

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



John R. DeGrace^{1, a}

¹Regional Geologist, British Columbia Ministry of Energy, Mines and Petroleum Resources,
Suite 350, 1011 Fourth Avenue, Prince George, BC, V2L 3H9

^acorresponding author: John.Degrace@gov.bc.ca

Recommended citation: DeGrace, J.R., 2018: Exploration and mining in the North Central and Northeast regions, British Columbia. In: Provincial Overview of Exploration and Mining in British Columbia, 2017. British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Information Circular 2018-1, pp. 35-55.

1. Introduction

From northeast to southwest, a transect from the Northeast Region to 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 basin 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 two producing coal mines, Conuma Coal Resources Limited's **Brule** and **Wolverine** (Perry Creek) operations, two on care and maintenance status, and several other 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. One small project, the **Wapiti East** phosphate deposit (Fertoz International Inc.) is in the mine evaluation phase.

The North Central Region is prospective for copper, gold, silver, zinc, lead, specialty metals, and rare earth elements, mostly in porphyry, vein and stockwork, SEDEX, and carbonatite settings. The region has one producing mine, Centerra Gold Inc.'s **Mt. Milligan** copper-gold mine and one mine on care and maintenance, Centerra Gold's **Endako** molybdenum mine. One major mine application, for AuRico Gold Inc.'s **Kemess Underground** mine (a copper-gold porphyry) was submitted in 2017, and an application to open a limestone quarry (Graymont Western Canada Inc.) near Giscome was under consideration. New Gold Inc.'s **Blackwater** gold-silver porphyry deposit remained in mine evaluation status, as did Taseko Mines' **Aley** niobium (carbonatite) project (Fig. 1).

Only one early-stage exploration project was active in the Northeast Region in 2017. In contrast, exploration projects in the North Central Region included 7 advanced, 24 early, and

7 grassroots (Fig. 1). One of the early exploration projects resulted in a significant discovery, a carbonatite deposit on Arctic Star Exploration's **CAP claims** north of Prince George. Diamond drilling was undertaken at the one Northeast Region project, and at 16 of those in the North Central Region.

As in 2016, 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 and Young LLP. For the North Central Region, exploration expenditures were estimated at \$31.3 million and exploration drilling was estimated at approximately 32,350 m. For the Northeast Region exploration expenditures were estimated at \$2.4 million and exploration drilling was estimated at approximately 2830 m (Clarke et al., 2018; Ernst & Young LLP, in press).

2. Geological overview

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

In the Northeast and North 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

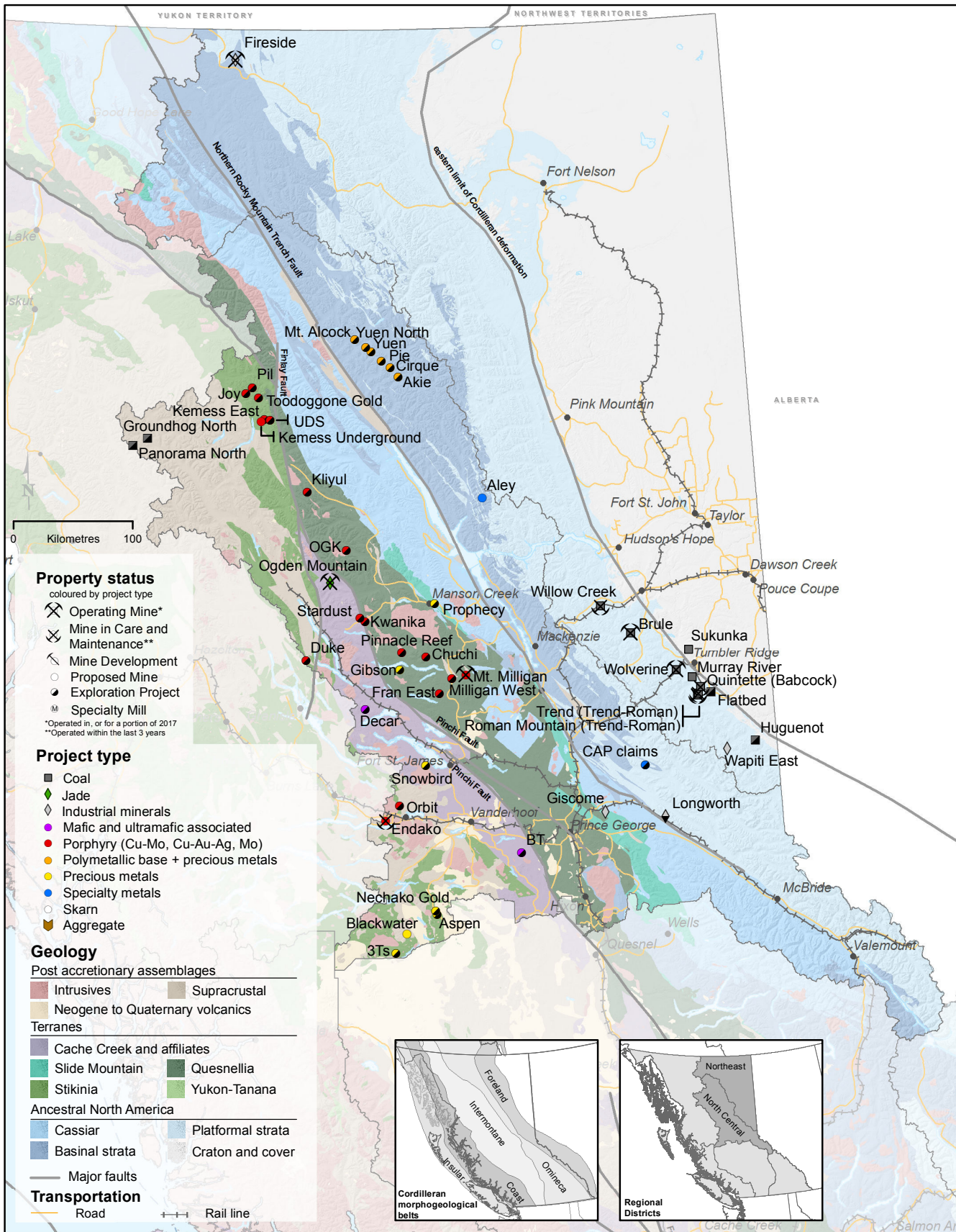


Fig. 1. Mines and selected exploration projects, North Central and Northeast regions, 2017. Terranes from British Columbia digital geology map (Cui et al., 2017).

