

# Exploration and mining in the North Central and Northeast regions, British Columbia



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## 1. Introduction

From northeast to southwest, a transect from the Northeast Region through the North Central Region provides a cross section from undeformed rocks deposited above Precambrian basement to allochthonous terranes accreted to Ancestral North America (Fig. 1). Platformal sedimentary rocks in the Northeast Region transition to deep-water basinal strata as the eastern limit of Cordilleran deformation is approached, close to the border of the North Central Region. The North Central Region shows a history of ocean opening and closing, island arc volcanism, and terrane accretion onto the western margin of Ancestral North America. Terrane emplacement was followed by continued orogeny, magmatism and sedimentation. Both regions were extensively glaciated.

The Northeast Region is prospective for coal and industrial minerals and, at present, has three producing coal mines, Conuma Coal Resources Limited's **Wolverine** (Perry Creek), **Brule**, and **Willow Creek** operations, two mines on care and maintenance status, and several major coal projects. In the far north of the region, Fireside Minerals Ltd. produces barite from its **Fireside** mine to supply the oil and gas drilling industry.

The North Central Region is prospective for Cu, Au, Ag, Zn, Pb, specialty metals, and rare earth elements, mostly in porphyry, vein and stockwork, SEDEX, and carbonatite settings. The **Mt. Milligan** Cu-Au operation (Centerra Gold Inc.) is the only producing mine in the region. Also owned by Centerra Gold Inc., the **Kemess Underground** project (porphyry Cu-Au) received its Mines Act permit in 2018. Graymont Western Canada Inc. applied for a Mines Act permit for its **Giscome** project. The **Blackwater** epithermal Au-Ag project (New Gold Inc.) remained in mine evaluation status, as did Taseko Mines' **Aley** niobium (carbonatite) project (Fig. 1).

Significant mine lease exploration programs in 2018 included on-lease drilling at each of the **Willow Creek**, **Brule**, and **Wolverine** mines in the Northeast Region, and at the Mt. Milligan mine in the North Central Region. The regions also saw numerous other exploration projects: five grassroots; 23 early stage; three advanced stage; and two mine evaluation stage (Fig. 1). At one of the grassroots projects (**AK**), a few km north of Prince George, an orogenic Au prospect was

discovered. Exploration diamond drilling was undertaken at 15 projects, the most significant of which occurred on- and off-lease at Centerra Resources' **Mt. Milligan** mine, at Serengiti Resources' **Kwanika** project, and at Sun Metals' nearby **Stardust** project. Significant coal exploration drilling was completed by Atrium Coal Limited at its **Panorama North** project.

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 North Central Region, exploration expenditures were estimated at \$32.7 million and exploration drilling was estimated at approximately 69,100 m. For the Northeast Region exploration expenditures were estimated at \$6.3 million and exploration drilling was estimated at approximately 15,000 m (Clarke et al., this volume: Ernst & Young LLP (EY), 2019, in press).

## 2. Geological overview

The Canadian Cordillera records a protracted history of supercontinent rifting followed by collisions between the westward-driven North American continental plate and a succession of island arc volcanosedimentary and intrusive assemblages (terranes), developed outboard of Ancestral North America and accreted to each other and to the continental margin (e.g., Nelson et al., 2013). Terrane evolution continues today as the Juan de Fuca plate slides beneath Vancouver Island.

In the Northeast and Central regions, the most easterly rocks are platformal sedimentary units that thicken westward and transition to deep-water basin strata. These rocks are deformed mainly by eastward-vergent thrust faults and folds along northwest-southeast trends. The Rocky Mountain trench marks the site of about 800 km of post-accretion dextral strike slip along the Tintina fault system.

Deformed deep-water basin sedimentary rocks immediately west of the Rocky Mountain Trench are referred to as the Cassiar terrane (Fig. 1). Outboard of the Cassiar terrane is a group of volcanic assemblages referred to (roughly from

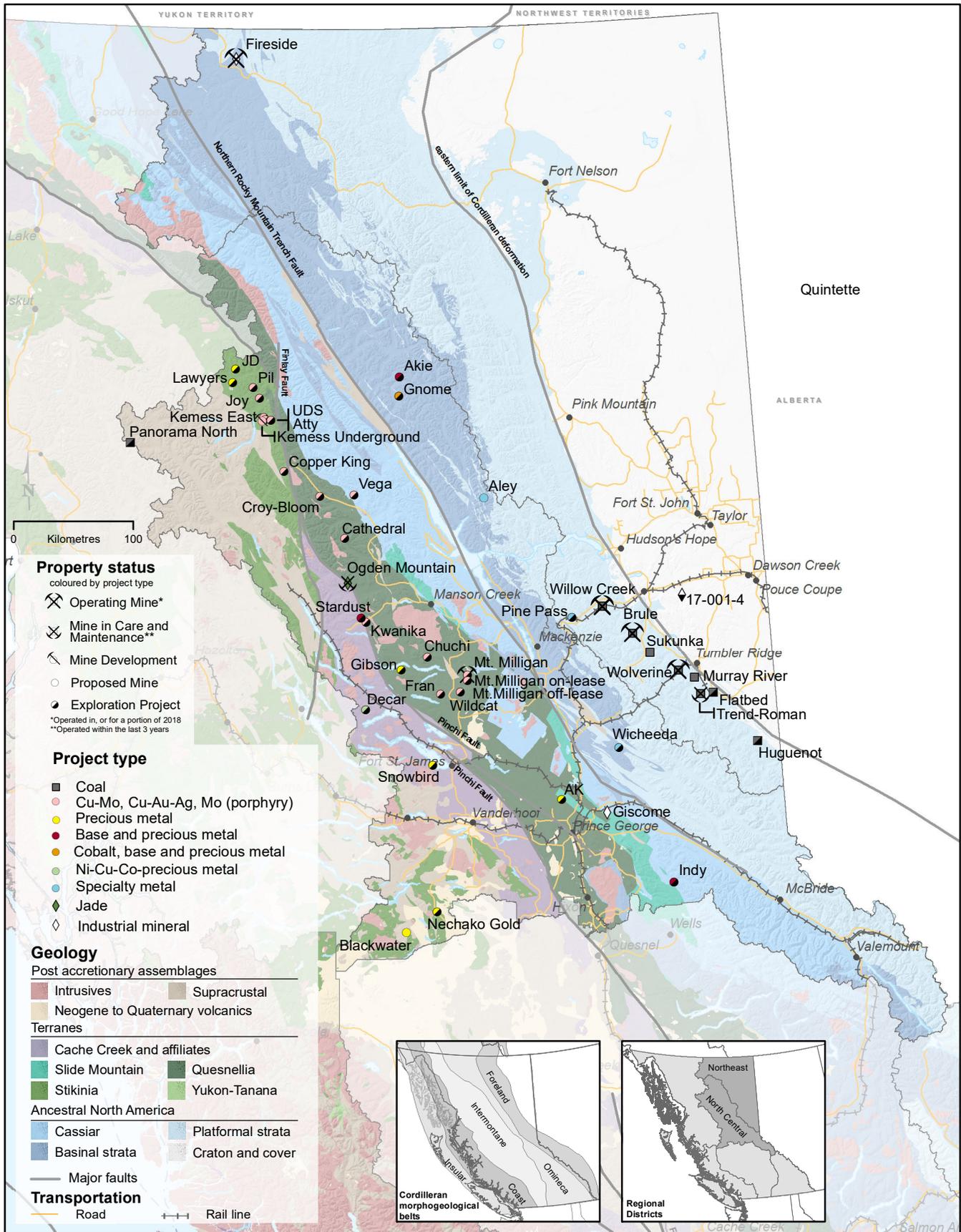


Fig. 1. Mines and selected exploration projects, North Central and Northeast regions, 2018. Terranes after Nelson et al. (2013).

east to west) as the Slide Mountain terrane, the Quesnel and Stikine terranes (Quesnellia and Stikinia), and the Cache Creek terrane. The Cache Creek terrane is separated from Quesnellia by another major crustal break, the Pinchi fault, along which areas of ultramafic rocks are locally exposed. These terranes are intruded by intermediate to felsic plutonic and volcanic rocks, and are in turn overlain by later sedimentary and volcanic rocks.

Mineral deposit types and distributions are intimately related to the geologic evolution of the terranes (e.g., Nelson et al., 2013; Jago, 2017). Thus, platformal rocks deposited above Ancestral North America host coal and potash deposits, and postaccretionary sedimentary rocks overlying the Stikine terrane host coal deposits. Deep-water basin strata host SEDEX and Mississippi Valley-type lead-zinc deposits, and are intruded by carbonatite bodies hosting niobium and rare earth elements (REE). The island arc assemblages of Quesnellia and Stikinia host the known large polymetallic porphyry and orogenic precious metal deposits in the region.

Both regions were extensively glaciated during successive Quaternary glacial periods (e.g., Hickin et al., 2017). Glaciation resulted in significant topographic modification so that, especially in mountainous areas, glacial valleys, cirques and arêtes, and attendant surficial deposits are widespread. In the Interior Plateau, till thicknesses commonly extend to several metres. Glaciofluvial deposits are widespread; glaciolacustrine deposits are in some low lying areas, such as near the confluence of the present day Nechako and Fraser Rivers.

