Exploration and mining in the Southwest Region, British Columbia

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1. Introduction

The Southwest Region (Fig. 1) has a long history of mining. This history includes: the use of native copper by First Nations; silver, gold, and coal mining by the mid-19th century; mining of iron in the mid-20th century; and substantial copper production throughout the 20th century. Although mining and exploration for metal and continues in the region, most mining is for construction materials, mainly aggregates for local markets with some exports from the largest coastal quarries.

The area has one major polymetallic metal mine, **Myra Falls** (Nyrstar N.V.), one coal mine on care and maintenance, **Quinsam** (ERP Compliant Fuels LLC), and numerous industrial minerals and aggregate operations. Having been on care and maintenance since 2015, Nyrstar prepared to return **Myra Falls** to production in 2017 and produced some concentrate in 2018. Operations were suspended in 2018 for compliance reasons but restarted in April 2019 and continued in 2020. The **Quinsam mine**, on care and maintenance since 2016, had returned to production in 2017, after being purchased by ERP Compliant Fuels LLC, and produced about 200,000 t in 2018. However, the mine was placed on care and maintenance again in May 2019 and remained so through 2020.

Mine site exploration at **Myra Falls**, which began late in 2017, continued in 2018 through 2020. **Privateer Gold** Ltd. continued a significant exploration program at Zeballos, and more than 30 other exploration projects were tracked, mainly grass roots or early stage and small scale.

Estimates for exploration expenditures, drilling programs, and other metrics were captured in the British Columbia Mineral and Coal Exploration Survey, a joint initiative of the Province of British Columbia Ministry of Energy, Mines and Low Carbon Innovation, the Association for Mineral Exploration in British Columbia, and EY LLP. For the Southwest Region, exploration expenditures were estimated at \$4.0 million and exploration drilling was estimated at approximately 23,000 m (Clarke et al., 2021; EY LLP, 2021).

The total area under mineral, placer, and coal tenure in the region was about 689,700 ha in late November 2020, a 10.5% increase relative to November 2019 (624,000 ha). The Chief Gold Commissioner issued a blanket extension order in March,

allowing more time to file assessment work, cash in lieu, or lease payments, making a decrease unlikely in 2020.

2. Geological overview

Metallogeny in British Columbia is closely 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).

The Southwest Region includes parts of the Insular, Coast, and Intermontane physiographic regions. Most of the area is underlain by rocks of the Wrangell terrane and the Coast Plutonic complex (Fig. 1). Wrangellia is a 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, which are 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 host the past volcanogenic massive sulphide polymetallic producer at Mount Sicker and the current mine at **Myra Falls**.

Unconformably overlying the Paleozoic rocks are Middle to Upper Triassic oceanic flood basalts and related sedimentary rocks of the Vancouver Group. The upper part of the Vancouver Group contains numerous skarn occurrences adjacent to Jurassic intrusions (Island Plutonic suite). The Tasu past producer on Haida Gwaii is one of the larger examples of numerous iron and iron-copper skarns. 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 and subaerial basalt to rhyolitic flows and tuffs (Nixon and Orr, 2007). The Bonanza Group north of Holberg Inlet host the past-producing Island Copper Cu-Mo-Au porphyry deposit and other undeveloped



porphyry and epithermal prospects where they are intruded by Island Plutonic suite granodiorite and quartz diorite.

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.

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 calcalkaline rocks with less abundant high-grade metamorphic rocks. For the most part, uplift and erosion have removed the levels at which epithermal and porphyry-style mineralization form, with some 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, 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. At the southeastern edge of the Coast ranges, the Giant Mascot ultramafic-mafic intrusive suite (Late Cretaceous, Manor et al., 2014, 2015, 2016, 2017) hosts the province's only pastproducing nickel mine, Giant Mascot Nickel, which operated between 1958 and 1974.

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 (Madsen et al., 2006). Mount Washington Copper (Eocene) produced 3548 t of copper, 131 kg gold and 7235 kg silver. Catface Copper (Eocene) has a significant undeveloped resource. Other presumably Cenozoic targets include **Giant Copper** and **Okeover**. **Harmony**, on Graham Island, Haida Gwaii (Fig. 1) is a Miocene epithermal deposit with a significant undeveloped gold resource. Some recent exploration targets Neogene mineralization along a magmatic belt between the Brooks Peninsula and Alert Bay on northern Vancouver Island (Nixon et al., 2011, a, b; 2020).

Quaternary 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.

On Vancouver Island, the western and southern margins of Wrangellia are structurally juxtaposed with the Pacific Rim terrane, which consists of possible mélange deposits (Rusmore and Cowan, 1985; Brandon, 1989) and the Leech River complex, an assemblage of greenschist- to amphibolitegrade mudstones, sandstones, and mafic volcanic rocks cut by granitic bodies (Groome et al., 2003). Slate and siltstone are quarried for building stone in the Leech River complex. The Leech River 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.