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 (upper mantle) rock are locally exposed. These terranes are intruded by intermediate to felsic plutonic rocks, and are 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, Ancestral North America platform strata are host to 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. The island arc assemblages of Quesnellia and Stikinia host the known large polymetallic porphyry deposits in the region.

Both regions were extensively glaciated during successive Quaternary glacial periods (e.g., Hickin et al., 2017). In North Central and Northeast British Columbia, glaciation resulted in significant topographic modification so that, especially in mountainous areas, glacial valleys, cirques and arêtes, and attendant deposits are widespread. In the Interior Plateau, till thickness commonly extends to several metres. Glaciofluvial deposits are widespread, and glacial lakes formed in some low lying areas, in particular near confluence of the present day Nechako and Fraser Rivers.

The geology of North Central and Northeastern British Columbia is treated in more detail by Jago (2017).

3. Mines and quarries

3.1. Metal mines

In 2017, the only producing metal mine was the copper-gold producer **Mt. Milligan**, wholly-owned by Centerra Gold Inc. (Table 1) in the North Central Region (Fig. 1). Also in the North Central Region, the **Endako** molybdenum mine (75% Centerra, 25% Sojitz Moly Resources Inc.) remained on care and maintenance.

3.1.1. Mt. Milligan (Centerra Gold Inc.)

The **Mt. Milligan** mine, in Quesnel terrane (Fig. 1,) is hosted by mafic to intermediate volcanic and pyroclastic rocks of the Takla Group (Triassic to Early Jurassic) that are intruded by Early Jurassic monzonite porphyry stocks. The ore body (2500 x 1500 m) is a silica-saturated alkalic porphyry copper-gold deposit contained in two principal zones. At the Main Zone, mineralization is mainly in volcanic rocks, and at the Southern Star Zone, mineralization is in a monzonite stock and volcanic rocks. Copper-gold (with accessory silver) mineralization occurs as sulphides in the host rocks (Fig. 2). Combined Measured and Indicated resources total 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).

Commissioned in 2013, the mine was up to its full design capacity of 60,000 tpd by 2016. Phase 3 mining (Fig. 3) was underway in 2017, and phase 4 extraction began. Before milling

and flotation, ore is processed through primary and secondary crushers (Fig. 4) in a concentrator upgraded to a 62,500 tpd design capacity. Mill feed throughput in 2017 was forecast to be 59,600 tpd, and for 2018 to be 60,700 tpd (Andrews et al., 2017), with full capacity being reached by 2019. 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. Average annual payable production, as forecast for the period 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).



Fig. 2. Ore specimen from Phase 3, Mt. Milligan mine, chalcopyrite and pyrite.



Fig. 3. Loading ore at Mt. Milligan mine, Phase 3 development.

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

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2017 Production (based on Q1-Q3)	Reserves	Resource	Comments
Mt. Milligan	Centerra Gold Inc. (Centerra B.C. Holdings)	Cu, Au, Ag; Alkalic porphyry Cu-Au; 093N 194, 093N 191	55-65 Mlbs Cu; 235,000-255,000 oz Au	P: 256.8 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. Over 350 employees.
Endako	75% Centerra Gold Inc. (25% Sojitz Moly Resources Inc.)	Mo; Porphyry Mo (Low F-type); 093K 006	na	na	M+I: 3.4 Mt at 0.049% Mo	Placed on care and maintenance in July 2015. Mineral reserves were re-classified as mineral resources in the 2015 mineral resources statement (Dec. 31, 2015).

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

**Fig. 4.** First-stage crusher at Mt. Milligan mine.

3.1.2. Endako (Centerra Gold Inc., 75%; Sojitz Moly Resources Inc., 25%)

The **Endako** mine has been on care and maintenance status since July 2015. Endako is a large (200 x 800 m) low-fluorine porphyry molybdenum deposit, about 320 m deep, hosted by Endako batholith quartz monzonites. The open pits extend across four structural blocks in a northwesterly direction.

3.2. Coal mines

Metallurgical coal mining returned to the Northeast Region with the reopening of two of three mines that Conuma Coal Resources Ltd. acquired in 2016 from Walter Energy Canada Holdings Inc. (Fig. 5; Table 2). The **Brule** mine, on care and maintenance since June 2014, reopened in late 2016, and the **Wolverine** (Perry Creek) mine, on care and maintenance since April 2014, reopened in January 2017. The third mine, **Willow Creek**, also placed on care and maintenance in 2014, is projected to return to production in late April 2018. Peace River Coal's **Trend-Roman** mine has been on care and maintenance since December 2014.

3.2.1. Brule mine (Conuma Coal Resources Ltd.)

The **Brule** mine (Table 2) releases pulverized coal injection (PCI) coal from three seams in the lower part of the Gething Formation (Cretaceous; Bullhead Group), with a cumulative thickness of about 12 m. The coal was transported by truck on a dedicated haul road and, later in the year, by rail to Conuma's loadout facility at its **Willow Creek** mine. The remaining mine life is about seven years. Like current and previously operating mines in Northeast British Columbia, the coal is contained in folded rocks modified by thrust faulting, so that the seams are commonly steeply dipping.