### 3. Mines and quarries

#### 3.1. Metal mines

In 2018, **Mt. Milligan** (Cu-Au), wholly-owned by Centerra Gold Inc., was the only producing metal mine (Table 1). In July 2018, the company received a Mines Act Permit for its Kemess Underground project in the Toodoggone area.

##### 3.1.1. Mt. Milligan (Centerra Gold Inc.)

The **Mt. Milligan** mine, in the Quesnel terrane (Fig. 1), is hosted by mafic to intermediate volcanic and pyroclastic rocks of the Takla Group (Triassic to Lower Jurassic) that are intruded by Lower Jurassic monzonite porphyry stocks. The ore body (2500 x 1500 m) is a silica-saturated alkalic porphyry deposit in which Cu-Au (with accessory Ag) mineralization is

in sulphides. The deposit consists of two principal zones. At the Main zone, mineralization is mainly in volcanic rocks; at the Southern Star zone, mineralization is in a monzonite stock and volcanic rocks.

The mine was commissioned in 2013, and by 2016 was up to its full design capacity of 60,000 td. In 2018, Centerra was well established in its Phase 3 mining operation (Fig. 2) and was moving on to Phase 4. Ore is initially processed through primary and secondary crushers, before milling and flotation in a 62,500 tpd design capacity concentrator (Fig. 3). Mill feed throughput in 2017 was forecast to be 59,600 tpd, and for 2018 to be 60,700 tpd (Andrews et al, 2017) but, early in 2018,



Fig. 2. Mt. Milligan mine open pit: Phase 3 blast area.



Fig. 3. Mt. Milligan mine concentrator; tailings ponds in background.

Table 1. Metal mines, North Central and Northeast regions.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2018 Production (based on Q1-Q3)	Reserves	Resource	Comments
<b>Mt. Milligan</b>	<b>Centerra Gold Inc.</b> (Centerra B.C. Holdings)	Cu, Au, Ag; alkalic porphyry Cu-Au; 093N 194, 191	40-47 Mlbs Cu 175-195 Koz Au	P: 236.5 Mt at 0.187% Cu and 0.424 g/t Au Pr: 239.4 Mt at 0.188% Cu and 0.293 g/t Au	M+I: 243.9 Mt at 0.16% Cu and 0.2 g/t Au (additional to reserves)	Concentrator design capacity 62,500 tpd. Estimated mine life 22 years. More than 350 employees.

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

water shortages forced the mill to be closed temporarily. The concentrate, averaging about 23% Cu, is moved by truck to Mackenzie, where it is transferred to rail cars and shipped to North Vancouver for transport to markets. Combined Measured and Indicated Mineral resources are 243.9 Mt at 0.134% Cu and 0.226 g/t Au containing 717.7 MLb of Cu and 1.77 Moz of Au (Andrews et al., 2017). In 2017, Proven and Probable reserves decreased to 468 Mt at 0.3 g/t Au from 496.2 Mt at 0.4 g/t reported in 2016. Average annual payable production forecast for 2017-2019 is 76.8 MLb of Cu and 253,700 oz of Au, and the estimated mine life is 22 years (Andrews et al., 2017). In 2018, the company undertook near-pit infill and expansion drilling, with 52 holes totalling 19,250 m to explore below depths drilled previously.

### 3.2. Coal mines

Having acquired three open-pit metallurgical coal mines from Walter Energy Canada Holdings Inc. in 2016, Conuma Coal Resources Ltd. is producing from the **Willow Creek** mine (Table 2; Fig. 4, reopened in July 2018), the **Wolverine** mine (reopened in January 2017), and the **Brule** mine (reopened in late 2016).

#### 3.2.1. Willow Creek mine (Conuma Coal Resources Ltd.)

Conuma Coal began ramping-up production at its **Willow Creek** mine in July 2018 (Fig. 5), and by year-end had produced an estimated 482,000 t of hard coking coal and pulverized coal injection (PCI) product. In 2018, the Company completed a major on-lease drilling project to both define and expand the mineable resource. Drilling was completed in 27 diamond drill holes (totalling 3680 m) and 10 reverse circulation holes (totalling 1023 m), all of which were geophysically logged.

#### 3.2.2. Brule mine (Conuma Coal Resources Ltd.)

Production continued at Conuma's **Brule** mine, from which about 2.47 Mt ROM of premium ultra-low volatile PCI metallurgical coal was released from three seams in the lower part of the Gething Formation (Cretaceous; Bullhead Group). The coal is contained in variably dipping folded and thrust faulted rocks. The coal product is moved by rail to the wash plant at the Willow Creek mine site before being shipped by rail for export at Ridley Terminal in Prince Rupert. Late in November the company began drilling to further develop the coal resource, with a planned 35 rotary holes totalling about 8000 m, all of which were to be surveyed and geophysically logged.

#### 3.2.3. Wolverine (Perry Creek) mine (Conuma Coal Resources Ltd.)

The **Perry Creek** mine, within the larger Wolverine project area, produces medium-volatile bituminous hard coking coal (HCC) from the Gates formation in the Fort St. John Group (Cretaceous). Coal from the mine is trucked to Conuma's rail facility at the Brule mine, where it is loaded for rail transport to the company's wash plant at Willow Creek. Reserves at Perry Creek, at 6.9 Mt, are the smallest of Conuma's three mines. Opportunities for open-pit expansion are limited but the company began an on-lease exploration program of about 4 drill holes in December 2018, to begin setting the parameters for underground mining.

### 3.3. Industrial mineral mines and quarries

In 2018, only one industrial mineral producer, Fireside Barite, was in operation in the Northeast Region. In the North Central Region, Green Mountain Jade Inc.'s Ogden Mountain mine was on care and maintenance (Fig. 1; Table 3).

**Table 2.** Coal mines, North Central and Northeast regions.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2018 Production (based on Q1-Q3)	Reserves	Resource	Comments
<b>Willow Creek</b>	<b>Conuma Coal Resources Limited</b>	HCC, PCI; bituminous coal; 093O 008	482,000 t ROM	P: 16.1 Mt saleable	na	About 220 employees, mine and plant. Restart began in July 2018. On-lease exploration program to extend resource base.
<b>Brule</b>	<b>Conuma Coal Resources Limited</b>	PCI; bituminous coal; 093P 007	2.47 Mt ROM	P: 14.8 Mt saleable	na	About 230 employees. November 2018, began on-lease exploration program to extend resource base.
<b>Wolverine (Perry Creek)</b>	<b>Conuma Coal Resources Limited</b>	HCC; bituminous coal; 093P 025	1.89 Mt ROM	P: 6.9 Mt saleable	na	About 300 employees, mine and plant. December 2018, began on-lease drill program to help set the parameters for underground mining.

