Exploration and mining in the Southwest Region, British Columbia

Bruce Northcote^{1, a}

T ROLOGICAL SURVEY

¹Regional Geologist, British Columbia Geological Survey, Ministry of Energy, Mines and Petroleum Resources, 300-865 Hornby Street, Vancouver, BC, V6Z 2G3

^a corresponding author: Bruce.Northcote@gov.bc.ca

Recommended citation: Northcote, B., 2019. Exploration and mining in the Southwest Region, British Columbia. In: Exploration and Mining in British Columbia, 2018. British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey, Information Circular 2019-01, pp. 101-113.

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 coal continue in the region, most mining is for construction materials, mainly aggregates for local markets.

The area has one major polymetallic metal mine, **Myra Falls** (Nyrstar N.V.), one coal mine, **Quinsam** (ERP Compliant Fuels LLC), and numerous industrial minerals and aggregate operations. In the summer of 2017, Nyrstar returned Myra Falls to production, having been on care and maintenance since 2015. Similarly, Quinsam, on care and maintenance since 2016, returned to production in 2017, after being purchased by ERP Compliant Fuels LLC. As of September 2018, Myra Falls was producing concentrate and shipment was expected late in the year. The Quinsam mine is expected to produce about 200,000 t in 2018. Mine site exploration began at Myra Falls late in 2017 and continued in 2018. A permitted exploration program by Quinsam, also began late in 2017 and continued in 2018.

Significant off-lease exploration drilling programs in 2018 include **Surespan Gold, Pemberton Hills** and **Ladner Gold**. About 25 active exploration projects were tracked; most were small scale. BURNCO Rock Products Ltd.'s large aggregate project on Howe Sound, **BURNCO Aggregate**, obtained provincial environmental certification in 2018; Fisheries and Oceans Canada considered that the project was unlikely to harm the environment.

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 Petroleum Resources, the Association for Mineral Exploration in British Columbia, and Ernst & Young LLP. For the Southwest Region, exploration expenditures were estimated at \$7.8 million and exploration drilling was estimated at approximately 39,800 m (Clarke et al., 2019; Ernst & Young LLP (EY), 2019, in press).

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, 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



102 Provincial Overview of Exploration and Mining in British Columbia, 2018. British Columbia Geological Survey, Information Circular 2019-01 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 now near Campbell River.

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 Late Cretaceous Giant Mascot ultramafic-mafic intrusive suite (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. 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.

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 is 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). For further details about the geology of the Southwest Region see Northcote (2017).

3. Mines

The Southwest Region has one metal mine, one coal mine 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 2018. Aggregate operations in the region number in the hundreds and only the most prominent (e.g., those producing at least one million tpy) are reported here.

3.1. Metal mines

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

Myra Falls Operations is an underground polymetallic mine that exploits a cluster of volcanogenic massive sulphide lenses. Nyrstar suspended mining activities at the beginning of the second quarter in 2015. In 2017, a \$100 million infrastructure upgrade began, which carried through 2018. The restart project includes: upgrading the H-W shaft and headframe; upgrading the paste plant; diamond drilling to increase resources and reserves; purchasing a new underground fleet; refitting and repairing the concentrator; constructing a new camp; and moving the power house. Infrastructure for hydroelectric power was upgraded. Production of concentrate had resumed by September 2018 and shipments were planned by the end of the year.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2018 Production (based on Q1-Q3)	Reserves	Resource	Comments
Myra Falls	Nyrstar Myra Falls Ltd. (parent company Nyrstar N.V.)	Zn, Cu, Pb, Au, Ag; Noranda/ Kuroko massive sulphide; 092F 072, 330, 71, 73	na	P+Pr: 4.89 Mt 6.84% Zn, 0.75% Pb, 0.91% Cu, 71.31 g/t Ag, 1.69 g/t Au	M+I: 7.29 Mt 6.59% Zn, 0.72% Pb, 1.01% Cu, 69.71 g/t Ag, 1.76 g/t Au Inf: 0.94 Mt 9.51% Zn, 1.05% Pb, 0.83% Cu, 136.78 g/t Ag, 2.90 g/t Au	Production ramp up in 2018. Resources inclusive of reserves Dec. 31, 2017.