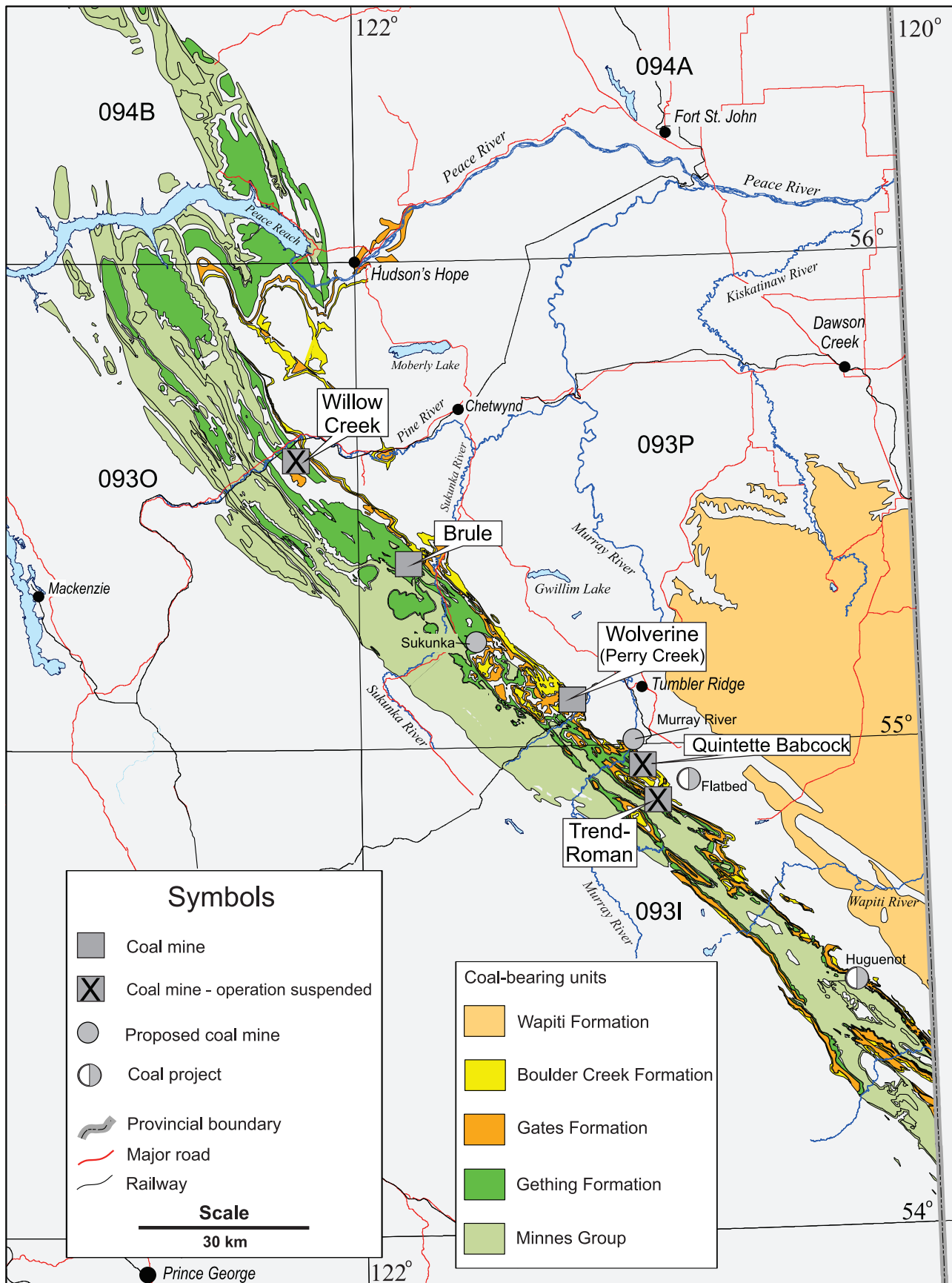


Fig. 5. Coal mines and exploration projects, northeastern British Columbia, 2017. From British Columbia Geological Survey (2018).

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

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2017 Production (based on Q1- Q3)	Reserves	Resource	Comments
Willow Creek	Conuma Coal Resources Limited	HCC, PCI; Bituminous coal; 093O 008	na	P+Pr: 16.6 Mt	na	Placed on care and maintenance in 2013. Anticipated to re-open late April 2018 with about 230 employees when in full production.
Brule	Conuma Coal Resources Limited	PCI; Bituminous coal; 093P 007	2.33 Mt	P: 16.3 Mt	na	Restart activities began in Sept. 2016, ramp-up complete June 2017. About 550 employees, Brule and Perry Creek combined.
Wolverine (Perry Creek)	Conuma Coal Resources Limited	HCC; Bituminous coal; 093P 025	1.14 Mt	P: 8.8 Mt	na	Placed on care and maintenance in 2014. Restart process began Jan. 2017, ramp-up complete June 2017.
Trend (Trend-Roman)	Anglo American plc (Peace River Coal Inc.)	HCC; Bituminous coal; 093I 043	na	P: 8.3 Mt	na	Placed on care and maintenance in 2014, 50,000 t mined inventory shipped in January 2015.
Roman Mountain (Trend-Roman)	Anglo American plc (Peace River Coal Inc.)	HCC; Bituminous coal; 093I 043	na	P: 25.8 Mt	na	Placed on care and maintenance in 2014.
Quintette (Babcock)	Teck Coal Limited	HCC, TC; Bituminous coal; 093I 011	na	P: 39.1 Mt	120.3 Mt mineable in situ (additional to reserves)	Placed on care and maintenance in 2014.

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

3.2.2. Wolverine (Perry Creek) mine (Conuma Coal Resources Ltd.)

Mining at **Wolverine** (Fig. 6) is from the Gates Formation in the Fort St. John Group (Cretaceous). The product is medium-volatile bituminous hard coking coal (HCC), which was trucked on Conuma's haul road and, later in 2017, moved by rail, to its load-out facility at the Willow Creek mine. The approximate remaining mine life is three years, but activity in the area will be extended if Conuma elects to move its operation to the nearby EB deposit.