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

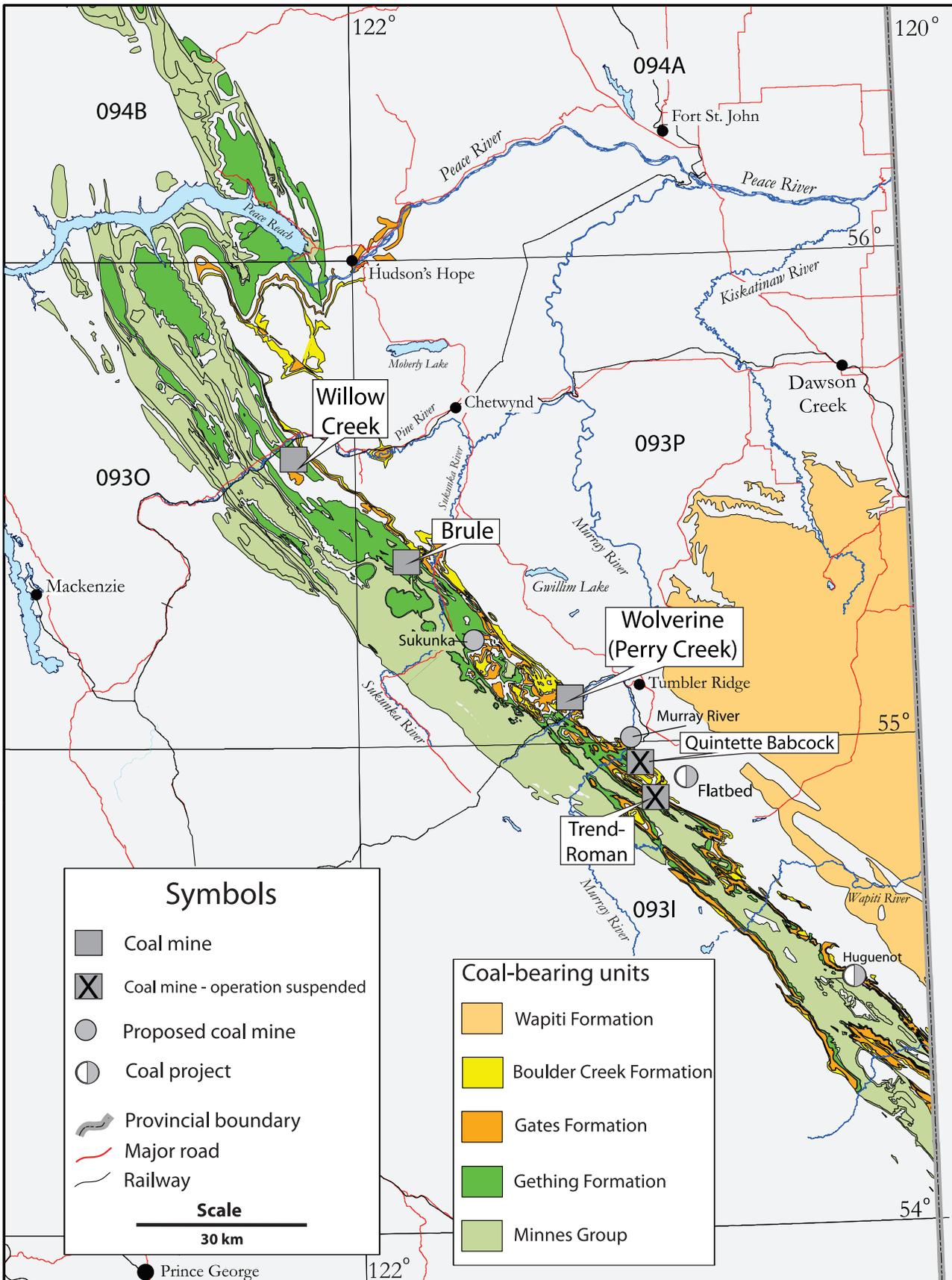


Fig. 4. Coal mines and exploration projects, northeastern British Columbia, 2018. From British Columbia Geological Survey (2019).



Fig. 5. Willow Creek Mine, shovel, haul truck and blasthole drill.

### 3.3.1. Fireside Barite (Fireside Minerals Ltd.)

Fireside Minerals Ltd. quarries massive white barite from veins cutting Paleozoic sedimentary rocks of the Kechika Group near the Yukon border. The barite veins are steeply dipping, trend north to northeast, and have a combined true thickness of 6.5 m. Barite concentrations in the veins range from 96.0 to 99.4% BaSO<sub>4</sub>. The product is bagged and trucked to Fort St. John and to Alberta, where it is used to produce high-density drilling mud. In 2018, production amounted to an estimated 30,000 t from the Moose Pit, which opened in 2016.

## 4. Placer operations

Placer exploration is a widespread activity in parts of British Columbia, and permits are required only when surface disturbance is proposed. In 2018, 98 placer gold operations were approved in British Columbia, 26 of which were in the North Central Region. These were distributed primarily in the Manson Creek, Fort St. James to Mackenzie, and Hixon areas, with total surface disturbance estimated at 20.45 ha. Larger scale operations are generally sited on abandoned stream channels and benches, and use backhoes and hydraulic excavators to extract gravel, which is then processed through a wash plant, either on-site or at a remote location. These paleochannels do not necessarily follow modern drainage patterns.

## 5. Mine or quarry development

One mine is under development in North Central and Northeast regions. Centerra Gold's **Kemess Underground** project, which received Mines Act approval in 2018, is in the earliest stage of construction.

### 5.1. Kemess Underground (Centerra Gold Inc.)

The **Kemess Underground** (KUG) project is a calc-alkaline porphyry Cu-Au-Ag deposit in the North Central Region. The deposit comprises a low-grade ore zone at a depth of 150 m on its western flank; and a higher grade zone, at 300 m depth, 550 m to the east. KUG is hosted by a porphyritic monzodiorite/diorite pluton and related dikes that intrude potassically altered Takla Group volcanic rocks and Black Lake plutonic rocks. Secondary biotite alteration in the volcanic rocks and the eastern plutonic rocks characterize the higher grade Cu-Au mineralization.

In a technical report issued in July 2017, KUG was estimated to contain 246.4 Mt of Indicated resource containing 1.195 Mlbs of Cu, 3.3 Moz of Au, and 13.9 Moz of Ag. Within this resource are Probable reserves of 107.4 Mt containing 629.6 Mlbs of Cu, 1.9 Moz of Au and 6.7 Moz of Ag.

In July 2018, a Mines Act permit for KUG was issued and by the end of September the North Tunnel portal was complete. Excavation was underway at the South Portal entrance and a nearby staging area was nearly complete, with the adit itself to be started in early 2019. Mine startup is anticipated in about 2022. During the construction period the project will provide about 575 jobs, dropping to about 475 with the start of mining operations.

The former **Kemess South** (KS) mine closed in 2011. However, KS infrastructure remains in place, and both the camp and ore processing plant will be used to service the newly developed mine, which is about 6.5 km north of the KS processing plant. KUG is considered a stand-alone operation, to be mined by panel caving with crushed ore conveyed underground to the process plant. **Kemess East** (KE), about 1 km east of KUG, is also being treated as a stand-alone underground operation, but will use facilities developed for KUG. Waste rock and tailings from KUG will be placed in the

Table 3. Selected industrial mineral mines and quarries, North Central and Northeast regions.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2017 Production (based on Q1-Q3)	Reserves	Resource	Comments
Fireside (Northeast Region)	Fireside Minerals Ltd.	Barite; vein barite; 094M 003, 19	30,000 t	P+Pr: 475,000 t (non NI 43-101 compliant)	na	Mined from the Moose Pit, with possible extension to north.
Ogden Mountain (North Central Region)	Green Mountain Jade Inc.	Nephrite jade; jade; 093N 156, 157, 165	na	na	na	Placed on care and maintenance in late 2017.

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

KS open pit modified by a 25 m high dam, along with a small amount of KE tailings. Non-acid generating tailings from KE would be placed in dry-stack storage.

## 6. Proposed mines or quarries

Two mines were at the proposal stage in 2018: **Blackwater** (New Gold Inc.), and **Aley** (Taseko Mines Ltd.). Aley saw significant drilling activity in 2018, and Blackwater plans drilling in 2019. In the Northeast Region, the **Murray River** (HD Mining International Ltd.) and **Sukunka** (Glencore Canada Corporation and JX Nippon Oil and Energy Corporation) coal projects are proposed for development, with Murray River having its Mines Act approval in place. Graymont Western Canada's **Giscome** limestone quarry is the sole significant industrial mineral proposal.

### 6.1. Proposed metal mines

There are two proposed metal mines, New Gold Inc.'s **Blackwater** Au-Ag project and Taseko Mines Ltd.'s **Aley** niobium project (Fig. 1; Table 4).

#### 6.1.1. Blackwater (New Gold Inc.)

The **Blackwater** project is accessible by existing roads, but development would require construction of a 140 km transmission line from a substation south of the community of Endako. Proven reserves stand at 124.5 Mt at 0.95 g/t of Au and 5.5 g/t of Ag. As proposed, Blackwater would be a 60,000 tpd operation with a 17-year mine life. The mine operation, once completed, would consist of an open pit, ore processing facility, waste rock dump, tailings pond, water management facilities, offices, employee accommodations, warehouses, and a truck shop.

The Blackwater deposit is hosted by a sequence of intermediate to felsic volcanic rocks in the Kasalka Group (Upper Cretaceous; the Stikine terrane). In this intermediate sulphidation, epithermal system, the host rocks are pervasively hydrofractured and sericitized, and sulphides include pyrite, sphalerite, marcasite and pyrrhotite. These occur as disseminations and pore fillings, which are strongly controlled by a set of northeast- and northwest-trending faults.

In 2018, New Gold continued advancing its environmental assessment process and coordinated with both federal and provincial governments, with the aim of meeting the requirements for Environmental Assessment Certificate (EAC) from the Province of British Columbia, and a Decision Statement from the federal Minister of the Environment. In November 2018, the Canadian Environmental Assessment Agency began a 30-day public and indigenous comment period on its draft Environmental Assessment report. New Gold continued collecting baseline data, completed additional soil and till sampling, and undertook geotechnical work related to mine design.

New Gold plans a major drilling program of up to 75,000 m over five years to extend the known resource and to collect material for metallurgical studies.

#### 6.1.2. Aley (Taseko Mines Ltd.)

Taseko Mines Ltd.'s wholly-owned **Aley** niobium-bearing carbonatite project is near the western extremity of platformal strata. The dolomite carbonatite intrusion (with minor calcite carbonatite) is oval in map view, measuring about 2.0 x 2.8 km. Within that body, reserves stand at 84 Mt grading 0.5% of Nb<sub>2</sub>O<sub>5</sub>. An open-pit mine is proposed, processing 10,000 tpd and producing ferroniobium. The projected mine life is 24 years with an output of about 9 Mkg of niobium annually, making it among the largest niobium deposits in the world. Environmental assessment is underway. In 2018, Taseko completed 25 drill holes at Aley, sited within the perimeter of previous exploration drilling and totalling 2700 m, to collect material for further metallurgical testing.

### 6.2. Proposed coal mines

HD Mining International's **Murray River** project received its Mines Act approval in 2018 and awaits a final investment decision. Progress on Glencore's **Sukunka** project was suspended pending the resolution of environmental concerns.