The southeastern Coast Belt, north of the international border is underlain by the Nooksack-Harrison and Chilliwack terranes (equivalent to Stikinia; Monger and Struik, 2006), and the Bridge River, Cadwallader, and Methow terranes, 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, 2016). Gambier Group-equivalent overlap deposits and parts of the Nooksack-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.

Tectonic uplift, erosion, and glaciation produced sand and gravel deposits important to the construction and transportation industries of the Lower Mainland. Most are products of the most recent retreat of the Cordilleran Ice Sheet in the Pleistocene (e.g., Howes, 1983; Clague and Ward, 2011).

3. Mines

The Southwest Region has one metal mine, one coal mine placed on care and maintenance in 2019 and numerous industrial minerals and aggregate operations (Fig. 1; Tables 1-3). Of eight large-scale industrial minerals operations in the region, two entered care and maintenance in 2016 and remained so in 2020. Aggregate operations in the region number in the hundreds and only the most prominent (e.g., those producing at least 1 Mtpy) are reported here.

3.1. Metal mines

3.1.1. Myra Falls Operations (Nyrstar N.V.)

Nyrstar N.V. owns and operates the **Myra Falls** underground Zn-Cu-Pb-Ag-Au mine through a 100% owned subsidiary, Nyrstar Myra Falls Ltd. Trafigura Group Pte. owned 98% of parent Nyrstar after a restructuring arrangement in July 2019. Trafigura is a private company and not required to publish a production forecast for the year or resource and reserve estimates (Table 1). After re-starting following infrastructure upgrades and closing again for compliance reasons in 2018, the mine reopened in April 2019 and continued operation in 2020. The mine has a history of replacing reserves through

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Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2020 Production (based on O1-O3)	Reserves (December 31, 2018)	Resource (December 31, 2018)

Table 1. Metal mines, Southwest Region.

		MINFILE	Production (based on Q1-Q3)			
Myra Falls	Nyrstar Myra Falls Ltd.	Zn, Cu, Pb, Ag, Au; Noranda/ Kuroko massiye	Not reported	P+Pr: 4.7 Mt 7.11% Zn, 0.78% Pb, 0.92% Cu, 76.55 g/t Ag 1 78 g/t Au	M+I: 7.64 Mt 6.59% Zn, 0.72% Pb, 0.99% Cu, 72.52 g/t Ag 1.79 g/t Au	Resumed production in April 2019, continued 2020.
		sulphide; 092F 330, 71, 72, 73				Underground drilling, approx. 20,000 m in 42 holes, VTEM survey.

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

Table 2. Coal mines, Southwest Region.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2020 Production (based on Q1-Q3)	Reserves	Resource	Comments
Quinsam	Quinsam Coal Corporation	TC; Bituminous coal; 092F 319	nil	Not reported	Unofficial, non- compliant resources estimated at 40 Mt in 2013 by mine staff.	Placed on care and maintenance May 2019. Property and assets offered for sale

HCC = hard coking coal; PCI = pulverized coal injection; TC = thermal coal; P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

Table 3. Selected industrial mineral and aggregate mines and quarries, Southwest Region.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2020 Production (based on Q1-Q3)	Reserves	Resource	Comments
Blubber Bay	CRH Canada Group Inc.	Limestone, dolostone; Limestone; 092F 479	Up to 75,000 t dolostone annually	na	100+ years	Opens for contracts.
Bute Inlet	Ironwood Clay Company Inc.	Clay; Sedimentary kaolin? (or illite)	na	na	na	Intermittent mining as needed.
Cabin Group	Northwest Landscape and Stone SupplyLtd.	Landscaping stone	na	na	na	
Cox Station	Mainland Construction Materials ULC	Aggregate; Crushed rock; 092GSE103	Approx. 3-4 Mtpy	na	na	
СТСТ	Vancouver Island Marble Ouarries Ltd.	Marble; Limestone; 092E 020	Typically, about 400 t annually	na	na	Supplies Matrix Marble and Stone Inc.