3.2.3. Willow Creek mine (Conuma Coal Ltd.)

The **Willow Creek** mine (Fig. 7) was placed on care and maintenance by Walter Energy in 2014 and is forecast to resume production under Conuma's management in late April 2018. In the interim, the wash plant and load-out facility at Willow Creek continues to serve operations at Brule and Perry Creek. As with the Brule Mine, at Willow Creek coal is extracted from the Gething Formation. Structure is more complex at Willow Creek than at the other mines, making production more expensive.



Fig. 6. Coal mining operations at the Wolverine mine, Conuma Coal Resources Limited.



Fig. 7. Stockpiled coal at the Willow Creek mine, Conuma Coal Resources Limited.

3.2.4. Trend and Roman Mountain mines (Peace River Coal Inc.)

Peace River Coal's **Trend** mine (and nearby Roman Mountain deposit) were placed on care and maintenance in December 2014, with Trend ceasing production, and development activities on Roman Mountain halted.

3.3. Industrial mineral mines and quarries

In 2017, two industrial mineral producers, Fireside Minerals Ltd. and Green Mountain Jade Inc., operated in the North Central Region (Fig. 1; Table 3).

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 ranges from 96.0 to 99.4% BaSO₄. The product is bagged and trucked

to Fort St. John and to Alberta, where it is used to produce high-density drilling mud. In 2017 production amounted to 38,800 t, from the Moose Pit opened in 2016. A small resistivity survey was conducted at the north end of the pit.

3.3.2. Ogden Mountain (Green Mountain Jade Inc.)

Green Mountain Jade Inc. continued its mining and exploration for jade at **Ogden Mountain**, north of Fort St. James. This nephrite jade deposit is hosted by serpentinite lenses emplaced along the Pinchi fault and is also found as boulders (Fig. 8). Only a small percentage of jade meets quality standards and, in 2017, only 20,000 kg were shipped of the 400,000 kg extracted.



Fig. 8. Jade boulders cut for evaluation at Ogden Mountain mine.

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 2017, about 98 placer gold operations were approved in British Columbia, 23 of which were 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, 094M 019	38,800 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, 093N 157, 093N 165	20 t	na	na	Exploration placer and open pit mining of alluvial jade boulders, excavation of in situ jade.

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

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 23.18 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

Although several mines and quarries are proposed for development in the North Central and Northeast regions (see section 6 below, and Table 4), none was as yet under construction in 2017. To be formally considered an operation under development, all government permits for construction and operation must be in place. Teck Coal's **Quintette** (Babcock) coal mine was in a combined development and early production stage when the operation was placed on care and maintenance in 2014. Development had been underway for the **Roman Mountain** expansion at Anglo American's Trend Mine, when Trend was placed on care and maintenance late in that year.

6. Proposed mines or quarries

At the point of a mine proposal (Fig. 1; Table 4), the character and content of a mineral deposit has been established to a degree of confidence that the proponent considers that mining would be economically feasible. Environmental review typically will have been ongoing for some time, but at this stage the proponent submits an application for an Environmental Assessment Certificate and/or receipt of a Section 10 permit, which states that a project is reviewable by the Environmental Assessment Office (EAO). For proposed small-scale operations that do not meet the EAO threshold criteria for review, a Mines Act permit application may be submitted directly. This category also includes projects that have received their Environmental Certificate but are in the final Mines Act permit application review process before development and production.

In 2017, the North Central and Northeast regions combined had five projects at various stages and activity in the pre-application phase of environmental assessment leading to the major mine application (Table 4). In December, the **Murray River** coal mining project received a positive environmental assessment decision from the federal government, although the **Sukunka** project ended the year on hold because of environmental concerns.

6.1. Proposed metal mines

6.1.1. Kemess Underground (AuRico Metals Inc.)

The **Kemess Underground** (KUG) is a calc-alkaline porphyry copper-gold-silver 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 to 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 copper-gold mineralization.

On 1 September, 2017, AuRico Metals Inc. applied to the Major Mines Permitting Office, with all applications to be reviewed concurrently. The Canadian Environmental Agency had already issued a positive decision statement, and the Environmental Assessment Office had granted an Environmental Assessment Certificate. On 2 November 2017, KUG's permit applications passed screening and were accepted for review by the Mine Review Committee.

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.

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

In November 2017, Centerra Gold Inc. announced its intent to purchase AuRico in a \$243 million cash payment of \$1.80 per share. Finalizing the arrangement will require court and regulatory approvals, and the approval of two-thirds of voters at a special meeting of AuRico shareholders expected in January 2018.

6.1.2. Blackwater (New Gold Inc.)

New Gold Inc. is 100% owner of the **Blackwater** project, about 110 km southwest of Vanderhoof. It is accessible by existing roads, but development would require construction of a 140 km transmission line from a substation south of Endako. 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.

Table 4. Selected proposed mines and quarries, North Central and Northeast regions.