#### 6.2.1. Murray River (HD Mining International Ltd.)

**Murray River** is a proposed underground mine that would extract metallurgical coal from the Gates Formation (Table 4). In 2015 HD Mining International Ltd. had completed bulk sampling for testing coal quality, processing, and marketability. Earlier concerns about the potential of impact on the Quintette herd of Southern Mountain Caribou were addressed and, in April 2018, the company received its Mines Act permit to begin operations. The adit in place at present (driven to collect the bulk sample in 2015, but also to be used for the mining conveyor) descends 1.3 km down a decline (Fig. 6). Two vertical shafts are to be completed, one for moving staff and equipment, and the other for ventilation. HD Mining plans to construct its own wash plant and use existing rail facilities. The project is expected to provide about 764 jobs in direct employment over a 25-year mine life. Chinese miners experienced in longwall methods would start production, but



Fig. 6. Portal to HD Mining International's Murray River mine.

**Table 4.** Proposed mines and quarries, North Central and Northeast regions.

<b>Project</b>	<b>Operator (partner)</b>	<b>Commodity; deposit type; MINFILE</b>	<b>Reserves</b>	<b>Resource</b>	<b>Comments</b>
<b>Aley</b> (North Central Region)	<b>Taseko Mines Ltd.</b>	Nb; carbonatite-hosted deposit; 094B 027	P+Pr: 83.8 Mt at 0.50% Nb <sub>2</sub> O <sub>5</sub> (at 0.30% Nb <sub>2</sub> O <sub>5</sub> cut-off)	M+I: 285.8 Mt at 0.37% Nb <sub>2</sub> O <sub>5</sub> (at 0.20% Nb <sub>2</sub> O <sub>5</sub> cut-off)	Proposed open-pit mine with 10,000 tpd ore processing rate and average annual production of 9000 t niobium over a 24-year mine life. In 2018, completed 24 boreholes, 2700 m total for metallurgical testing.
<b>Blackwater</b> (North Central Region)	<b>New Gold Inc.</b>	Au, Ag; epithermal Au-Ag-Cu (intermediate sulphidation); 093F 037	P: 124.5 Mt at 0.95 g/t Au, 5.5 g/t Ag, containing 3.79 Moz Au, 22.1 Moz Ag. Pr: 169.7 Mt at 0.68 g/t Au, 4.1 g/t Ag, containing 3.73 Moz Au, 22.3 Moz Ag	M: 117 Mt at 1.04 g/t Au, 5.6 g/t Ag containing 3.90 Moz Au, 21.06 Moz Ag. I: 189 Mt at 0.78 g/t Au, 6.0 g/t Ag, containing 4.73 Moz Au, 36.47 Moz Ag, additional to reserves	Environmental Assessment (under review), engineering and environmental studies. Proposed open-pit mine with 60,000 tpd ore processing rate and life-of-mine average annual production of 12.8 t (413 Koz) Au and 54.2 t (1.74 Moz) Ag over a 17-year mine life.
<b>Giscome</b> (North Central Region)	<b>Graymont Western Canada Inc.</b>	CaCO <sub>3</sub> ; limestone; 093J 041, 25	na	I: >100 Mt of limestone (>95% calcium carbonate, <5% magnesium carbonate) in situ	Environmental Assessment under review. Proposed 600,000 tpy limestone quarry to feed a vertical lime kiln producing 198,000 t of lime annually over a 50+ year mine life.
<b>Kemess Underground (KUG)</b> (North Central Region)	<b>Centerra Gold Inc.</b>	Cu, Au, Ag; porphyry Cu±Mo±Au; 094E 021	Pr: 107.38 Mt at 0.27% Cu, 0.54 g/t Au, 1.99 g/t Ag; containing 285.6 Kt (629.6 Mlbs) Cu, 58.1 t (1.87 Moz) Au, 214 t (6.88 Moz) Ag	I: 246.4 Mt at 0.22% Cu, 0.42 g/t Au, 1.75 g/t Ag; containing 542.2 Kt (1195 Mlbs) Cu, 103 t (3.33 Moz) Au, 431.3 t (13.87 Moz) Ag; inclusive of reserves	Mine permit approved July 2018. Mine start-up estimated for 2022. Proposed underground panel cave mine with 24,600 tpd ore processing rate and life-of-mine average annual production of 3.30 t (106,000 oz) Au and 21 Kt (47 Mlbs) Cu over a 12-year mine life.
<b>Murray River</b> (Northeast Region)	<b>HD Mining International Ltd.</b>	Coal; bituminous; 093I 035	P: 261.6 Mt mineable coal	M+I: 314.2 Mt coal in situ; Inf: 373.9 Mt coal in situ	Provincial and Federal EA certificates in place. Mine plan and reclamation program approved April 2018. Would produce 6 Mtpy from two longwall faces over 25-year mine life with 764 direct jobs.
<b>Sukunka</b> (Northeast Region)	<b>Glencore Canada Corporation</b>	Coal; bituminous; 093P 014	na	145.0 Mt coal in situ	20+ year mine life at 1.5-2.5 Mt saleable coal per year, 250 permanent jobs once operational.

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

would be replaced within 10 years once Canadian miners are trained. Murray River awaits a final investment decision by HD Mining's parent company, China Huiyong Holdings.

### 6.2.2. Sukunka (Glencore Canada Corporation and JX Nippon Oil and Energy Corporation)

The **Sukunka** project has been planned as both an open-pit and underground operation, extracting coal from the Gething Formation (Table 4). The environmental assessment process was suspended in January 2016, and remains so pending further study on the effects upon caribou and water quality.

## 6.3. Proposed industrial mineral mines or quarries

### 6.3.1. Giscome (Graymont Western Canada Inc.)

At the **Giscome** project in the North Central Region (Fig. 1; Table 4), Graymont Western Canada proposes to exploit a high-purity limestone deposit in basaltic rocks of the Triassic Antler Formation (Slide Mountain Group). Crushed stone would be transported about 5 km by truck to lime kilns at a former stone quarry, owned and operated by CN Rail, in the community of Giscome. An existing CN Rail line would be used for transporting the product.

The environmental assessment review for the project is in place, and the Mines Act Permit process is underway. The company anticipates starting construction in about 2020, with up to 600 Kt of limestone quarried annually. The product would service mining and pulp and paper operations in northern British Columbia. Once in operation, the project would provide about 10 seasonal jobs at the quarry and a further 15 or more at the lime plant, and would remain in production for about 50 years.

## 7. Selected exploration activities and highlights

Exploration projects in 2018 (Tables 5, 6) proceeded at about the same overall level of activity as in the previous year but with some notable additions, including drilling at **Lawyers** (Benchmark Metals Inc.), **Fran** (MGX Minerals Inc.), and **Stardust** (Sun Metals Corp.). Two new greenfield projects were **AK** (Au; Exodus Mineral Exploration Ltd.) and **Pine Pass** ( $V_2O_5$ ; Ethos Gold Corp.)

### 7.1. Selected precious metal projects

Seven significant precious metals projects were underway in 2018, of particular note **Lawyers** (Benchmark Metals Inc.), and **Snowbird** (Gitennes Exploration Corp.). **AK** (Exodus Exploration Ltd.) was a 2018 discovery.

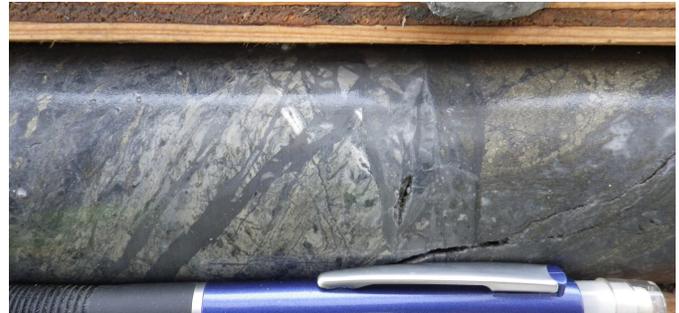
#### 7.1.1. AK (Exodus Mineral Exploration Ltd.)

The **AK** Au prospect was discovered by prospectors Max Keogh and Andreas Angele in early 2018. It consists of a set of quartz veins with associated shear zones, intruding Takla Group volcanic rocks. Grab sampling of veins and shear zones followed clearing of newly exposed bedrock and hand trenching. Ninety-four rock specimens were analyzed, and 126 soil samples were taken. Analysis of one specimen from the

discovery vein returned 8 g/t Au; others contained from 2.0 to 5.5 g/t of Au and low values of antimony. One sample from a shear zone in contact with the 'discovery vein' returned about 3 g/t of Au.

#### 7.1.2. Gibson (CANEX Metals Inc.)

CANEX completed 10 holes totalling 1001 m on this precious metal-bearing vein deposit, nine of which were spaced at roughly 20 m intervals to explore a known resource, and one of which was a 'step out', about 300 m from the others. All holes, and two trenches, were within about 1 km of the Hogem batholith, and targeted Ag mineralization with associated galena. A new zone of quartz-sulphide veins was discovered adjacent to the main Gibson trend. The company reported that drilling intersected multiple quartz-sulphide veins containing pyrite, sphalerite, galena, and minor chalcopyrite, arsenopyrite and sulphosalts (Fig. 7).



**Fig. 7.** Gibson project, hole G18-10, 62.8 m, late-stage very fine grained quartz-sulphide veinlets (dark grey) cutting mineralized Takla Group host rock.

#### 7.1.3. JD (Freeport-McMoRan Mineral Properties Canada Inc.)

**JD** is a low-sulphidation epithermal Au and Ag prospect hosted by a vein, breccia, and stockwork network. The company completed 41.45 line km of IP and 671 line km of airborne magnetometer surveys, and drilled 2 holes totalling 1294 m.