Earle Creek	Lafarge Canada Inc.	Sand and Gravel	Typically, >1 Mtpy	na	na	
Garibaldi Pumice (Vulcan/ Salal)	Garibaldi Pumice Ltd.	Pumice; Volcanic ash; 092JW 039	10,000 m ³ , in anticipation of lower demand	na	11,396,000 m ³ pumice 4,990,000 m ³ pumicite (fines)	2014 resource. Additional exploration 2015, 2018, 2019.
Haddington Island	Adera Natural Stone Supply Ltd.	Dimension stone, Building stone; 092L 146	na	na	na	Not active every year.
Hardy Island	Hardy Island Granite Quarries Ltd.	Dimension stone, Building stone; Dimension stone-granite; 092F 425	3000-5000 tpy	na	na	
Imperial Limestone	Imperial Limestone Co. Ltd.	Limestone; Limestone; 092F 394	Approx. 600,000 t	na	75 years	250,000 t high purity product + cement feedstock.
K2	K2 Stone Quarries Inc.	Dimension stone, flagstone; Flagstone; 092C 159	15,000-20,000 t annually	na	na	Production number represents material extracted.
Mount Meager Pumice	Great Pacific Pumice Inc.	Pumice; Volcanic ash; 092JW 039	na	na	na	
Orca	Polaris Minerals Corporation (US Concrete Inc. and Namgis First Nation)	Sand and Gravel	Up to 6 Mtpy	na	na	Planning increased production.
Pipeline Road (2)	Lehigh Hanson Materials Ltd., Allard Contractors Ltd.	Sand and Gravel	na	na	na	Two adjacent operating sites.
Pitt River	Lafarge Canada Inc.	Aggregate; Crushed rock; 092GSE007	Typically, >1 Mtpy	na	na	
Sechelt	Lehigh Hanson Materials Limited	Sand and Gravel	Typically, 5-6 Mtpy	na	Several decades	
Spumoni	Northwest Landscape and Stone Supply Ltd.	Flagstone; Flagstone; 092GNW100	na	na	na	Seasonal quarry.

Sumas Shale	Sumas Shale Ltd. (Lafarge Canada Inc., Clayburn Industrial Group)	Shale, clay, sandstone; Residual kaolin; 092GSE024	About 500,000 t annually	na	50+ years	Approximately 55% shale, 45% sandstone for cement production.
Texada Quarry	Texada Quarrying Ltd. (Lafarge Canada Inc.)	Limestone, aggregate; Limestone; 092F 395	Typically, approx. 3.5 Mtpy	na	100+ years	Mostly produces limestone for cement manufacture.
Treat Creek	Lehigh Hanson Materials Limited	Aggregate; Crushed rock	Approx. 500 ktpy	na	na	

Table 3. Continued.

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

exploration, and mine site exploration continued in 2020 with underground drilling and a VTEM airborne survey. The Myra Falls camp hosts Kuroko-type, or bimodal felsic type Zn-Cu-Pb-Ag-Au VMS deposits from which more than 30 Mt of ore have been mined since 1966 (Fig. 2).



Fig. 2. The H-W headframe at Myra Falls, the entrance and exit for personnel, equipment and ore. In 2020, the mine also began to use a portal to haul ore. Limited access was a factor in a workforce reduction in 2020, but production continued through the Covid-19 pandemic. A multi-year exploration campaign continued in 2020.

3.2. Coal mines

3.2.1. Quinsam (ERP Compliant Fuels LLC)

Quinsam is an underground coal mine that began commercial production of thermal coal in 1988 (Table 2). At its peak, it produced approximately 1 Mt clean coal annually. It ceased operation and entered care and maintenance in early 2016. It was then purchased by ERP Compliant Fuels LLC in 2017 and operated by Quinsam Coal Corporation until 2019. In 2018, its last full year of operation, it produced about 200,000 t and employed approximately 50 people.

Quinsam placed the mine on care and maintenance at the end of May 2019. The company subsequently made an assignment into bankruptcy. The receiver and manager Bowra Group Inc. offered the property and assets for sale in 2020.

3.3. Industrial minerals and aggregates

Large quarries on the coast (Table 3) serve the Lower Mainland, Vancouver Island, and U.S. Pacific northwest markets by barge. Those with access to freighter loadout facilities can also supply eastern Pacific international markets and Hawaii. Aggregates are an important part of the mining industry on the south coast, generating many 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. General sales and production trends follow those of the construction industry. Lafarge North America Inc., Lehigh Hanson Materials Ltd., U.S. Concrete, Inc. and a local company, Mainland Sand and Gravel Ltd., are the 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 5-6 Mt range in recent years. It is permitted for up to 7.5 Mtpy. They expect reserves to last several more decades. 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**) each of which typically produces more than 1 Mtpy.

Pipeline Road is the site of large operations by Lehigh Hanson Materials Ltd. and Allard Contractors Ltd. Together they produce more than 1 Mtpy. Lehigh Hanson also has a large crushed aggregate operation at **Treat Creek** on Jervis Inlet.

Polaris Minerals Corporation, a subsidiary of U.S. Concrete Inc. operates the **Orca** quarry near Port McNeill, in partnership with the 'Namgis First Nation, which holds a 12% interest. The owner-operator partnership is Orca Sand and Gravel LP. The quarry produces sand and gravel mainly for export to California. The operation was originally permitted for up to 6 Mtpy, but Polaris plans to increase production to 8.5 Mtpy in 2021-23. In 2017, Polaris applied to the British Columbia Environmental Assessment Office for an amendment to its **Orca** project certificate to allow for producing aggregate at a site approximately 4 km from current operations. The new site was previously known as the **Black Bear** project. This site was to supply 250,000 tpy of a crushed basalt product, but in 2020 Polaris revised the proposal to 3-4 Mtpy.

