry.

6.6.2. Quaternary sediments

Another public company, Nomad Ventures Inc., acquired a permit to quarry aggregate at Saint Vincent Bay on Jervis Inlet, however at the time of writing it had not acquired the property on which the quarry was to operate. The Ministry of Energy and Mines received more than 25 Notices of Work for aggregate in the region by November 2015 and 40 in 2014, typical for recent years. There are more than 600 active quarry and sand and gravel permits in total, although not all are currently producing or conducting investigative work.

7. Geological research

7.1. Wrangellia

Geoscience BC commissioned a catchment analysis applying to stream sediment data gathered as part of its recent Northern Vancouver Island project (Arne and Brown, 2015).

Research culminating in a University of British Columbia Ph.D. thesis (Ruks, 2015) was in part funded by Geoscience BC. This work on Sicker Group stratigraphy and VMS mineralization began in 2007 as a Geoscience BC project.

7.2. Nooksack-Harrison terrane

Rukhlov and Ferbey, 2015a, b, published findings of a study using the Seneca VMS prospect as a field area for a test of the application of lead isotopes in till for mineral exploration. The relatively low-cost high resolution ICP-MS method they describe is similar to techniques applied to Paleozoic and older targets. This study demonstrates effectiveness with a Jurassic target.

7.3. Giant Mascot ultramafic intrusion

Nixon et al., 2015, Manor et al, 2015 and Manor et al., in press, have published results of recent work at the Giant Mascot Ni-Cu-PGE deposit. This work results from collaboration between the British Columbia Geological Survey, Geological Survey of Canada, and the University of British Columbia in a study of Ni-Cu-PGE mineralization in convergent-margin or supra-subduction-zone tectonic settings. Among the findings is a precise 93 Ma crystallization age for the ultramafic suite that hosts the past-producing deposit, identifying it as the youngest known magmatic Ni-Cu-PGE sulphide deposit.

8. Summary

While demand for construction materials continues to support industrial minerals and aggregates production and development, coal and metals exploration and production have

been curtailed severely over the past two years. There were no major exploration drill programs for metals in the southwest, other than the on-lease program at **Myra Falls**, where operations are now suspended. Production at the **Quinsam** coal mine is supported by sales to local cement plants, making it effectively a supplier to the local construction materials market.

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Note added in proof

Hillsborough Resources Ltd. announced in January 2016 that the Quinsam mine would suspend mining operations indefinitely. Hillsborough would fulfill current contracts from stockpiles.

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