#### 7.1.4. Lawyers (Benchmark Metals Inc.)

The **Lawyers** deposit is a low-sulphidation epithermal vein and stockwork system hosted by Lower Jurassic fragmental volcanic units of the Toodoggone Formation. Benchmark Metals now considers that Lawyers resembles a porphyry-style deposit, with potential for bulk tonnage. In 2018, Benchmark completed a 30 hole, 4116 m exploration drilling program on the Duke's Ridge, Cliff Creek and Phoenix zones. The company also relogged and sent for assay 1051 m of historic mineralized core from the Duke's Ridge and Cliff Creek zones, collected 1041 soil and 312 rock samples for assay, and completed an airborne VTEM survey. Highlight results from new core include 4.36 m at 6.15 g/t Au and 124.37 g/t Ag (hole 18PXDD001) and 3.05 m at 5.62 g/t Au and 292.31 g/t Ag (hole 18CCRC009). The company considers that the Phoenix, Duke's Ridge and Cliffs Creek zones may be connected. Grab samples from the nearby

**Table 5.** Selected exploration projects, North Central Region.

<b>Project</b>	<b>Operator (partner)</b>	<b>Commodity; deposit type; MINFILE</b>	<b>Resource (NI 43-101 compliant unless indicated otherwise)</b>	<b>Comments</b>
<b>17-001 to 17-004</b>	<b>Sil Industrial Minerals Ltd.</b>	Sand and gravel (as frac sand)	na	33 hammer drill and auger holes totalling 200 m.
<b>AK</b>	<b>Exodus Mineral Exploration Ltd.</b>	Au-quartz veins	na	Hand trenching and grab sampling returned up to 8 g/t Au.
<b>Akie</b>	<b>Canada Zinc Metals Corp.</b>	Zn, Pb, Ag; sedimentary exhalative Zn-Pb-Ag; 094F 031	Updated 43-101: I: 22.7 Mt at 8.32% Zn, 1.81% Pb, 14.1 g/t Ag. Inf: 7.5 Mt at 7.04% Zn, 1.24% Pb, 12.9 g/t Ag, all at 5% Zn cut-off	5 holes on Sitka extension of Cardiac Creek zone, 2013 m total, 567 samples taken. All holes intersected mineralization. June PEA proposed 18-year mine life, mine production rate 4000 tpd, 25.8 Mt total mined, initial capital cost \$302.3 million.
<b>Atty</b>	<b>Serengeti Resources Inc.</b>	Cu, Mo, Au; porphyry Cu±Mo±Au	na	Trenching and sampling.
<b>Cathedral</b>	<b>Thane Minerals Inc.</b>	Cu, Au; alkalic porphyry Cu- Au; 094C 018, 48, 72, 109	na	Mapping, sampling, IP.
<b>Chuchi</b>	<b>Centerra Gold Inc.</b>	Cu, Au; alkalic porphyry Cu- Au; 093N 159	I: historic non NI 43-101 compliant: 50 Mt at 0.21- 4.0% Cu, 0.21-0.44 g/t Au (Digger Resources Inc., 1991)	Relogged 17 holes, 3450 m of historic core.
<b>Copper King</b>	<b>Pacific Empire Minerals Corp.</b>	Cu, Au; alkalic porphyry Cu- Au; 094D 004, 149, 150, 151	na	4 RC holes, total 459 m. Significant Cu, Au and Ag assays returned.
<b>Croy-Bloom</b>	<b>Serengeti Resources Inc.</b>	Cu, Au; alkalic porphyry Cu- Au; 094D 015, 25, 094C 039, 156	na	11.5 line-km IP.
<b>Decar</b>	<b>FPX Nickel Corp.</b>	Ni; ultramafic-hosted; 093K 039, 72, 89	2018 I: 1843 Mt at 0.143 DTR (Davis tube recoverable) Ni Inf: 391 Mt at 0.115% DTR Ni, at 0.06% cut-off	Metallurgical study to improve on 2013 results. Announced an updated mineral resource estimate.
<b>Fran</b>	<b>MGX Minerals Inc.</b>	Cu, Au; alkalic porphyry Cu- Au; 093K 108, 093N 207	na	112 line-km IP, 10 holes total 3000 m intersected “numerous zones of late-stage infilling sulphides.”
<b>Gibson</b>	<b>Canex Metals Inc.</b>	Au, Ag, Cu; epithermal Au- Ag-Cu, low sulphidation; 093N 185	na	10 holes total 1001 m. Intersected quartz-sulphide veins up to 2.5 m in thickness.
<b>Gnome</b>	<b>AsiaBaseMetals Inc.</b>	Zn, Pb, Ag; sedimentary exhalative Zn-Pb-Ag; 094F 011, 16	na	Prospecting, mapping, and soil and rock sampling. Anomalous Co, Zn, Mn.
<b>Indy</b>	<b>InZinc Mining Ltd.</b>	Zn, Pb, Ag; sedimentary exhalative Pb-Zn-Ag; 093N 240	na	11 holes total 1271 m. Significant Zn, Pb, Ag intersected.

Table 5. Continued.

<b>JD</b>	<b>Freeport McMoRan Mineral Properties Canada Ltd.</b>	Au, Ag; epithermal vein Au-Ag; 094E 171	na	2 holes, 1294 m, 42.6 line-km IP, 671 line km airborne magnetics.
<b>Joy</b>	<b>Amarc Resources Ltd.</b>	Cu, Mo, Au; porphyry Cu±Mo±Au; 094E 106	na	Completed 3 holes total 1527 m to test coincident IP and geochem anomalies. Airborne mag, 49 line-km IP, 638 talus fine samples for analysis, mapping. Farm-in agreement with Hudbay Mining (Amarc was 2017 operator).
<b>Kemess East</b>	<b>Centerra Gold Inc.</b>	Cu, Mo, Au; porphyry Cu±Mo±Au; 094E 315	I: 113.12 Mt at 0.38% Cu, 0.46 g/t Au, 1.94 g/t Ag, containing 954 Mlb Cu, 1680 Koz Au, 7066 Koz Ag	27 line-km IP on Nugget, Hilda South, Oriobn, Kemess South extension targets. Relogged historic core, revised deposit model.
<b>Kwanika</b>	<b>Kwanika Copper Corp.</b> (65% Serengeti Resources Inc., 35% Daewoo Minerals Canada Corp.)	Cu, Au, Ag; porphyry Cu±Mo±Au; 093N 073	I: Central zone pit: 11.8 Mt at 0.37% Cu, 0.39 g/t Au, 1.07 g/t Ag. Central zone underground: 41.4 Mt at 0.46% Cu, 0.52 g/t Au, 1.36 g/t Ag	21 holes, 7411 m.
<b>Lawyers</b>	<b>Benchmark Metals Inc.</b>	Au, Ag, Cu, Zn; epithermal low sulphidation Au-Ag-Cu; 094E 066	Inf: Cliff Creek North zone, 550 Kt at 4.51 g/t Au, 209.15 g/t Ag; Duke's Ridge zone, 58 Kt at 4.30 g/t Au, 139.13 g/t Ag	30 holes, 4116 m, soil and rock samples, airborne VTEM. Discovered two new zones, Marmot and Phoenix East.
<b>Mt. Milligan on-lease (brownfield)</b>	<b>Centerra Gold Inc.</b>	Cu, Au, Ag; alkalic porphyry Cu-Au; 094N 194, 093N 091	Producing mine; see Table 1	12 holes, 5559 m on Goldmark, North Slope, Saddle West zones. On-lease portion of 14 line-km IP.
<b>Mt. Milligan off-lease (greenfield)</b>	<b>Centerra Gold Inc.</b>	Cu, Au, Ag; alkalic porphyry Cu-Au; 094N 194, 093N 091	na	13 holes, 5616 m on Mitzi East (north of lease boundary, D2 and Heidi Stock (west of lease boundary), and Fugro-1 (south of lease boundary). Off-lease portion of 14 line-km IP.
<b>Nechako Gold</b>	<b>Tower Resources Ltd.</b>	Au, Ag; epithermal low sulphidation; 093F 060, 4	na	5 holes, 751 m. One significant hole: 10 m intersection at 0.22% Cu, 0.212 g/t Au.
<b>Panorama North</b>	<b>Atrum Coal Panorama Inc., JOGMEC (Japan Oil, Gas, and Metals National Corporation)</b>	Coal; anthracite; 104A 085, 89	na	8 holes, 1979 m targeting low-S PCI coal.
<b>Pil (Pillar East)</b>	<b>Finlay Minerals Ltd.</b>	Cu, Au, Ag; porphyry Cu±Mo±Au, epithermal; 094E 213, 215, 216, 217	na	Trenching discovered new mineralized zones. 23 samples over 1 g/t Au, max 20.3 g/t. 15 samples over 50 g/t Ag, max 694 g/t.

Table 5. Continued.