The **Cox Station** quarry, on the north side of Sumas Mountain, is operated by Mainland Sand and Gravel Ltd. More than 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 on the order of 3-4 Mtpy. The quarry employs 45-50 people.

Small operations produce building stone on Vancouver Island. Island Stone Landscape Supply is a producer and supplier of flagstone, as is San Juan Quarries. Vancouver Island Marble Quarries Ltd. continues to quarry marble on Vancouver Island and fabricate a line of products including countertops, sinks, and tiles at Matrix Marble and Stone Inc. They quarry marbles referred to as 'Tlupana Blue Grey' and 'Vancouver Island White' near Hisnit Inlet (CTCT quarry). Pacific West Stone Inc. also has a quarry permit near Tahsis and proposed quarry at the **Leo D'Or** site at Bonanza Lake.

Landscaping stone and dimension stone is quarried in the Squamish-Whistler corridor. The largest operator is Northwest Landscape and Stone Supply Ltd., 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., and Alpine Natural Stone Ltd.

Haddington Island and **Hardy Island** have been two regular sources of dimension stone. 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). Adera Natural Stone Supply Ltd. supplies the Haddington Island andesite as needed. Most of the product is used for restoration work on historic buildings, but it has also been used in modern monuments and buildings.

Hardy Island Granite Quarries Ltd. produces up to 5000 tpy from a Coast Plutonic complex granodiorite unit. Like Haddington Island, it is an historic quarry that mainly serves the local market. Hardy Island has opened another quarry on Valdes Island that supplies sandstone from the Nanaimo Group, another rock type common to many older buildings in Vancouver and Victoria.

3.3.1. Texada (Texada Quarrying Ltd.)

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. 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, which has operated for more than 60 years, has extensive reserves and, at current rates, could produce for more than 100 years. They produce about 3.5 Mt annually.

3.3.2. Imperial Limestone (Imperial Limestone Co.)

In recent years, the **Imperial Limestone** quarry near Van Anda on Texada Island (Fig. 1) has produced approximately 250,000 to tpy of high-purity product, most of which is shipped to their parent company in Seattle; production was similar in 2020. Imperial Limestone Co. also mine and stockpile a larger quantity of lower quality limestone that goes to local cement plants. Quarrying at the Imperial site dates to the 1930s. The company anticipate reserves will last about 75 years.

3.3.3. Blubber Bay Quarry (CRH Canada Group Inc.)

The **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 dolostone periodically. They plan to ship product in 2021.

3.3.4. Sumas Shale (Sumas Shale Ltd.)

The **Sumas Shale** quarry of Sumas Shale Ltd., operated by contractor Fraser Pacific Enterprises Inc., delivers sandstone and shale product to the Lafarge and Lehigh cement plants in Richmond and Ash Grove in Seattle. Sumas Shale Ltd is 50% owned by Lafarge Canada Inc. and 50% by Clayburn Industrial Group. Production and shipments have been approximately 500,000 tpy in recent years. Mining plans include an average 475,000 tpy of approximately 55% shale and 45% sandstone. Because Clayburn's brick and refractory products plant in Abbotsford closed, fire clay is no longer produced separately.

3.3.5. Bute Inlet (Ironwood Clay Company Inc.)

Ironwood Clay Company Inc. mines glacial marine clay on the central coast. Until 2015, production was from the **De Cosmos Lagoon** south of Bella Bella (Fig. 1). The company has a new site at the head of **Bute Inlet**, which is likely to supply future raw material. Mining is intermittent. Ironwood produces cosmetic products using the clay at its Richmond plant, a business that has continued for 30 years. Glacial Bay Organic Clay Inc. is extracting material near the head of Bute Inlet but reported only sampling in 2020. 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 these glacial marine clay operations are unreported.

3.3.6. Garibaldi Pumice and Mount Meager Pumice (Garibaldi Pumice Ltd.; Great Pacific Pumice Inc.)

In the Mount Meager area, Garibaldi Pumice Ltd. produces 15,000-20,000 m³ of pumice annually from their quarry (**Vulcan/Salal**). Exploration on the property consisted of 14 test pits to further delineate the existing resource (Table 3). Neighbouring Great Pacific Pumice Inc. has been producing smaller quantities but have stockpiles in Squamish from which they can ship year-round.

3.3.7. K2 (K2 Stone Quarries Inc.)

K2 Stone is a natural stone product supplier with a quarry near Port Renfrew on Vancouver Island (**K2**). They extract about 15,000-20,000 t annually and expect about the same in 2020. The rock is trucked to Nanaimo for processing into masonry and landscaping products.