Table 1. Metal mines, Southwest Region.

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

Table 2. Coal mines, Southwest Region.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2017 Production (based on Q1-Q3)	Reserves	Resource	Comments
Quinsam	Quinsam Coal Corporation (ERP Compliant Fuels LLC)	Thermal coal; bituminous coal; 092F 319	Approx. 200,000 t clean coal	na	na	Resources and reserves are unpublished. Resumed operations Sept. 2017. Exploration 2017-2018.

Current reserves and resources (Table 1) may be adequate for approximately 10 years at recent mining rates. However, pointing to exploration potential, the company anticipates a longer operating life. Untested target areas remain in this camp, which so far consists of at least 7 significant deposits consisting of at least 50 different sulphide lenses.

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

3.2.1. Quinsam (ERP Compliant Fuels LLC)

Underground coal mining on Vancouver Island dates back to 1849. The **Quinsam** thermal coal mine near Campbell River (Fig. 1) began operation in 1986 but went on care and maintenance in 2016. In 2017, Hillsborough Resources Limited sold the mine. ERP Compliant Fuels, LLC, is affiliated with Conuma Coal Resources Ltd., the company that resumed operations at Wolverine, Brule and Willow Creek in northeastern British Columbia (e.g., DeGrace, 2019). Mining resumed at Quinsam in early fall of 2017. By the end of 2018 more than 80 workers were on site. Production for 2018 was approximately 200,000 t of clean coal. 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 (Upper Cretaceous). The mine is capable of producing more than half a million tonnes a year. ERP Compliant Fuels is a private company that does not release reserve and resource figures. Product is blended to meet customer specifications. Most recently, the mine supplied local cement plants. The mine can also serve international markets using a freighter loading facility on Texada Island.

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 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.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2018 Production (based on Q1-Q3)	Reserves	Resource	Comments
Apple Bay (PEM 100)	Linceo Media Group Inc.	Silica+alumina; volcanic glass-perlite; 092L 150	na	na	na	Care and maintenance 2018.
Benson Lake	Benson Lake Carbonates ULC	High brightness carbonate; limestone; 092L 295	na	na	na	Care and maintenance 2018.
Blubber Bay	Ash Grove Cement Company	Limestone, dolostone; limestone; 092F 479	Up to 50,000 t dolostone annually	na	100+ years	Care and maintenance, most of 2018. Continues to ship dolomite on contract.
Garibaldi Pumice	Garibaldi Pumice Ltd.	Pumice; volcanic ash; 092JW 039	Approx. 20,000 m ³ annually	na	11,396,000 m ³ pumice 4,990,000 m ³ pumicite (fines)	2014 resource. Additional exploration 2015, 2018.
Imperial Limestone	Imperial Limestone Co. Ltd.	Limestone; limestone; 092F 394	Approx. 250,000 t annually	na	50+ years	Production number is their high quality product. Resource estimated at roughly 200 Mt.
К2	K2 Stone Quarries Inc.	Dimension stone, flagstone; 092C 159	15,000-20,000 t annually	na	na	Number represents material extracted.
Mount Meager Pumice	Great Pacific Pumice Inc.	Pumice; volcanic ash; 092JW 039	na	na	na	Exploration in 2018.
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.
Tahsis	Pacific West Stone Inc.	Marble; limestone; 092E 020	na	na	na	Previous owner obtained a quarry permit for Tahsis, but new owner indicates marble production from Leo D'Or site (bulk sample).
Texada Quarry	Texada Quarrying Ltd. (Lafarge Canada Inc.)	Limestone, aggregate; limestone; 092F 395	na	na	100+ years	Mostly produces limestone for cement manufacture. High brightness carbonate and aggregates also produced.

Table 3. Selected industrial mineral mines and quarries, Southwest 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 Mt 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**) each of which typically produces more than 1 Mt per year. Production and employment estimates for 2016 reported by Lafarge for their four largest aggregate operation serving the Lower Mainland include: 1.0 Mt and 23 people at Earle Creek, 1.1 Mt and 21 people at Pitt River Quarry; 1.0 Mt and 17 people at **Central Aggregate**; and 0.9 Mt and 10 people at Ward Road. Remediation work continues at Lafarge's Pipeline Road site.