<b>Pine Pass</b>	<b>Ethos Gold Corp.</b>	V; sediment-hosted; 093O 009	na	Trenching, sampling. Best result 0.45% V <sub>2</sub> O <sub>5</sub> over 20 m.
<b>Snowbird</b>	<b>Omineca Gold Ltd.</b>	Au epithermal in quartz veins; 093K 036	na	10 holes, 1616 m. Connected North and Main zones, open at depth and along strike. Plans to focus on Main zone.
<b>Stardust</b>	<b>Sun Metals Corp.</b>	Ag, Pb, Zn; skarn Ag-Pb-Zn; 093N 009	na	22 holes, 6838 m, downhole EM survey. Mapping, prospecting, soil sampling, lidar survey, VTEM/ Magnetic survey.
<b>UDS</b>	<b>Serengeti Resources Inc.</b>	Cu, Au, Ag; porphyry Cu±Mo±Au; 094E 070	na	Expanded IP survey.
<b>Vega</b>	<b>Canasil Resources Inc.</b>	Cu, Au, Ag; porphyry Cu±Mo±Au; 104A 013	na	Lidar survey.
<b>Wicheeda</b>	<b>Spectrum Mining Corporation</b>	Nb, REE; carbonatite-hosted deposits; 093J 014	Inf: non NI 43-101 compliant 11.26 Mt, 2.3% LREE (Ce+La+Nd)	Beginning bulk sample, drilling program.
<b>Wildcat</b>	<b>Pacific Empire Minerals Corp.</b>	Cu, Au; alkalic porphyry Cu-Au; 093N 228	na	RC 11 holes, 550 m.

M = Measured; I = Indicated; Inf = Inferred

Table 6. Selected exploration projects, Northeast Region.

<b>Project</b>	<b>Operator (partner)</b>	<b>Commodity; Deposit type MINFILE</b>	<b>Resource (NI 43-101 compliant unless indicated otherwise)</b>	<b>Comments</b>
<b>Brule</b>	<b>Conuma Coal Resources Ltd.</b>	Coal; bituminous	P: 14.8 Mt saleable	On-lease exploration: estimated 40 +/-10 rotary holes, possible 8 +/-3 diamond holes, to extend resource.
<b>Flatbed/Gordon Creek</b>	<b>Colonial Coal International Corp.</b>	Coal; bituminous	Inf: 298 Mt	PEA report.
<b>Huguenot</b>	<b>Colonial Coal International Corp.</b>	Coal; bituminous	M+I: 132.0 Mt in situ surface, 145.7 Mt underground Inf: 119.2 Mt combined	Continued environmental monitoring.
<b>Willow Creek South</b>	<b>Conuma Coal Resources Ltd.</b>	Coal; bituminous	na	On-lease exploration: 27 holes diamond drilling, 3680 m. 10 holes rotary drilling, 1023 m. Geophysical logging.
<b>Wolverine</b>	<b>Conuma Coal Resources Ltd.</b>	Coal; bituminous	6.9 Mt saleable	On-lease exploration: 4 +/-2 diamond holes to help set parameters for underground mining.

M = Measured; I = Indicated; Inf = Inferred

Marmot occurrence returned up to 38 g/t of Au and 1590 g/t of Ag. The company plans a large-scale drilling program for 2019, targeting the Marmot occurrence. A 2016 NI 43-101 technical report posited an inferred resource for the Cliff Creek North zone of 550 Kt at 4.51 g/t of Au and 2019.15 g/t of Ag, and for the Duke's Ridge zone of 58 Kt at 4.30 g/t of Au and 139.13 g/t of Ag, both with a 4.0 g/t AuEq cut-off.

#### 7.1.5. Nechako Gold (Tower Resources Ltd.)

Tower Resources' targets on the **Nechako Gold** property are epithermal Au-Ag mineralization, and porphyry Cu-Au mineralization in the Hazleton Group (Upper Triassic to Middle Jurassic) and the Bowser Lake Group (Middle to Upper Jurassic).

In 2018, the company completed five short diamond drill holes totalling 751 m, following-up on a 2017 reverse circulation drill program. Only drill hole (NDH-18-004) showed significant results: 10 m at 0.22% Cu and 0.12 g/t of Au; and 14 m at 0.15% of Cu and 0.11 g/t of Au, including 2 m at 0.32% of Cu and 0.36 g/t of Au. Tower Resources planned to drill 15 reverse circulation holes in December 2018.

#### 7.1.6. Pil (Finlay Minerals Ltd.)

Following-up on encouraging 2017 results, Finlay Minerals Ltd. undertook trenching and sampling on its newly discovered **Pillar East** Au-Ag epithermal zone, hosted by rocks of the Black Lake Plutonic suite (quartz monzonite and quartz diorite). The company collected 102 samples from 14 trenches cut across strike, sampling 500 m of an 800 m south-southwest trending mineralized zone, and identified 19 new Au-Ag mineralized sites. Twenty-three samples returned greater than 1.0 g/t of Au, with a maximum of 20.63 g/t of Au. Fifteen samples returned in excess of 50 g/t of Ag, with a maximum of 694 g/t. The company considers that the deposit forms a structural Au-Ag system consisting of silicified rocks, quartz veins, and quartz-carbonate breccias.

#### 7.1.7. Snowbird (Gitennes Exploration Inc.)

The **Snowbird** project is an orogenic gold in quartz deposit that has been actively explored for at least 10 years. It is about 2 km to the north of the Snowbird antimony (stibnite) former mine. Vein and shear zone mineralization is hosted by argillite, alpine-type ultramafic rocks (harzburgite), andesite, and diorite along the Sowchea fault zone (Fig. 8).

Gitennes has been exploring the property since 2016 and, in 2018, completed 10 holes totalling 1612 m. Results indicated continuity between the North and Main zones, and showed the mineralized area to be open at depth and along strike. Hole SB18-06 intersected 32 g/t Au over 1.32 m including 15.85 g/t of Au over 0.82 m. Hole SB18-02 intersected 24 g/t of Au over 0.7 m and 4.53 g/t of Au over 0.9 m. Hole SB18-03 intersected 81 g/t of Au over 0.5 m from 30.4 to 30.9 m. Sampling indicated Au values in both veins and shear zones. Gitennes planned further drilling, to total about 1600 m, before the end of 2018.



**Fig. 8.** Snowbird project, hole SB-18-03, 45 m, shear zone with stibnite in quartz stockwork.

## 7.2. Selected porphyry projects

Porphyry projects continued to be the principal focus of mineral exploration in the Quesnel and Stikine terranes of the North Central region. Centerra Gold Inc. undertook intensive exploration in and around its Mt. Milligan mine, and Kwanika Copper Corporation continued work to develop its Kwanika project.

### 7.2.1. Cathedral (Thane Minerals Inc.)

The **Cathedral** porphyry prospect is hosted by quartz monzonitic plutonic rocks of the Hogen batholith (Early Jurassic), in contact to the east with intermediate volcanic rocks of the Takla Group (Late Triassic-Early Jurassic). Mineralization is within a west-plunging alkali porphyry system. In 2018, the company completed a modest program of mapping and grid establishment in advance of a planned 60 km IP program.

### 7.2.2. Chuchi (Centerra Gold Inc.)

The **Chuchi** Cu-Au property is at the northeast margin of the Hogen batholith (Early Jurassic), where a cluster of porphyritic monzonite stocks, dikes, and sills intrude the Chuchi Lake succession of volcanic and sedimentary rocks. In 2018, Centerra Gold relogged 3450 m of core from 17 drill holes to categorize vein types and density, and engaged in site cleanup.

### 7.2.3. Copper King (Pacific Empire Minerals Corp.)

The **Copper King** property is underlain by Triassic mafic to intermediate volcanic flows and breccias of the Takla Lake Group that are cut by Early Jurassic diorite, feldspar porphyry, and granodiorite. Mineralization is coincident with propylitic alteration and consists mainly of bornite-chalcocite-magnetite-epidote veins and of bornite-chalcocite disseminations in wall rock. Pacific Empire completed four reverse circulation holes, totalling 450 m, to test four targets on the property. Two holes intersected rocks with fine visible chalcocite disseminations associated with epidote with and without clay alteration. Samples returned low values of Cu, Au and Ag.

### 7.2.4. Croy-Bloom (Serengeti Resources Inc.)

The **Croy-Bloom** property hosts several Cu-Au porphyry targets. The property is underlain by Middle to Upper Triassic volcanoclastic and volcanic rocks of the Takla Group that are

cut by intrusive bodies that comprise the northern end of the Hogem batholith. In 2018, Serengeti completed an 11.5 km IP program, and defined a large IP and resistivity anomaly coincident with encouraging soil and shallow drilling results from previous operators.

#### 7.2.5. Fran (MGX Minerals Inc.)

In 2018, Rio Minerals Ltd., contracted by MGX, oversaw a 112 line-km IP survey and diamond drilling of 10 holes totalling 3000 m on this alkalic porphyry target. The deposit is hosted by volcano-sedimentary rocks of the Takla Group that are cut by en-echelon shear zones containing quartz-sulphide veins and stockworks. The company reports numerous zones of late-stage infilling sulphides (Fig. 9) as well as replacement pyrrhotite accompanied by chlorite, actinolite and mafic minerals, and high K-feldspar alteration. A follow-up drill program began in December. Upon completion of their exploration program, the company plans to issue an NI 43-101 report.