4. Placer gold

Historic placer camps include the Lower Fraser River, Leech River, and China Creek. Although short lived, a gold rush in the Fraser Canyon, beginning in 1858 at Hills Bar, led miners farther up the Fraser River into the Chilcotin and Cariboo. In 1864, reports of gold in the Leech River on southern Vancouver Island led to another brief gold rush. Both camps are worked by placer miners to the present day. The Lillooet River was also on a historic route to the Cariboo. It also remains an active placer camp.

5. Mine development

Mine development projects are those for which a decision to produce has been made, key government approvals are in place, and on-site construction has begun. The Southwest Region has no such large-scale projects.

6. 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). The Southwest Region has three such projects (Table 4); several small-scale and inactive larger projects are not covered in this report.

6.1. Proposed metal mines

The Southwest Region had no proposed major metal mine projects active in 2019.

6.2. Proposed coal mines

The region has no active proposed coal mine projects.

6.3. Selected proposed industrial minerals mines

Proposed mines include the **BURNCO Aggregate** Project and the **Sechelt Carbonate** project, which has been inactive apart from a request by the owner to remain in the provincial environmental assessment process. The **Black Bear** aggregate project near Port McNeill is the subject of an application to amend the **Orca** environmental certificate.

6.3.1. BURNCO Aggregate (BURNCO Rock Products Ltd.)

The **BURNCO Aggregate** Project in the McNab Creek Valley (Fig. 1) now has environmental certification and may

Table 4. Selected proposed mines or quarries, Southwest Region.

Project	Operator (partner)	Commodity; deposit type; MINFILE	Reserves	Resource	Comments
Black Bear and Orca	Polaris Materials Corporation (US Concrete, Inc. and Namgis First Nation)	Aggregate; na	na	20 years (proposed life)	Orca environmental certificate amendment application. Proposed 250,000 tpy near the Orca quarry revised to 3-4 Mtpy.
BURNCO Aggregate	BURNCO Rock Products Ltd.	Aggregate; Sand and Gravel; na	na	Approx. 20 Mt	Has environmental certification, would require Mines Act and other permits.
Sechelt Carbonate	Ballinteer Management Inc.	Limestone, dolostone, aggregate; Limestone, dolomite, crushed rock; 093GNW031	na	Carbonate Rock: 76.1 Mt Gabbro: >700 Mt	Proponent requests project remain in environmental assessment pre- application stage.

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

proceed with British Columbia Mines Act and other permitting. Fisheries and Oceans Canada concluded that the project is unlikely to cause significant environmental harm. The proposed sand and gravel mine would ramp up to a 1.6 Mtpy 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.

6.3.2. Sechelt Carbonate (Ballinteer Management Inc.)

Ballinteer Management Inc. now holds the property comprising the **Sechelt Carbonate** project. They filed engineering, archeological, and baseline environmental studies for assessment in 2016; activity was not reported for 2017-2020. The property contains resources of calcite- and dolomite bearing carbonate rock and gabbroic rock for potential use as aggregate. The original proposal was for a 4-6 tpy carbonate quarry producing both limestone and dolostone. Product was to be shipped from a barge load out on Sechelt Inlet.

6.3.3. Black Bear and Orca (Polaris Materials Corporation)

As noted above, Polaris Materials Corporation is including **Black Bear** near its **Orca** sand and gravel quarry in an environmental certificate amendment for Orca. If the project proceeds, it will be a source of up to 3-4 Mtpy of crushed basalt, an increase over the 250,000 tpy proposed in a 2017 project description.

6.3.4. Eagle Rock (Polaris Materials Corporation)

In January the BC Environmental Assessment Office decided that Polaris Materials had not made a substantial start on its Eagle Rock quarry, for which they had granted an environmental certificate in 2003. In 2020, the EAO gave written notice that the certificate had expired in 2013 and a new assessment would be required for the 3-6 Mtpy project to proceed.

7. Exploration activities and highlights

Exploration projects are categorized as grassroots, early stage, advanced, and mine evaluation, depending upon the nature of recent work. Work directed at discovering new resources away from ore bodies in an existing mine plan can be considered mine-lease or on-site exploration. The Southwest Region had few large exploration programs in 2020 (Table 5).

7.1. Selected precious metal projects

Precious metal prospects are found in a variety of settings in the region. There was one major exploration project in 2020, in addition to several smaller projects.

7.1.1. New Privateer (Privateer Gold Ltd.)

Privateer Gold Ltd. drilled at **New Privateer** (previously called Surespan) in the Zeballos gold camp, completing about 3000 m in 16 holes and an 800-sample soil survey. The target is vein mineralization like that mined historically. Privateer

Gold holds a land position including Crown grants covering the Privateer mine (Fig. 3) and other past producers in the historic Zeballos gold camp. As a private company working mainly on Crown-granted mineral claims they are not obligated to release results but indicated success in following drill-targeted veins and an intention to continue the project.