Project	Operator (partner)	Commodity; deposit type; MINFILE	Reserves	Resource	Comments
Blackwater (North Central region)	New Gold Inc.	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.
Kemess Underground (KUG) (North Central region)	AuRico Metals Inc.	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	New NI 43-101 report, EA certificate granted, engineering and environmental studies ongoing. Major Mine permit application submitted Aug. 31. 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.
Aley (North Central region)	Taseko Mines Limited (Aley Corporation)	Nb; Carbonatite-hosted deposit; 094B 027	P+Pr: 83.8 Mt at 0.50% Nb ₂ O ₅ ; containing 293 Kt* Nb *calculated by Jago, 2017	285.8 Mt at 0.37% Nb ₂ O ₅ ; containing 739.2 Kt* Nb (including reserves) *calculated by Jago, 2017	Environmental Assessment (pre-app), geochemical characterization studies, environmental baseline monitoring. 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.
Giscome (North Central region)	Graymont Western Canada Inc.	CaCO ₃ ; Limestone; 093J 041, 093J 025	na	I: >100 Mt of limestone (>95% calcium carbonate, <5% magnesium carbonate) in situ.	Environmental Assessment under review. Proposed 600,000 tpd limestone quarry to feed a vertical lime kiln producing 198,000 t of lime annually over a 50+ year mine life.
Wapiti East (Northeast region)	Fertoz International Inc.	P ₂ O ₅ ; Sedimentary phosphate deposits; 093I 039, 093I 022, 093I 008	na	I: 0.81 Mt at 22.3% P ₂ O ₅ ; Indicated	Mines Act permit application, bulk sample (17,500 t permitted), temporary road (2.2 km). Proposed seasonal shallow open-pit mine with average annual production of less than 75,000 t phosphate rock over a 20+ year mine life; organic certification obtained.
Murray River (Northeast region)	HD Mining International Ltd.	HCC; bituminous coal; 093I 010	P: 261.6 Mt mineable	M+I: 314.2 Mt in situ	Proposed underground longwall mine with average annual production of 4.8 Mt of saleable coal over 25-year mine life. Provincial EA Certificate issued 2015; Federal EA Decision Statement issued December 2017.

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred; HCC = hard coking coal

In 2017, the company continued advancing its environmental assessment process and coordinated with both federal and provincial governments, with the aim of meeting the requirements for an Environmental Assessment Certificate (EAC) from the Province of British Columbia, and a Decision Statement from the federal Minister of the Environment. In addition, New Gold continued collecting baseline data, completed additional soil and till sampling, and undertook geotechnical work related to mine design. Proven and Probable reserves stand at 8.2 Moz of Au, and 60.8 Moz Ag. As proposed, Blackwater would be a 60,000 tpd operation with a 17-year mine life.

6.1.3. Aley (Taseko Mines Ltd.)

Taseko Mines Ltd.'s wholly-owned **Aley** niobium-bearing carbonatite project is near the western extremity of platformal strata, about 140 km north of Mackenzie in the North Central Region (Fig. 1). The dolomite carbonatite intrusion (with minor calcite carbonatite) is oval in surface intersection, measuring about 2.0 x 2.8 km. Within that body, reserves stand at 84 Mt grading 0.5% Nb₂O₅. 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.

6.2. Proposed coal mines

Two coal mines are proposed, both in the Northeast Region.

6.2.1. Murray River (HD Mining International Ltd.)

Murray River is a proposed underground mine that would extract coal from the Gates Formation by longwall methods, producing 4.8 Mt of saleable coal annually during a 25-year mine life. Proven mineable reserves are 261.6 Mt, and Measured plus Indicated resources are 314.2 Mt. In 2015, HD Mining International Ltd. completed bulk sampling for testing coal quality, processing, and marketability and in December 2017, the Government of Canada issued an Environmental Assessment Decision Statement that approved the project subject to legally binding conditions. These included: consultation with First Nations on implementing the conditions; avoiding, mitigating or offsetting impacts on caribou habitat; and limiting methane emissions to not more than 500,000 t of equivalent CO₂ annually. The provincial Environmental Assessment Certificate had been issued in October 2015.

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

The **Sukunka** project had been planned as both an open pit and underground operation, extracting coal from the Gething Formation. The environmental assessment process was suspended in January 2016, pending further study on the effects to caribou and water quality. The project did not have an active permit in 2017.

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), Graymont Western Canada proposes to exploit a high-purity Paleozoic limestone deposit in basaltic rocks of the Antler Formation (Slide Mountain Group). Crushed stone would be transported about 5 km by conveyor 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 British Columbia Environmental Certificate for the project is in place, and the Mines Act Permit process is underway. The company anticipates starting construction in 2019 or 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.

6.3.2. Wapiti East (Fertoz International Inc.)

Fertoz International Inc. continued progress on its Mines Act permit for the **Wapiti East** phosphate project in the Northeast Region. The deposit is of pelloidal and nodular phosphate-bearing units interbedded with siltstones of the Spray River Group (Triassic). The product is intended for direct crop application in organic food production. From a 17,500 t bulk sample permitted in 2016, the company offered 1100 t for sale in early 2017, with more material to be extracted during the year. In 2017, the company focused on completing infrastructure. Once permit and infrastructure are in place, Fertoz would mine from a seasonal, shallow open-pit, with a 20-year mine life, producing up to 75,000 tpy of phosphate-bearing rock.

7. Selected exploration activities and highlights

Mineral exploration projects are classified as grassroots, early-stage exploration, or advanced-stage exploration. Grassroots exploration is at the level of a first look, and may include prospecting, mapping, airborne geophysics, and sampling for geochemistry. At the early-stage level, work may include continued grassroots work and also ground geophysical surveys, systematic soil and/or stream geochemistry, trenching, and drilling. Advanced-stage exploration progresses to resource delineation, preliminary economic assessment, and prefeasibility work. Drilling may be at the level of infill to define a resource, a bulk sample may be collected, and environmental baseline work might begin. Encouraging advanced stage exploration work progresses to mine evaluation, where much more detailed environmental, engineering, financial, and social impact studies are undertaken. The culmination of successful exploration is submission of an application to mine: for larger projects, to the Major Mines Permitting Office; for smaller projects (extracting <75,000 tpy), to the Regional Office of the Ministry of Energy, Mines and Petroleum Resources.

Although exploration activity was slow in the Northeast

Region, the North Central Region saw a significant increase from 2016, with 38 Notices of Work (excluding placer and aggregate) approved in 2017, and a further 16 under consideration. Not all of these permits saw exploration in 2017 (most are multi-year permits). Work on many of the projects begun in 2017 was at a preliminary level, with the proponents intending to ramp up activity as new funding was attracted. Among the active projects in the North Central Region, seven were at the grassroots level, 24 were early exploration, seven were advanced exploration, and two were on-lease mine site exploration projects aimed at expanding the resource (Tables 5, 6).