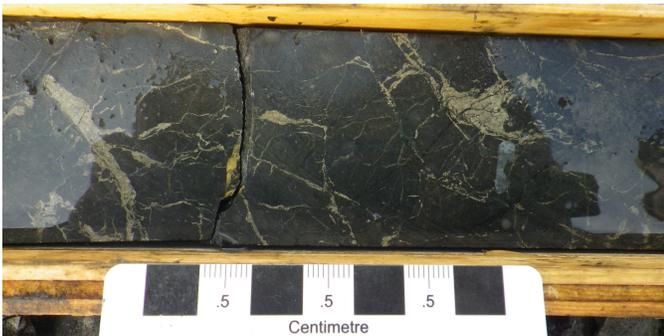


Fig. 9. Fran project, hole FR 18-90, 337 m, pyrite in hornfelsed siltstone.

#### 7.2.6. Joy (Amarc Resources Ltd.)

In 2018, Amarc Resources Ltd., with its partner HDI (Hunter Dickinson Inc.), completed a 1356 km airborne magnetic survey, a 63 line km IP survey, extensive soil sampling, geological mapping, and a 2 hole, 946 drill program on its Joy property in the Toodoggone region. Exploration was focussed on the northeast-trending 'Finlay Magnetic Corridor', an area prospective for Au-Cu porphyry deposits underlain by the Hazleton Group (Upper Triassic to Middle Jurassic). The project identified 5 drill targets and plans an exploration program for 2019.

#### 7.2.7. Kwanika (Kwanika Copper Corporation)

Kwanika Copper Corporation (65% Serengeti Resources Inc., 35% Daewoo Minerals Canada Corp.) was formed in 2017 to continue exploration on the Kwanika property. In 2018, the company completed a 21-hole, 7411 m drill program targeting the Central zone. Three of these were to test the foundation characteristics for a potential tailings storage facility. Nine of them were also to be used for ongoing hydrogeological monitoring to support detailed engineering design. The program was part of the company's ongoing "Kwanika Pre-

Feasibility Study," expected to be released in mid-2019 as a new NI 43-101 report.

The Central zone deposit is hosted by andesitic volcanic rocks of the Takla Group (Triassic) intruded by rocks related to the Hogem batholith (Triassic-Jurassic), with disseminated chalcopyrite, bornite and pyrite distributed in and around a potasically-altered monzonite stock. A supergene enrichment blanket with a maximum thickness of 70 m is contains native Cu, chalcocite and covellite (Fig. 10).

Kwanika (Central and South zones) has been the object of some 82,650 m of drilling since 2006. As conceived at present, a Kwanika (Central zone) mine would be a combined open-pit and underground operation. The total Indicated resource for the open-pit portion, before taking 2018 results into account, is 11.8 Mt at 0.37% of Cu, 0.39 g/t of Au, and 1.07 g/t of Ag. For the underground portion, the Indicated resource is 41.4 Mt at 0.46% of Cu, 0.52 g/t of Au, and 1.36 g/t of Ag (Moose Mountain Technical Services, 2017). The 2018 drill program encountered generally higher values than had been predicted based on the 2017 Preliminary Economic Assessment resource model. For example, Hole K-182 returned 0.80 g/t Au, 0.66% of Cu and 2.24 g/t of Ag (2.19 g/t Au equivalent) over 500.3 m from 25.00 to 525.3 m, including 1.3 g/t of Au, 1.3% of Cu and 4.12 g/t of Ag (4.09 g/t AuEq) over 113.0 m, from 25.0 to 138.0 m. Drilling in 2018 confirmed that the Central zone has a higher grade core.



Fig. 10. Kwanika project, hole K-18-181, 317.5 m, native copper in supergene zone monzonite. Scale in cm.

#### 7.2.8. Mt. Milligan on-lease, brownfield projects (Centerra Gold Inc.)

In 2018, Centerra Gold completed an extensive drill program within the ultimate pit boundary of the Mt. Milligan mine, below depths drilled previously (see 3.1.1., above). Results indicate that the ore body was displaced by a set of east-northeast trending normal faults. Twelve drill holes totalling 6669 m were completed to delineate the nearby Goldmark, North Slope and Saddle West zones. An IP program begun in 2017, which also extended off-lease, was also completed.

#### 7.2.9. Mt. Milligan off-lease, greenfield projects (Centerra Gold Inc.)

Off-lease, but close to the Mt. Milligan mine, Centerra Gold completed 13 holes totalling 5616 m to test four areas for porphyry mineralization: **Mitzi East**, north of the mine

lease boundary; D2 and Heidi Stock, west of the mine lease boundary; and Fugro-1, south of mine lease boundary.

#### 7.2.10. UDS (Serengeti Resources Inc.)

The **UDS** prospect is immediately northeast of Centerra Resources' Kemess South mine, and appears to have formed in a similar geological setting. Mineralization in the area consists of vein-type epithermal precious metal occurrences and porphyry Au-Cu deposits. In 2018, Serengeti Resources expanded coverage of a previous IP survey.

#### 7.2.11. Vega (Canasil Resources Inc.)

The **Vega** property is hosted by Takla Group volcanic rocks (Upper Triassic to Jurassic) that are cut by dikes and sills related to the Hogem batholith to the southwest. Mineralization occurs as pyrite, chalcopyrite, magnetite, and bornite along shear and fracture zones in brecciated and altered volcanic rocks and syenite. In 2018, Canasil Resources completed a lidar survey of the property.

#### 7.2.12. Wildcat (Pacific Empire Minerals Corp.)

The **Wildcat** property is about 10 km southwest of the Mt. Milligan mine and, although covered by thick overburden (up to 30 m), the geological setting appears similar. Previous drilling (Cayden Resources in 2011) intersected rocks that were considered typical of a Cu-Au porphyry system. In 2018, Pacific Empire completed 11 reverse circulation holes in three areas. The lightweight reverse circulation drill unit (Fig. 11)



Fig. 11. Wildcat project, adding casing to reverse circulation drill rig.

was able to penetrate the thick overburden and then drill up to 60 m into bedrock. Material returned to the surface was screened using XRF scanning, but was not considered to be of sufficient interest to be sent for further analysis.

### 7.3. Selected polymetallic base and precious metal projects

The Kechika trough and its along-strike equivalents remained of interest for a variety of Pb-Zn SEDEX projects, in particular **Akie** (ZincX Resources Corp.) as an ongoing exploration program, and **Indy** (InZinc Mining Ltd.) as a renewed project.

#### 7.3.1. Akie (ZincX Resources Corp.)

ZincX Resources continued exploration on its **Akie** SEDEX project. In August, the company released a new Preliminary Economic Assessment which proposed a 4000 tpd underground mine feeding a 3000 tpd concentrator over a mine life of at least 18 years. In 2018, the company completed five drill holes totalling 2013 m, on the Southeast, North Lead and Sitka, and Sitka extension zones. The North Lead zone is along strike with the Cardiac Creek deposit, about 3 km to the northwest. Drill hole A-18-148 in this zone intersected 125 m of zinc-enriched shale, limestone and siltstone of the Road River Group, including a 2.96 m interval at 0.31% of Zn. Similar results were found in holes A-10-68 and A-13-104 from previous drill programs. The Southeast zone is a previously untested target about 200 m outside of the Cardiac Creek deposit limits. Drill hole A-18-147 intersected a 7.04 m interval that graded 0.31% of Zn.

Perhaps the most encouraging results came from the Sitka zone, a Zn-Pb massive barite unit about 4 km east of the Cardiac Creek deposit within the 'eastern thrust panel' of Gunsteel Formation stratigraphy. This is the first known mineralized unit within this thrust panel. Hole A-18-144 intersected 5.08 m at 3.78% of Zn and 1 m at 11.33% of Zn. Hole A-18-145 (Fig. 12) intersected 3.5 m at 3.72% of Zn, which included 0.86 m at 11.09% of Zn. In the 'Sitka extension, about 400 m along strike southeast of the Sitka zone, hole A-18-149 encountered 12.98 m grading 1.10% of Zn, including 2.18 m at 3.47%.

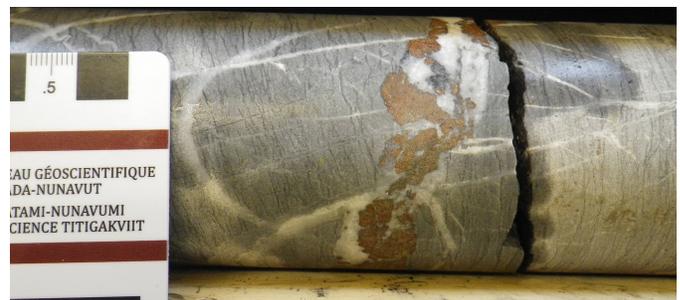


Fig. 12. Akie project, hole A18-145, 175.3 m, sphalerite in quartz vein, Road River Group.

#### 7.3.2. Gnome (AsiaBaseMetals Inc.)

The **Gnome** SEDEX prospect, south of the Akie project, is in a barite-rich sedimentary unit with anomalous values of zinc and other metals. In 2018, AsiaBaseMetals undertook prospecting,

mapping, and sediment and soil sampling on the property, identifying drill targets. Rock samples were anomalous in Zn (up to 9840 ppm), Co (808 ppm) and Mn (10,000 ppm).