7.1.2. Harrison Gold (Bayhorse Silver Inc.)

Bayhorse Silver Inc. entered into an agreement with Bear Mountain Gold Mines Ltd. to earn a 50% interest in the **Harrison Gold** property. They collected samples for assay and metallurgical testing. Nine chip samples from the Jenner adit ranged from 2.86 to 414.20 g/t Au. Metallurgical testing achieved gravity recovery of 77.6% and gravity tails flotation recovered 17.1% for a total of 94.7% on a sample grading 11.89 g/t Au. Underground development and a bulk sample are permitted. The company mobilized a drill rig in December. An historical (1989) resource estimate has 1.845 Mt 2.79 g/t Au in the indicated category and 0.6 Mt 2.8 g/t Au in the inferred category.

7.1.3. Ladner Gold (New Carolin Gold Corp.)

At the **Ladner Gold** project, New Carolin Gold Corp. reported final results of its 2019 drill program and confirmed a historical 900 m long gold-in-soil anomaly.

7.1.4. Tahsis (Cross River Ventures Corp.)

Cross River Ventures Corp. carried out soil and rock geochemistry at **Tahsis** late in the year. Targets include goldand copper-bearing skarns and veins. The company has an option to acquire 100% of the property, which is about 12 km south east of the Zeballos camp.

7.1.5. Gold Standard (Juggernaut Exploration Ltd.)

Juggernaut carried out lidar and orthophoto surveys at **Gold Standard** and **Goldstar** properties in 2020. They have a permit to drill at Gold Standard where they plan to target the Goldzilla vein, which they traced for more than 900 m along strike. Both properties contain recently discovered gold veins.

7.1.6. Angus (PeakBirch Logic Inc.)

Kootenay Zinc Corp. (now PeakBirch Logic Inc.) has an option to acquire the **Angus** property from Longford Capital Corp. Kootenay collected rock and soil samples early in 2020. Targets included porphyry style mineralization. PeakBirch Logic is no longer a mineral exploration company.

7.1.7. Brandywine (Bayhorse Silver Inc. 80%; Turnagain Resources Inc. 20%)

Bayhorse Silver Inc. expanded the **Brandywine** property in 2020. The company released results from 2019 resampling of core drilled in 2010, verifying earlier work. Metallic screen assays returned up to 20.2 g/t Au along 1.5 m. They planned a 1500 m 10-hole drill program and applied for a permit. Brandywine has vein targets and massive sulphide targets



Fig. 3. Privateer portal. a) in 1939; b) in 2017. Topography and rainforest vegetation on the west coast of Vancouver Island make exploration challenging, with the result that some historical deposits remain underexplored.

 Table 5. Selected exploration projects, Southwest Region.

Project	Operator (partner)	Commodity; deposit type; MINFILE	Resource (NI 43-101 compliant unless indicated otherwise)	Comments
Adam West	GoldHaven Resources Corp.	Au, Ag, Cu; Volcanic redbed Cu; 092L 222	na	Rock geochemistry. Highlight 46.4% Cu, 144 g/t Ag, 16.55 g/t Au.
Angus	Kootenay Zinc Corp. (now PeakBirch Logic Inc.)	Au, Ag, Cu, Zn; Polymetallic veins; 092C 192	na	Rock and soil geochemistry.
Bakar	District Metals Corp., Sherpa II Holdings Corp.	Cu, Ag; Volcanic Redbed Cu; 102I 010, 7, 6, 15, 16, 17, 092L 080, 462, 247	na	Technical report by Sherpa II.
Brandywine	Bayhorse Silver Inc., Turnagain Resources Inc.	Ag, Au, Pb, Zn; Polymetallic veins; 092JW 001, 21, 22	na	Technical report, preparation for drilling.

Table 5. Continued.