7.1. Selected precious metal projects

With the exception of the proposed Blackwater mine (see Section 6.2.1. above), seven significant precious metal exploration projects were active in the North Central Region in 2017.

7.1.1. Aspen (ML Gold Corp.)

Aspen is a low-sulphidation gold-silver (copper) epithermal prospect about 25 km northwest of New Gold's Blackwater project. It is at the margins of a large, potentially mineralizing pluton, with gold and silver intersections trending onto the property, which is also the site of multi-element geochemical anomalies. Work in 2017 consisted of 9.6 km of IP survey with the aim of developing drill targets.

7.1.2. Prophecy (Joe Hirak)

Prophecy is an early-stage exploration prospect in the Manson Creek area. The deposit consists of gold-bearing quartz veins and galena-bearing veins. In 2017, nine boreholes totalling 700 m were drilled in a 200 m radius around the surface showings.

7.1.3. Snowbird (Omineca Gold Ltd., Gitennes Exploration Inc.)

At the **Snowbird** project, gold is in quartz veins and stringer zones associated with the Sowchea fault zone. Nearby showings contain stibnite veins and disseminations. In 2017, 11 km of ground magnetics were carried out, following-up on a 1994 airborne survey. A 2.5 km magnetic low was considered related to gold mineralization. Soil samples (139) were collected on 100 m line spacings, and rock samples (111) were collected for assay. Ten boreholes were completed, totaling approximately 1212 m. Eight of these intersected multi-gram gold intervals, including Hole SB14-04 (16.20 g/t Au over 1.0 m), Hole SB17-02 (9.73 g/t Au over 1.0 m), and Hole SB17-08 (8.24 g/t Au over 0.52 m). The exploration focus was on the North and Main Zones, and the deposit remains open below a depth of 50 m.

7.1.4. Gibson (CANEX Metals Inc., Vector Resources Inc.)

The **Gibson** prospect is a gold-silver-copper high sulphidation mesothermal deposit hosted by quartz-carbonate veins, stockworks, and breccias. In 2017, access was established,

eight exploration trenches were dug, and 157 rock and 445 soil samples were collected. Trenching exposed mineralization in a 400 x 150 m area, and soil sampling showed strong anomalies over an 850 x 500 m area. Significant gold and silver values were reported through the sampled area. The proponents have defined drill targets and expect to initiate drilling in the spring of 2018.

7.1.5. Nechako Gold (Tower Resources Ltd.)

The Nechako Gold property is about 30 km northeast of New Gold's Blackwater project. In June 2017, the company completed an IP survey that defined a 1000 x 500 m anomaly over an untested till-covered area. In October 2017, Tower began a 30-hole reverse circulation drill program to test the till cover and top of bedrock.

7.1.6. 3Ts (Independence Gold Corp.)

The **3T's** project is a low sulphidation gold-silver bearing epithermal vein system hosted by rhyolitic units in Hazleton Group volcanic rocks. About 126 km southwest of Vanderhoof, the operation is readily accessible by resource roads. The deposit consists of more than a dozen north-striking subvertical veins along faults. Individual veins are up to 900 m long and 20 m wide. Mineralization in mainly quartz-calcite veins consists of pyrite, possible gold-silver sulphosalt disseminations and veinlets, and accessory chalcopryrite, sphalerite, and galena. In 2017, Independence gold completed a MMI soil survey that identified new drill targets. The company is seeking a partner for 2018.

7.1.7. Toodoggone Gold (Sable Resources Ltd.)

Sable Resources has a long history in the Toodoggone region, as operator of the Shasta mine (now on care and maintenance) and Baker mill, and proponent of several mineral occurrences. The area, north of the Kemess projects, is readily accessible by forest service and mineral exploration roads in its southern (Baker) area; but more northerly prospects, such as Bot, are not accessible by road. In 2017, the company came under new management, acquired new funding, and partnered with JDS Energy and Mining Inc. and Talisker Exploration Services Inc. The Baker project includes the Shasta mine.

The **Toodoggone Gold** projects lie along the eastern limb of the Stikine arch, which in its western limb hosts advanced exploration targets in the so-called 'golden triangle' of northwestern British Columbia. Deposit types of interest in the Baker area are copper-gold porphyry systems and low-to intermediate-sulphidation gold-silver (+/-copper) vein systems. The Bot project is 43 km northwest of Baker, and the initial target is copper-zinc-lead-silver-gold-barite stockworks in a sheared volcanic host rock, related to the emplacement of a mineralized monzonite. Sable Resources is committed to cleanup and site stabilization in the Baker area, including dam and spillway inspection. In October, the company was permitted for a significant diamond drilling program and an IP survey.

Table 5. Selected exploration projects, North Central Region.