Near the **Pipeline Road** site are large operations by Jack Cewe Ltd and Allard Contractors Ltd. Together they produce more than 1 Mt most years. Cewe also operates a large quarry on Jervis Inlet at Treat Creek. They do not release yearly production figures.

Polaris Minerals Corporation operates the **Orca** quarry near Port McNeill, which produces sand and gravel mainly for export. Polaris Minerals produced about 3 Mt in 2017. They no longer make production estimates public. In November 2017, shareholders of Polaris Materials Corporation approved an offer from U.S. Concrete Inc. to purchase Polaris. Meanwhile, Polaris has 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 would supply up to 250,000 tpy of a crushed basalt product.

The **Cox Station** quarry, on the north side of Sumas Mountain, is operated by Mainland Sand and Gravels 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 2-3 Mtpy. The quarry employs 45-50 people.

Small operations produce building stone on Vancouver Island. Van Isle Slate offers a line of hand-cut slate products quarried from rocks of the Leech River complex. The quarry operates intermittently, last producing in 2016. Island Stone Landscape Supply is another established producer and supplier of flagstone, as is San Juan Quarries. Matrix Marble and Stone Inc. continues to quarry marble on Vancouver Island and fabricate a line of products including countertops, sinks, and tiles. They quarry marbles referred to as 'Tlupana Blue Grey' and 'Vancouver Island White' near Hisnit Inlet.

Landscaping stone and dimension stone is quarried in the Squamish-Whistler corridor. The largest operator is Northwest Landscape and Stone Supply, with the Spumoni quarry 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 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 that can be found on 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, is capable of producing 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 300,000 tpy of high-purity product, most of which is shipped to their parent company in Seattle. They also mine and stockpile 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 for more than 50 years.

3.3.3. Blubber Bay Quarry (Ash Grove Cement Company)

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 dolomite. It has a contract for 150,000 t and plans 75,000 tpy this year and next.

3.3.4. PEM 100 (Linceo Media Group LLC)

On northern Vancouver Island, the new operator of the **PEM 100** or **Apple Bay** quarry, Linceo Media Group LLC, left the site on care and maintenance, but with environmental monitoring ongoing. When operating, the quarry ships silica and alumina products from silicified and clay-altered rhyolitic flows and volcaniclastic rocks. Ash Grove Cement Company and previous quarry operator Electra Stone Ltd. conducted mine site exploration programs to better define its resources

and to identify higher-silica (>97% SiO_2) material in 2015-2016. The new operator is proposing exploration and a higher production rate, pending discussions with the lease holder.

3.3.5. Benson Lake (Benson Lake Carbonates ULC)

At the **Benson Lake** white carbonate deposit on northern Vancouver Island, new owner Benson Lake Carbonates ULC reported 2016 production totalling approximately 19,000 t. In 2017 and 2018, the quarry was on care and maintenance.

3.3.6. 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. In future, they plan to mine an average 475,000 tpy of approximately 55% shale and 45% sandstone. Because Clayburn's brick and refractory products plant in Abbotsford closed, fireclay is no longer produced separately.

3.3.7. Bute Inlet (Ironwood Clay Company Inc.)

Ironwood Clay Company Inc. mines glacial marine clay on the central Coast. Until 2015, production was 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. Mining is intermittent: they collected approximately 595 t in 2017. Ironwood produces cosmetic products using the clay at its Richmond plant, a business that has continued for 30 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. Generally, Mines Act permits are not required where material is collected by hand, and therefore some glacial marine clay operations are unreported.

3.3.8. 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 the **Garibaldi Pumice** quarry. Exploration on the property consisted of 12 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. They also reported exploration in 2018.

3.3.9. 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. 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.

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 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 2018.

6.2. Proposed coal mines

In 2016, the BC Environmental Assessment Office terminated environmental assessment of the Raven Underground Coal mine project of Compliance Coal Corporation, and the region now 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 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 proceed with British Columbia Mines Act and other permitting. 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.