### 7.3.3. Indy (InZinc Mining Ltd.)

The **Indy** project has been of exploration interest since the early 1980s. Hosted by carbonate rocks, it has generally been categorized as a Mississippi Valley-type (MVT) deposit, although SEDEX affinities have long been recognized. Four anomalous areas (designated from north to south as Anomalies A, B, C, and D) have been identified within deformed rocks of the Black Stuart Group (Ordovician to Mississippian). In 2018, InZinc completed 11 holes totalling 1271 m, exploring the southern portion of Anomaly B. Drilling encountered mineralization in all holes, mostly at shallow depths. For example, hole IB18-008 intersected 5.76% of Zn, 0.48% of Pb and 3.41 g/t of Ag (6.18% ZnEq) over 6.73 m at 56 m depth. Hole IB18-009 intersected 12.33% of Zn, 2.98% of Pb, and 24.46 g/t of Ag (14.98% ZnEq) over 6.29 m at 60 m depth (Fig. 13). The company now considers Indy to be a vent-proximal SEDEX deposit equivalent in age to others in north-central British Columbia.



**Fig. 13.** Indy project, hole IB18-009, 79 m, galena, sphalerite and pyrite in quartz, Black Stuart Group.

### 7.4. Selected skarn projects

Sun Metals' **Stardust** project (formerly referred to as 'Lustdust') is the only significant skarn deposit in the North Central Region.

#### 7.4.1. Stardust (Sun Metals Corp.)

The **Stardust** property was acquired by Sun metals in 2017. Historically regarded as a skarn deposit, it was explored intermittently for many years (Fig. 14). Mineralization is hosted by the Sowchea, Pope and Copely successions, west of the Pinchi fault, in the Cache Creek terrane (Pennsylvanian-Permian). In 2018, the company extended previous mapping and prospecting, collected more than 2800 soil samples, completed an airborne lidar with photogrammetry survey, and a 1103 line-km VTEM and magnetic survey on a 100-m line spacing. Twenty-two drill holes were completed, totalling 6838 m, and a post-drilling downhole EM survey was



**Fig. 14.** Historic core at Sun Metals' Stardust property.

undertaken. Drilling of hole DDH18-SD-421 on the 'Canyon Creek extension zone' returned a 100 m intersection grading 2.51% of Cu, 3.03 g/t of Au, 52.5 g/t of Ag. The company considers that this mineralization represents the distal part of a larger system.

### 7.5. Selected specialty metal projects

Deep-water basinal strata east of the Rocky Mountain Trench host a number of specialty metal projects, including Taseko Mine Ltd.'s **Aley** niobium-bearing carbonatite proposed mine (see section 6.1.2.). In 2018, an early exploration project **Wicheeda** (LREE), and a grassroots project, **Pine Pass** (Vanadium) were also active.

#### 7.5.1. Wicheeda (Spectrum Mining Corporation)

The **Wicheeda** carbonatite is a deformed intrusion that hosts light rare earth elements (LREE) in the Kechika Group. The core of the intrusion is a dolomite carbonatite, which transitions outward to a calcite carbonatite. Hydrothermal veins and plugs in the dolomite carbonatite are mineralized with REE fluorocarbonates, ancylite (cerium, lanthanum) and monazite (cerium, lanthanum, neodymium). Minor concentrations of niobium are present as well. A non-NI 43-101 compliant resource estimate concluded that, at an LREE cut-off of 1.00%, the deposit contained an indicated resource of 11.26 Mt grading 1.95% LREE (1.16% cerium, 0.54% lanthanum, 0.24% neodymium, 0.03% niobium, and 0.01% samarium). To start

in late 2018, Spectrum planned to extract a 30 t bulk sample from trenches completed in 2008, and begin a drilling program at up to 51 sites.

### 7.5.2. Pine Pass (Ethos Gold Corp.)

Ethos Gold began work on its **Pine Pass** black shale-hosted vanadium prospect, exposed along Highway 97. The host rocks are calcareous mudstone and siltstone of the Sulphur Mountain Formation (Middle and Upper Triassic). In 2018, the company completed five hand-dug trenches and continuous rock chip samples in the roadcut. Trench 1 returned grades averaging 0.27% of  $V_2O_5$  over 255 m across strike, and Trench 2 gave grades averaging 0.43% of  $V_2O_5$  over 155 m across strike. The company's immediate plan is to conduct a deep IP survey and continue trenching in an effort to define a drill program.

### 7.6. Selected coal projects

Exploration for coal in the Northeast Region remained at low levels except at active mine sites. In the North Central Region, Atrum Coal drilled at its **Panorama** anthracite coal project in the Bowser Basin.

#### 7.6.1. Flatbed/Gordon Creek (Colonial Coal International Corp.)

Colonial Coal released a Preliminary Economic Assessment (PEA) on the 'Gordon Creek Project' (part of the Flatbed property) near the Trend mine (Fig. 4). Like Trend, the coal is in the Gates Formation; unlike Trend, the sedimentary units are east of the Cordilleran fold and thrust deformation front and dip gently. Gordon Creek is a proposed underground mining operation within the larger Flatbed property and was estimated to have a Net Present Value (NPV) of \$US650.9 million, which includes metallurgical coal (based on \$US164.80 per t) and PCI coal (based on \$US140.50 per t). These estimates were based on a resource of 111.6 Mt ROM coal and production of 57.4 Mt of clean coal over a mine life of 30 years. The Inferred metallurgical coal resource is 298 Mt.

#### 7.6.2. Huguenot (Colonial Coal International Corp.)

Colonial Coal released a PEA on its **Huguenot** project south of Tumbler Ridge (Fig. 4). As a combined open-pit and underground operation, Huguenot was estimated to have an NPV of \$US1.166 million in metallurgical coal based on \$US172.00 per t, with break-even at \$US 120.00 per t. Measured plus Indicated surface mining resources across three resource blocks (north, middle and south) were reported as 132.0 Mt, and underground as 145.7 Mt. Mine life was projected at 31 years.

#### 7.6.3. Panorama (Atrum Coal Panorama Inc.)

**Panorama** is a joint venture of Atrum Coal Limited (65%) and Japan Oil, Gas and Metals National Corporation (JOGMEC) (35%). The coal-bearing units lie in the Bowser Basin (Bowser Lake Group, Middle-Upper Jurassic), which straddles the boundary between the North Central and Northwest Regions.

The Bowser Lake Group, in common with the younger coal measures in northeast British Columbia, consists of alternating marine and non-marine deltaic sequences containing multiple coal seams. In 2018, Atrum conducted a drilling program on the Panorama North project, targeting PCI anthracite coal (Fig. 15) in an open syncline for blending to produce metallurgical coal. Eight holes were completed, totalling 1979 m, and seam thicknesses of up to about 4 m were identified.



Fig. 15. Panorama North project, hole PNDH-18-04, 63 m, fractured anthracite coal.

### 7.7. Selected industrial mineral projects

Apart from the **Giscome** limestone quarry (see section 6.3.1.), the only significant industrial mineral project was in the Northeast Region, where Sil Industrial Minerals began work on its **Sil** project, searching for frac sand resources.

#### 7.7.1. Sil 17-001 to 17-004 (Sil Industrial Minerals Ltd.)

Sil Industrial Minerals Ltd. completed initial exploration in the Northeast Region on a multi-year project in search of frac sand resources, in sandy post-glacial sediments. Accessing exploration sites using existing cutlines and tracks, the proponent plans to complete about 486 shallow holes using a tracked solid stem auger and a reverse circulation drill. In 2018, the company completed 33 holes totalling 200 m.

### 8. Geological research

In 2018, the British Columbia Geological Survey initiated a three-year, 1:50,000-scale bedrock and surficial geology mapping project in the northern part of the Hogen batholith, north-central British Columbia. During the course of mapping, 17 new mineral occurrences were discovered, mostly porphyry Cu, but also Au- and Cu-bearing quartz veins (Ootes et al., 2019 a, b). Building on work done in 2017 (Milidragovic, et al., 2018), Milidragovic and Grundy (2019) continued a study to better understand the origin of Ni-bearing rocks in the Decar area and the tectonostratigraphy of the Cache Creek terrane. Geoscience BC published the final report of a project focussed on groundwater resources and locating potential aquifers in the Peace region (Morgan and Allen, 2018).

## 9. Summary

Activity in the Northeast Region expanded in 2018, with Conuma coal reopening the third of the mines that it had purchased in 2016, Willow Creek, and undertaking on-lease exploration programs at all three mines. HD Mining International received a Mines Act permit for its Murray River mine project.

Exploration expenditures decreased slightly in the North Central Region as some exploration companies reported difficulties in raising funds for their programs, but that trend is expected to reverse in 2019 as Centerra Gold continues an aggressive exploration program and New Gold begins a major drilling program at its Blackwater project. Major highlights in 2018 include the following.

- Initiation of construction activity in connection with Centerra Gold's Kemess Underground project.
- Completion of the permitting approvals process for HD International Mining's Murray River coal project.
- Large drilling programs both on- and off-lease at Centerra Gold's Mt. Milligan mine.
- Extensive exploration drilling by Kwanika Copper Corporation in the Central zone at the Kwanika Project, and also at Sun Metal's Stardust property a short distance to the north.
- Re-opening of the Willow Creek mine by Conuma Coal Resources Limited, and the initiation of on-lease exploration programs at the Brule, Wolverine and Willow Creek mines.
- Discovery of possible orogenic Au mineralization (AK project) just north of Prince George.

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