Project	Operator (partner)	Commodity; Deposit type; MINFILE	Resource (NI 43-101 compliant unless indicated otherwise)	Comments
3Ts	Independence Gold Corp.	Au, Ag; Epithermal Au-Ag-Cu (low sulphidation); 093F 055, 093F 068	I: 5.452 Mt at 2.52 g/t Au, 71.5 g/t Ag; containing 13.7 t (441,000 oz) Au and 390.0 t (12.54 Moz) Ag	MMI soil survey. New drill targets identified; considering further work in 2018.
Akie	Canada Zinc Metals Corp.	Zn, Pb, Ag; Sedimentary exhalative Zn-Pb-Ag; 094F 031	I: 19.6 Mt at 8.17% Zn, 1.58% Pb, 13.6 g/t Ag; containing 1.6 Mt (3540 Mlbs) Zn, 311 Kt (685 Mlbs) Pb, 267 t (8.6 Moz) Ag	Structural reinterpretation of satellite imagery. 8 holes on Cardiac Creek zone, 4700 m total. 1100 samples taken. All holes intersected mineralization; final two expanded indicated resource.
Aspen	ML Gold Corp.	Au, Ag; Low sulphidation epithermal; 093F 038, 093F 028	na	9.6 km IP survey.
Blackwater	New Gold Inc.	Au, Ag, Cu; Low sulphidation epithermal Au-Ag-Cu; 093F 037	M: 117Mt 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 Mg/t Au, 6.0 g/t Ag, containing 4.73 Moz Au, 36.47 Moz Ag, additional to reserves	Continued to advance EA process, geotechnical site investigations, soil and till sampling, reclamation. EA approval anticipated 2017.
BT	Porpoise Bay Minerals Ltd.	Ni, Cu, Au, Co; Serpentine-hosted; 093G 063, 064, 073, 074	na	Rock samples over 6 years averaged 0.185% Ni. Backpack drilling and sampling for analysis. 2017: sampling over 24 m in serpentinite returned over 1% Cu values, with anomalous cobalt.
CAP claims (formerly Carbo)	Arctic Star Exploration Corp.	Nb ₃ O ₅ ; Carbonatite- hosted deposits	na	4 drill holes, total 647.5 m, prospecting. Discovered a new carbonatite deposit. Drilling highlight 0.63% Nb ₂ O ₅ over 2.26 m.
Cat	Cat Syndicate	Cu, Au, Ag; Alkaline porphyry Cu-Au; 094C 069	na	Prospecting sampling.
Chuchi	AuRico Metals Inc.	Cu, Au; Alkaline 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)	Property inspection for familiarize and to outline 2018 exploration targets. AuRico Metals Inc. purchased the property from Kiska Metals Corp.
Coral	Minfocus Exploration Corp.	Zn, Pb; Mississippi Valley-type Pb-Zn; 094B 008, 094B 021	na	Completed a 16 km ² LiDAR survey over the property.

Table 5. Continued.

Decar	FPX Nickel Corp.	Ni; Ultramafic-hosted; 093K 039, 093K 072	2013 I: 1160 Mt at 0.124% Ni Inf: 870 Mt at 0.125% Ni	8 holes total 1197 m, along strike from previous drilling. Results support expansion of Baptiste deposit 650 m to SE. 2017 and previous drilling in the southeast portion of the Baptiste deposit defined a zone approximately 1000 metres long east-west by 200 to 600 metres wide of near-surface mineralization.
Duke	Amarc Resources Ltd.	Cu, Mo, Au; Porphyry Cu-Au; 093M 009, 093M 121, 093M 163	historic non-NI 43-101 compliant I: 41 Mt at 0.25% Cu, 0.01% Mo	2 holes, total 1045.5 m, with several intersections over 1.1 g/t Au.
Fran East	MGX Minerals Inc.	Cu, Au; Alkaline porphyry Cu-Au; 093K 108, 093N 207	na	3 holes total 112.6 m intersected mostly overburden, except one that bottomed in mineralized Takla volcanic rocks. Deeper drilling planned for 2018.
Gibson	Canex Metals Inc.	Au, Ag, Cu; High sulphidation epithermal Au-Ag-Cu; 093N 185	na	8 trenches; Au values across 400 x 150 m. Strong Au soil anomalies across 500 x 850 m.
Groundhog North	Atrum Coal Ltd.	Coal; Anthracite; 104A 086, 104A 078	M+I: 349 Mt in situ Western Domain Inf: 260 Mt in situ Eastern Domain	Environmental baseline water survey and monitoring. Permit on hold in context of new management board.
JD	Freeport McMoRan Mineral Properties Canada Ltd.	Au, Ag; Epithermal vein Au-Ag; 094E 171	na	13.8 line km IP, mapping.
Joy	Amarc Resources Ltd.	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 fines samples for analysis, mapping. Farm-in agreement with Hudbay Mining (Amarc was 2017 operator).
Kemess East	AuRico Metals Inc.	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.	New NI 43-101 July 2017. 10 holes (8 on Kemess East and 2 on “offset zone,” total 13,923 m. AuRico Metals purchased by Centerra Gold, subject to final approval Jan. 2018.
Kliyul	Aurico Metals Inc.	Cu, Au, Ag; Au skarn, subvolcanic Cu-Ag-Au (As-Sb); 094D 023, 094D 182	I: historic non-NI 43-101 compliant: 2.3 Mt at 6.9 g/t Ag, 1.3 g/t Au, 0.45% Cu.	350 m grid total 383 rock/soil samples for analysis, surface ELF survey. AuRico acquired Kiska Metals Corp. March, 2017.

Table 5. Continued.

Kwanika	Kwanika Copper Corp. (65%) Serengeti Resources Inc. (35%) Daewoo Minerals Canada Corp.	Cu, Au, Ag; Porphyry Cu±Mo±Au; 093N 073	I: Central Zone pit: 101.5 Mt at 0.31% Cu, 0.32 g/t Au, 0.96 g/t Ag, containing 316.2 Kt (697.2 Mlbs) Cu, 32.3 t (1.04 Moz) Au, 97.0 t (3.12 Moz) Ag; Central Zone UG: 29.7 Mt at 0.34% Cu, 0.36 g/t Au, 1.05 g/t Ag, containing 100.8 Kt (222.3 Mlbs) Cu, 10.9 t (350 Koz) Au, 31.4 t (1.01 Moz) Ag	New NI 43-101 released April 2017. Serengeti and Daewoo formed joint venture company, Kwanika Copper Corp., agreement completed October 2017.
Longworth	MGX Minerals Inc.	Silica; Silica-rich rocks; 093H 038	na	3 drill holes total 500 m, 28 line km IP and Mag, 744 soil samples, ZTEM heli survey reinterpretation. 99.5% SiO ₂ average value (Snow zone boreholes).
Milligan West	Serengeti Resources Inc. (56%) Fjordland Exploration Inc. (44%)	Cu, Au; Alkalic porphyry Cu-Au; 093N 131	na	3-hole, total 1220 m drill program. Further work indicated.
Mt. Milligan	Centerra Gold Inc. (Centerra BC Holdings)	Cu, Au, Ag; Alkalic porphyry Cu-Au; 094N 194, 093N 091	Producing mine; see Table 1	On-lease exploration 13 holes total 6100 m, Off lease, 68.6 line km IP, 320 line km ground magnetics.
Nechako Gold	Tower Resources Ltd.	Au, Ag; Epithermal; 093F 060, 093F 004	na	IP survey detected 1000 x 500 m anomaly over untested area. 38 RC drill holes to test till and top of bedrock in area of anomaly, results pending.
OGK (Nova Block)	Cat Syndicate	Cu, Au, Ag; Alkalic porphyry Cu-Au; 094C 177, 094C 138, 094C 174	na	Geochemical sampling (rock), prospecting.
Orbit	Jonathan Rempel	Mo; Porphyry; 093K 115, 093K 106	na	Mechanical till sampling.
Panorama North	Atrum Coal Ltd. (JOGMEC (Japan Oil, Gas, and Metals National Corporation))	Coal; Anthracite; 104A 085, 104A 089	na	5 wide-spaced drill holes, total 1227.5 m, extensive surface mapping, core studies and interpretation. JOGMEC entered a farm-in agreement in 2016.
Pil (Pillar East)	Finlay Minerals Ltd.	Cu, Au, Ag; Porphyry Cu±Mo±Au, Au-Ag-Cu (low sulphidation); 094E 213, 094E 215, 094E 216, 094E 217	na	Airborne magnetometer survey. Permitted for heli-supported drill program.