Project	Operator (partner)	Commodity; deposit type; MINFILE	Reserves	Resource	Comments
Black Bear	Polaris Materials Corporation (Parent company US Concrete, Inc.)	Aggregate; crushed rock; na	na	na	Orca environmental certificate amendment Application Information Requirements approved for proposed 250,000 tpy near the Orca quarry.
BURNCO Aggregate	BURNCO Rock Products Ltd.	Aggregate; sand and gravel; na	na	Approx. 20 Mt	Has environmental certification.
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.

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

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; no activity was reported for 2017 or 2018. The property contains resources of calcite- and dolomite-bearing carbonate rock and gabbroic rock for potential use as aggregate.

6.3.3. Black Bear (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 250,000 tpy of crushed basalt.

7. Exploration activities and highlights

Exploration projects are categorized as grassroots, earlystage, 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 2018 (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 2018, in addition to several smaller projects.

7.1.1. Ashlu (Ashlu Mines Inc.)

Ashlu Mines Inc. is a private company that has assembled

a land position near the former Ashlu mine near Squamish (**Ashlu property**). In 2017 and 2018, they reported continuing geological work and geochemical sampling. A geological, geophysical (VLF-EM), and geochemical (rock, soil, and silt sampling) program that began in 2009 and continued annually since 2011, has relocated showings near the former mine. The Ashlu mine, not part of this project, is a past producer that exploited a narrow (<1 to 4.6 m) gold-bearing quartz vein along a strike length of 90 m and extending 85 m down dip. In 1981, reserves were about 90,000 t of 8.57 g/t Au and 12.31 g/t Ag. The principal target of the surrounding project is mineralization similar to the Ashlu mine. The property is largely underlain by the Cloudburst pluton (Jurassic).

7.1.2. Dancer Group (AMA Gold Exploration Ltd.)

AMA Gold began its proposed program of trenching in 2018, with plans to continue in 2019. AMA is a private company that does not report results. Targets are precious metal bearing veins (Table 5).

7.1.3. GoldCrest, Goldstandard, Goldstar (DSM Syndicate Holdings Ltd.)

Juggernaut Exploration Ltd., a 20% partner in the DSM Syndicate, reported chip sample assays up to 56.1 g/t Au and 124 g/t Ag over 1 m at the **GoldCrest** property northeast of Bella Coola. They also hold the **Goldstandard** property (71.8 g/t Au and 64.4 g/t Ag over 0.5 m) to the west and **Goldstar** property (20.6 g/t Au and 329 g/t Ag over 1 m) to the south. All three are grass roots stage properties in Coast Plutonic complex intrusive, metasedimentary and metavolcanic rocks. Mineralization is mostly described as quartz vein hosted.

Table 5.	Selected	exploration	projects,	Southwest Region.

Project	Operator (partner)	Commodity; deposit type; MINFILE	Resource (NI 43-101 compliant unless indicated otherwise)	Comments
Ashlu	Ashlu Mines Inc.	Au, Ag, Cu; polymetallic veins; 092GNW013	na	Multi-year geology, geochemistry and geophysics continued. Property surrounds the Ashlu past-producing mine.
Dancer Group	AMA Gold Exploration Ltd.	Au, Ag; Au- quartz veins, polymetallic veins; 092GNW008, 12, 63	na	Trenching.
Giant Copper	Imperial Metals Corporation	Cu, Au, Ag, Mo; porphyry Cu ±Mo±Au; 092HSW001, 2, 27, 161	Invermay zone I: 17,532,570 tons 0.226% Cu, 0.011 oz/t Au, 0.310 oz/t Ag AM Breccia zone Historical (open pit): 29,523,030 tons 0.653% Cu, 0.011 oz/t Au, 0.360 oz/t Ag, 0.007% Mo	Permitting, rock geochemistry.
Goldcrest	DSM Syndicate Holdings Ltd.	Au, Ag; Au quartz veins	na	Prospecting, rock geochemistry.
Goldstar	DSM Syndicate Holdings Ltd.	Au, Ag, Zn, Cu	na	Prospecting, sampling. Discovery of gold mineralization.
Jasper	Nitinat Minerals Corporation	Cu, Zn, Au, Ag; Noranda/Kuroko massive sulphide; 092C 080, 37, 81, 88	na	Geophysical interpretation.
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	Drilling; planned 3400 m underground.
Le Mare Lake	Le Mare Gold Corp.	Cu, Mo, Au; porphyry Cu±Mo±Au; 092L 381, 328, 385, 378	na	Drilling 300.5 m in 2 holes.
Lode Gold	Pacific Bay Minerals Ltd.	Au, Ag, Cu, Zn; polymetallic veins Ag-Pb-Zn±Au; 092HSW070	na	Drilling (2 holes).