Consortium	Gold Basin Resources Corporation	Au, Ag, Cu; Au quartz veins, Cu+/-Ag quartz veins; 092K 175	na	Rock and soil geochemistry. Grab samples up to 30.4 g/t Au.
Dancer Group	AMA Gold Exploration Ltd.	Au, Ag, Au; Quartz veins, polymetallic veins; 092GNW008, 12, 63	na	Technical report.
Empire Mine	Roughrider Exploration Limited	Au, Ag, Cu, Fe, Co; Fe skarn, Cu skarn; 092L 044, 45, 46	M+I: 1,950,000 t 2 g/t Au, 5.6 g/t Ag, 0.34% Cu, 0.013% Co Inf: 120,000 t 1.2 g/t Au, 2.8 g/t Ag, 0 13% Cu 0 008% Co	Soil and rock geochemistry.
Gold Standard	Juggernaut Exploration Ltd.	Au, Ag; Au quartz veins	na	Lidar, orthophotos, permitting for drilling.
Goldstar	Juggernaut Exploration Ltd.	Au, Ag; Au quartz veins	na	Lidar, orthophotos.
Harrison Gold	Bear Mountain Gold Mines Ltd., Bayhorse Silver Inc.	Au, Ag; Au quartz veins; 092HSW092	Historical I: 1.845 Mt 2.79 g/t Au Inf: 0.6 Mt 2.8 g/t Au	Sampling, metallurgical testing. Underground development, bulk sample.
Ladner Gold	New Carolin Gold Corp.	Au, Ag; Au quartz veins; 092HNW003, 7, 18, 092HSW034	Carolin Inf: 12,352,124 t 1.53 g/t Au McMaster Inf: 3,575,000 t 0.69 g/t Au Tailings I: 445,378 t 1.83 g/t Au Inf: 93,304 t 1.85 g/t Au	Final 2019 results released.
Lemare	Homegold Resources Ltd.; Private co.	Cu, Mo, Au, Ag, pyrophyllite; Porphyry Cu±Mo±Au; 92L 381, 328, 385, 378, 380, 329, 382, 379	na	IP survey.
New Privateer (Surespan Gold)	Privateer Gold Ltd.	Au, Ag; Au-quartz veins; 092L 008, 311, 155	na	Drilling 3000 m in 16 holes, soil survey.
North Island	Northisle Copper and Gold Inc.	Cu, Au, Mo, Re; Porphyry Cu±Mo±Au; 092L 185, 240, 200	I: 341,743,000 t 0.24% Cu, 0.29 g/t Au, 0.008% Mo, 0.48 ppm Re Inf: 190,788,000 t 0.19% Cu, 0.24 g/t Au, 0.007% Mo, 0.35 ppm Re	Resource estimate combines Red Dog and Hushamu. 2020 work included metallurgical tests which improved recoveries at Red Dog and Hushamu.
Silver Peak	Homegold Resources Ltd., M. Nugent	Ag; Polymetallic veins; 092HSW011	na	Trenching, sampling, drilling.
Tahsis	Cross River Ventures Corp.	Au, Cu; Fe skarn, Cu skarn, Au skarn; 092E 010, 85	na	Rock and soil geochemistry.

Table 5. Continued.

Teeta Creek	Teck Resources Limited, ArcWest Exploration Inc.	Cu, Mo, Au; Porphyry Cu±Mo±Au; 092L 454, 235	na	Mapping, drilling permitted.
Yreka	Karmamount Mineral Exploration Ltd.	Cu, Ag, Au; Cu skarns, porphyry; 092L 052, 104, 451, 336, 236, 105, 452	na	IP survey.

M = Measured; I = Indicated; Inf = Inferred

with precious metals in the Gambier Group, which Bayhorse interprets as volcanogenic. In 1977-78, about 10,000 t of ore from **Brandywine** yielded 23,000 oz Ag and 11,000 oz Au, with Pb, Zn, and Cu co-products.

7.1.8. Silver Peak (Johan Shearer, 15%; Michael Nugent, 85%)

Homegold Resources Ltd., on behalf of the owners, began sampling and drilling at **Silver Peak**, site of the Eureka-Victoria, a past silver producer dating back to 1868. Current operators report silver assays up to 15,000 g/t, consistent with historical high-grade results along intervals of less than 1 m.

7.1.9. Dancer Group (AMA Gold Exploration Ltd.)

AMA did not carry out field work on its **Dancer** claims but prepared a technical report for the project.

7.1.10. Consortium (Gold Basin Resources Corporation)

Gold Basin carried out a mapping, prospecting, and rock and soil sampling at the **Consortium** project. Ten grab samples averaged 4.5 g/t Au and 14 g/t Ag with a high value of 30.4 g/t Au. The area is underlain by Karmutsen Formation tholeiitic basalts. Mineralization is in quartz veins with ankerite alteration.

7.2. Selected porphyry projects

Jurassic porphyry mineralization is a target on Vancouver Island. Southwestern British Columbia also has several advanced Eocene to Miocene porphyry copper targets.

7.2.1. North Island (NorthIsle Copper and Gold Inc.)

NorthIsle Copper and Gold's **North Island** property is divided into eastern and western halves. The eastern half, referred to as the Pemberton Hills project in this report, is an early stage exploration project under option by Freeport McMoRan Minerals Canada Inc. Because of the Covid-19 pandemic, the company did not carry out exploration in 2020. The western half is a more advanced project by NorthIsle Copper and Gold, comprising the **Hushamu** and **Red Dog** Cu-Mo-Au-Re porphyry deposits. Preliminary metallurgical tests for the Hushamu deposit improved relative to the 2017 Preliminary Economic Assessment (PEA) values by 24% for copper, and by 24% for gold. For low-pyrite mineralization, copper recovery is now estimated at 86.6% and gold recovery 50.6%. For high-pyrite mineralization, the estimates are 87.9% recovery for copper and 46.4% for gold. For the Red Dog, recovery improved relative to 2017 PEA values by 5% for copper and by 65% for gold; the new estimates are 89.8% copper recovery and 53.0% gold recovery (Fig. 4). The 2017 PEA considered a project combining the Red Dog and Hushamu deposits (Table 5). The model considered a 22-year operation with a throughput of 27.4 Mtpy and a strip ratio of 0.72.