Provincial Overview of Exploration and Mining in British Columbia, 2018. British Columbia Geological Survey, Information Circular 2019-01

Pacific Copper	Vancouver Island Iron Ore Corporation	Cu, Mo, Au, Ag; Cu±Ag quartz veins; 092F 207, 459, 216, 092C 252, 62	na	Geophysics.
Pemberton Hills	Northisle Copper and Gold Inc. (Freeport- McMoRan Mineral Properties Canada Inc.)	Cu, Mo; porphyry Cu ±Mo±Au; 092L 131, 308	na	Drilling 3400 m in 6 holes. IP, geochemistry.
Prosper	New Sunro Copper Ltd.	Au, Ag, Cu; Cu±Ag quartz veins; 092F 053	Historical: 8150 t 32 g/t Au	Proposed work late 2018.
Skyhigh	DSM Syndicate Holdings Ltd.	Au, Ag Cu, Mo; epithermal Au- Ag-Cu, high sulphidation	na	Rock geochemistry.
Surespan Gold	640895 B.C. Ltd.	Au, Ag; Au-quartz veins; 092L 008, 311, 155	Privateer historical: 122,475 t 17 g/t Au	Drilling 6700 m in 34 holes.
Wahleach Creek	Inua Studio	Jade; jade (nephrite); 092HSW099	na	Trenching.
White Fang	Homegold Resources Ltd.	Cu, Ag, Au; Cu skarns; 092L 255	na	Early stage.

M = Measured; I = Indicated; Inf = Inferred

7.1.4. Skyhigh (DSM Syndicate Holdings Ltd.)

Juggernaut Exploration Ltd., a partner in the DSM Syndicate, reported on grass roots prospecting and sampling at the **Skyhigh** property. A highlight was a chip sample returning 15.75 g/t Au and 1845 g/t Ag over 1 m. The property covers a cluster of known epithermal and porphyry occurrences hosted by metamorphic and intrusive rocks of the Coast Plutonic complex, about 32 km north of gold past producers on Loughborough Inlet and Phillips Arm.

7.1.5. Surespan Gold (640895 B.C. Ltd.)

A numbered company doing business as Surespan Gold, drilled approximately 6700 m in the Privateer area near Zeballos (Fig. 2). The project is privately funded and results of 2017 and 2018 work have not been made public. The area is underlain mainly by Jurassic basaltic to rhyolitic volcanic rocks of the Bonanza Group and Eocene intrusive rocks. The Zeballos area hosted 19 gold producers from the 1930s to the late 1990s, mainly from quartz veins. The Privateer mine was the most productive of these, with 170,463 oz of gold recovered. Between 1934 and 1975, the Zeballos camp produced approximately 300,000 oz gold from veins, mostly at the Privateer and Spud Valley mines. Before Surespan's work in 2017, the last significant exploration was in the early 2000s.



Fig. 2. View looking southwest down the Zeballos River valley. Historical mining, including the Privateer mine was mainly on the southeast side of the river. This rugged, heavily vegetated area has seen limited modern exploration.

7.1.6. Ladner Gold (New Carolin Gold Corp.)

New Carolin Gold Corp. completed its acquisition of the **Ladner Gold** project in 2016 and now holds 100% of the property, including the former Carolin mine site (subject to percentage of net smelter returns royalty). Following a surface program in 2016, 2017 work included preparing for underground drilling with a survey of workings, upgrades, and re-timbering. Work in 2018 included the underground drilling. The planned program for 2018 was 3400 m in 28 holes of

which results for 1489 m in 13 holes were reported. This first phase drilling on the Main zone included a highlight of 93 m averaging 1.39 g/t Au including 7 m of 5.75 g/t Au.

Before the recent surface and underground drilling, the company had resource estimates at the past-producing Carolin mine for an open-pit operation of Inferred at 0.5 g/t cut-off of 12,352,124 t grading 1.53 g/t Au and for an underground operation of Inferred at 2.0 g/t cut-off of 2,588,376 t grading 3.34 g/t Au.

The McMaster zone has an Inferred resource of 3,575,000 t grading 0.69 g/t Au at a 0.5 g/t Au cut off. The Carolin mine tailings estimate has 445,378 t at 1.83 g/t Au in the Indicated category and 93,304 t grading 1.85 g/t in the Inferred category.

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 has generally not been well explored by modern methods. Veins of economic interest are found in sedimentary and mafic volcanic rocks northeast of the East Hozameen fault and Coquihalla serpentine belt.

7.1.7. Lode Gold (Pacific Bay Minerals Ltd.)

Pacific Bay drilled two holes targeting a known gold-bearing quartz vein. The property was previously known as **Weaver Lake** or **LD**. It was drilled and trenched in the 1970s and 1990s returning some high grade Au-Ag assays. Aaron Mines Ltd. drove a short adit in 1979-80.

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. Giant Copper (Imperial Metals Corporation)

Imperial reported results of 2017 trenching that followed sampling in 2016, which delineated a 250 x 400 m gold in soil anomaly. Two perpendicular trenches had weighted average gold values of 12.8 g/t Au over 10 m and 9.8 g/t Au over 8 m in continuous channel samples. The company has a Notice of Work for drilling in process.

Elsewhere on the property, a 2006 resource estimate for the Invermay zone describes 17,532,570 tons 0.226% Cu, 0.011 oz/t Au and 0.310 oz/t Ag Indicated. Giant Copper also has historical resources for the AM breccia zone. The open-pit estimate is 29,523,030 tons 0.653% Cu, 0.11 oz/t Au, 0.360 oz/t Ag, 0.007% Mo. The historical underground estimates are 2,565,200 tons 1.223% Cu, 0.017 oz/t Au, 0.626 oz/t Ag, 0.005% Mo and 1,234,500 t 1.155% Cu, 0.013 oz/t Au, 0.682 oz/t Ag, 0.024% Mo historical inferred (non-compliant).

7.2.2. Le Mare Lake (Le Mare Gold Corp.)

Le Mare Gold released a technical report recommending mapping, sampling, and a small initial drill program. This was completed, with 300.5 m in 2 holes at a coincident EM and gold-in-soil anomaly. Since the late 1960s the area was explored intermittently for porphyry mineralization similar to a cluster of deposits near the past producing Island Copper mine (see Pemberton Hills, below). This remains the primary target.

7.2.3. Pacific Copper (Vancouver Island Iron Ore Corporation)

Vancouver Island Iron Ore, a subsidiary of Canadian Dehua International Mines Group Inc. reported airborne geophysics at **Pacific Copper**. Previously reported mineralization in the area includes copper-bearing veins and copper skarn mineralization. The WWW Au-Ag-Cu-Pb-Zn-vein past producer lies to the west and the Columbia Shear property lies to the east. The area is mainly underlain by basaltic volcanic rocks and lesser carbonate rocks of the Vancouver Group, that are cut by Island Plutonic suite diorite, quartz diorite and feldspar porphyry. Bonanza Group rocks are also mapped in fault contact with the Island Plutonic suite.

7.2.4. Pemberton Hills (Northisle Copper and Gold Inc. 35%; Freeport-McMoRan Mineral Properties Canada Inc. 65%)

In the Island Copper belt on northern Vancouver Island, 2018 work focussed on the early-stage Pemberton Hills area, under option to Freeport McMoRan. In addition to an IP survey, they drilled 3400 m in 6 holes. The target is a 1.5 x 3.5 km area of advanced argillic alteration (Figs. 3, 4). Historically, drilling has encountered anomalous copper about 200 m deep, suggesting there may be blind porphyry copper mineralization at depth. Several porphyry copper and epithermal gold targets extend along a 40 km west-northwest trend from Island Copper. Among these are the more-advanced Hushamu and Red Dog deposits to the west. Hushamu has an Indicated 304,000,000 t of 0.21% Cu, 0.29 g/t Au, 0.010% Mo, and 0.56 ppm Re and Inferred 205,600,000 t 0.18% Cu, 0.26 g/t Au, 0.008% Mo and 0.38 ppm Re. Red Dog has 23,633,000 t at 0.32% Cu, 0.46 g/t Au and 0.007% Mo Indicated and 848,000 t at 0.23% Cu, 0.33 g/t Au and 0.003% Mo Inferred. The Red Dog and Hushamu resources together were subject of a 2017 preliminary economic assessment. The Island Copper mine produced 345 Mt with average head grades of 0.41% Cu, 0.017% Mo, and 0.19 g/t Au between 1971 and 1994. Alteration similar to that observed at higher levels of these nearby deposits is well known in the Pemberton Hills area, but similar mineralization has not yet been discovered.