Fig. 4. Silica-clay-pyrite is one of the principal alteration types at Hushamu. This sample has disseminated chalcopyrite and minor bornite.

7.2.2. Teeta Creek (Teck Resources Limited)

Teck Resources Limited has an option to acquire 60% of optioned **Teeta Creek** from ArcWest Exploration Inc. In 2020, Teck began geological mapping ahead of planned drilling. The drilling was permitted in the fall but may be deferred pending improvement in Covid-19 infection rates.

7.2.3. NVI (Teck Resources Limited)

The **NVI** property is approximately 12 km northeast of Teeta Creek, along a newly recognized suite of Neogene intrusions with spatially associated porphyry style Cu-Mo occurrences. It is also subject of an option agreement by which Teck may acquire a 60% interest from ArcWest Exploration Inc.

7.2.4. Yreka (Karmamount Mineral Exploration Inc.)

Karmamount continued an IP survey started in 2019 at their **Yreka** project to test possible porphyry stockwork mineralization west of the Yreka past Cu-Au-Ag producer. Lines also extended over known Cu-Au skarn mineralization. The Yreka past producer is a Cu skarn that produced Cu, Au and Ag in the early 20th century and late 1960s.

7.2.5. Lemare (Homegold Resources Ltd.; Private Co. optionee)

An unidentified operator conducted an IP survey over porphyry Cu-Mo targets at the **Lemare** property in 2020. The property also hosts pyrophyllite prospects.

7.3. Selected polymetallic base and precious metal projects

Apart from a continuing multi-year program at Myra Falls, volcanogenic massive sulphide deposits in the southwest saw limited exploration in 2020. The precious metals-enriched **Brandywine** is included under the precious metals section, above.

7.3.1. Adam West (GoldHaven Resources Corp.)

GoldHaven Resources Corp. (Formerly Altum Resources Corp.) reported results of rock sampling at **Adam West**. Of 147 grab samples, 102 returned >0.25% Cu. Highlights include 46.4% Cu and 144 g/t Ag and 16.55 g/t Au at the Lucky Jim occurrence. Targets include vein, fracture, and amygdule fillings of bornite, chalcocite and chalcopyrite in Karmutsen Formation basalt, overlain by limestone. The Lucky Jim is described as skarn or metasomatic mineralization.

7.3.2. Bakar (Sherpa II Holdings Corp.)

Sherpa II has an option to acquire 80% of the **Bakar** property from District Metals Corp. The company reported preliminary fieldwork at the site and prepared a revised technical report. Optionor and previous operator District Metals Corp. reported stratabound Cu-Ag mineralization in 2019.

7.4. Selected skarn projects

7.4.1. Empire Mine (Roughrider Exploration Limited)

Roughrider has an option to acquire a 100% interest in the **Empire Mine** property from Mirva Properties Ltd. Initial exploration included a soil survey and rock chip and channel samples. The property includes the past producing Merry Widow, Raven and Kingfisher skarn deposits, which produced iron in the 1950s and 60s. Copper-gold skarn mineralization has been a target of more recent exploration (Fig. 5).

8. Geological research

Fieldwork by the British Columbia Geological Survey was limited in 2020 because of the Covid-19 pandemic. Several porphyry mineral occurrences on northern Vancouver Island, previously assumed to be related to the Island plutonic suite (Jurassic), are now recognized as part of a much younger (Neogene) mineralizing event (Nixon et al., 2020); sampling for geochronologic continued in 2020. Testing the dispersion of atmospheric mercury above buried deposits as an exploration tool, Rukhlov et al (2021) conducted in-situ measurements at



Fig. 5. A pod of massive sulphide (pyrrhotite-pyrite-chalcopyrite) in Cu-Fe skarn at the Empire Mine project.

the Lara VMS deposit on southern Vancouver Island using a highly sensitive mercury vapour analyzer.

Partnered with the Geological Survey of Canada and others, Geoscience BC has an ongoing project to assess the geothermal potential at Mount Meager. Grasby et al. (2020) reported on 2019 work that included detailed geological mapping, fracture and rock property studies, a gravity survey, thermal spring geochemistry, and an array of seismometers and magnetotelluric stations. Precision Geosurveys Inc. (2020) published the results of the Geoscience BC-funded airborne magnetic and radiometric survey of northern Vancouver Island. Morris and Canil (2020) provided preliminary results from mapping and sampling at the past-producing Merry Widow magnetite skarn deposit on northern Vancouver Island.

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