7.3. Selected polymetallic base and precious metal projects

With the exception of a program at Myra Falls, volcanogenic massive sulphide deposits in the southwest saw limited exploration in 2018.

7.3.1. Jasper (Nitinat Minerals Corporation)

Nitinat reports geological mapping and lithogeochemistry in 2018. This follows re-interpretation of existing geophysical data in 2017.



Fig. 3. The Pemberton Hills area. The hill in the centre of the field is being mined for silica-rich and clay-rich altered volcanic rock. Hills are resistant silicic caps over an area of intense hydrothermal alteration. The possibility of mineralization at depth has prompted speculation, but limited exploration until 2018.



Fig. 4. Advanced argillic alteration is common in the Pemberton Hills area where rocks are exposed. Historical drilling encountered anomalous copper at depth.

7.3.2. Lara (Treasury Metals Inc.)

Treasury Metals carried out a lidar and orthophoto survey at the **Lara** in 2018. The high forest fire hazard during the summer delayed further work.

7.4. Industrial minerals, jade, and aggregates

Exploration for industrial minerals and aggregates is commonly carried out by individuals and private companies and typically goes unreported. Of the more than 600 quarry and sand and gravel operations with active permits not all are currently producing or conducting investigative work.

7.4.1. Wahleach Creek (Inua Studio)

Inua Studio is exploring and trenching a jade occurrence in ultramafic rocks mapped as Yellow Aster complex near the Washington Border. They have obtained nephrite samples up to A- grade.

8. Summary

A restart project at Myra Falls that began in 2017 continued in 2018, including a substantial exploration effort. Although the footprint of the operation is geographically constrained by park boundaries, Nyrstar and previous operators have demonstrated the ongoing exploration potential of the Myra Falls camp. Production of concentrate ramped up through the second half of the year. Quinsam coal mine continued to produce after a shut down in 2016 and re-start in 2017 under new ownership. Resource areas could augment reserves for many years.

Away from mine sites, the level of exploration in the southwest remains low, as has been typical of recent years. Exceptions were in areas of high mineral potential that appear under-explored by modern methods and where communities generally welcome industry: Pemberton Hills, the Zeballos camp and Coquihalla gold belt. Grass roots work on the central coast and a recent discovery at Giant Copper point to potential for discovery in both unexplored and established camps.

Industrial minerals and aggregates remain the backbone of the mining industry in the southwest. Recent years have seen a trend toward consolidation in the hands of major international construction materials companies with large operations.

Acknowledgments

Thanks to those in industry who generously provided information and access to their properties. Inwon Nteogwuija drafted Figure 1. Gordon Clarke provided editing.

References cited

- Brandon, M.T., 1989. Deformational styles in a sequence of olistostromal mélanges, Pacific Rim Complex, western Vancouver Island. Geological Society of America Bulletin, 101, 1520-1542.
- Bustin, A.M.M., Clowes, R.M., Monger, J.W.H., and Journeay, J.M., 2013. The southern Coast Mountains, British Columbia: New interpretations from geological, seismic reflection, and gravity data. Canadian Journal of Earth Sciences, 50, 1033-1050.
- Clague, J.J., and Ward, B., 2011. Pleistocene glaciation of British Columbia. Developments in Quaternary Science. Vol. 15, Chapter 44, 563-573.
- DeGrace, J.R., 2019: Exploration and mining in the North Central and Northeast regions, British Columbia. In: Provincial Overview of Exploration and Mining in British Columbia, 2018. British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey, Information Circular 2019-01, pp. 39-56.
- Ernst & Young LLP (EY), 2019, in press. British Columbia Mineral and Coal Exploration Survey 2018 Report. http://www.ey.com/ca/en/industries/mining---metals/bc-mineral-and-coal-exploration-survey
- Groome, W.G., Thorkelson, D.J., Friedman, R.M., Mortensen, J.K., Massey, N.W.D., Marshall, D.D., and Layer, P.W., 2003. Magmatic and tectonic history of the Leech River Complex, Vancouver Island, British Columbia: Evidence for ridge-trench intersection and accretion of the Crescent Terrane. In: Sisson, V.B., Roeske, S.M., and Pavlis, T.L. (Eds.), Geology of a Transpressional Orogen Developed During Ridge-Trench Interaction Along the North

Pacific Margin. Geological Society of America Special Paper 371, pp. 327-353.

Howes, D.E., 1983. Late Quaternary sediments and geomorphic history of northern Vancouver Island, British Columbia. Canadian Journal of Earth Sciences, 20, 57-65.

Madsen, J.K., Thorkelson, D.J., Friedman, R.M., and Marshal, D.D., 2006. Cenozoic to Recent plate configurations in the Pacific Basin: Ridge subduction and slab window magmatism in Western North America. Geosphere, 2, 11-34.

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

Manor, M.J., Wall, C.J., Friedman, R.M., Gabites, J., Nixon, G.T., Scoates, J.S., and Ames, D.E., 2015. Geology, geochronology and Ni-Cu-PGE orebodies of the Giant Mascot ultramafic intrusion, Hope, southwestern British Columbia. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey, Geoscience Map 2015-01. scale 1:10,000.

Manor, M.J., Scoates, J.S., Nixon, G.T., and Ames, D.E., 2016. The Giant Mascot Ni-Cu-PGE deposit, southwestern British Columbia: mineralized conduits and sulphide saturation mechanisms in a convergent margin tectonic setting. Economic Geology, 111, 57-87.

Manor, M.J., Scoates, J.S., Wall, C.J., Nixon, G.T., Friedman, R.M., Amini, M., and Ames, D.E., 2017. Age of the Late Cretaceous ultramafi c-hosted Giant Mascot Ni-Cu-PGE deposit, southern Canadian Cordillera: Integrating CA-ID-TIMS and LA-ICP-MS U-Pb geochronology and trace element geochemistry of zircon. Economic Geology, 112, 1395-1418.

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

Monger, J.W.H., and Brown, E.H., 2016. Tectonic Evolution of the southern Coast-Cascade orogen, northwestern Washington and southwestern British Columbia. In: Cheney, E.S., (Ed.), Rocks, Fire and Ice: The Geology of Washington, University of Washington Press, pp. 101-130.

Monger, J.W.H., and Struik, 2006. Chilliwack terrane: A slice of Stikinia? A tale of terrane transfer. In: Haggart, J.W., Enkin, R.J., and Monger, J.W.H., (Eds.), Paleogeography of North American Cordillera: Evidence for and Against Large-Scale Displacements. Geological Association of Canada Special Paper 46, 351-368.

Monger, J.W.H., van der Heyden, P., Journeay, J.M., Evenchick, C.A., and Mahoney, J.B. 1994. Jurassic-Cretaceous basins along the Canadian Coast Belt – Their bearing on pre-mid-Cretaceous sinistral displacements. Geology 22, 2, 175-178.

Mustard, P.S., 1994. The Upper Cretaceous Nanaimo Group, Georgia Basin. In: Geology and Geological Hazards of the Vancouver Region, Southwestern British Columbia. Edited by Monger, J.W.H. (Ed.), Geological Survey of Canada, Bulletin 481, 27-95.

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

Nixon, G.T., and Orr, A.J., 2007. Recent revisions to the Early Mesozoic stratigraphy of northern Vancouver Island (NTS 102I; 092L) and metallogenic implications, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Geological Fieldwork 2006, pp. 163-177.

Northcote, B., 2018. Exploration and mining in the Southwest Region, British Columbia. In: Provincial Overview of Exploration and Mining in British Columbia, 2017. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey, Information Circular 2018-1, pp. 133-147.

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