Table 5. Continued.

Pinnacle Reef (formerly Later)	Pacific Empire Minerals Corp. (ML Gold Corp.)	Cu, Au; Alkalic porphyry Cu-Au; 093N 169	na	5 holes from 3 sites, total 1079.6 m, access trail drill site reclamation.
Snowbird	Omineca Gold Ltd.	Au epithermal in quartz veins; 093K 036	na	10 holes, focus on Main and North zones, total 1212 m. 50 line km ground mag, mapping, soil (139) and rock (111) sampling. 8 holes showed multi-gram Au intervals. Deposit open below 50 m.
Stardust (formerly Lustdust)	Sun Metals Corp.	Ag, Pb, Zn; Skarn Ag-Pb-Zn; 093N 009	na	3 drill holes total 500 m, 28 line km IP and Mag, 744 soil samples, ZTEM heli survey reinterpretation. June 2017, optioned by Lorraine Copper Corp. to 1124245 BC Ltd. Nov. 2017, acquired by Sun Metals Corp.
Toodoggone Gold	Sable Resources Ltd.	Au, Ag; Epithermal Au-Ag-Cu (low sulphidation); 094E 026, 094E 072, 094E 027	na	Airborne geophysics. Permitted for IP, Drilling. 2017 focus was on site cleanup, development of reclamation/closure plans (Baker and Shasta).
UDS	Serengeti Resources Inc.	Cu, Au, Ag; Porphyry Cu±Mo±Au; 094E 070	na	3 holes, total 1140 m, roughly triangular layout, 330-650 m apart. Additional work considered warranted.

M = Measured; I = Indicated; Inf = Inferred

Table 6. Selected exploration projects, Northeast Region.

Project	Operator (partner)	Commodity; Deposit type; MINFILE	Resource (NI 43-101 compliant unless indicated otherwise)	Comments
Flatbed	Colonial Coal International Corp.	Coal; Bituminous 093I 049	Inf: 298 Mt	5 vertical holes on approx. 1800 m centres, total 2832 m. Flat-lying Gates Fm. coal at about 700 m depth.
Huguenot	Colonial Coal International Corp.	Coal; Bituminous	M: 96.2 Mt surface, 18.85 Mt underground. I: 35.75 Mt surface, 126.88 Mt underground	Continued environmental monitoring.

M = Measured; I = Indicated; Inf = Inferred

7.2. Selected porphyry projects

All ten of the porphyry projects discussed below are in the North Central Region.

7.2.1. Mt. Milligan (Centerra Gold Inc.)

Centerra Gold's **Mt. Milligan** mine is the only current producer in the North Central Region. (see section 3.1.1. above). During 2017, Centerra undertook significant on-lease exploration activities close to the open pit. Thirteen boreholes, totalling 6,100 m were completed, all near the west and northwest pit walls, to infill areas of low-density drilling and to test for extensions to the ore body. In addition, about

68.8 line km of IP exploration on 400 m line spacing were completed on Centerra claims south of the open pit, and 320 line km of ground magnetics, southwest of the open pit, on 100 m line spacing.

7.2.2. Duke (Amarc Resources Ltd.)

Amarc's **Duke** (formerly Dorothy) property, includes a copper+/-molybdenum porphyry deposit that was the subject of an historic (NI 43-101 non-compliant) inferred resource estimated at 40.8 million tons at 0.25% Cu and 0.01% Mo. The property was explored intermittently by IP and magnetic surveys, and by shallow drilling, between 1965 and 2010,

and was acquired by Amarc in 2016. The early IP work had suggested that the mineralized system might be offset by faulting, leaving significant prospective areas unexamined. In late autumn 2017, the company had a significant drilling program underway on Duke.

7.2.3. Milligan West (Serengeti Resources Inc. (56.3%), Fjordland Exploration Inc. (43.7%))

The **Milligan West** project is a copper-gold alkalic porphyry in the Quesnel terrane just west of the Mt. Milligan mine site. It has been operated as a joint venture by Serengeti and Fjordland since 2007. In 2016, a deep-penetrating IP survey discovered a strong anomaly 4 km west of the Mt. Milligan mine and, in 2017, a 30-hole, 1220 m program was completed. Sulphide-bearing rocks were intersected, including intrusive rocks that the partners considered part of the Mt. Milligan intrusive suite.

7.2.4. Fran East (MGX Minerals Inc.)

The **Fran East** property, accessible by logging roads, is about 60 km north of Fort St. James in an area underlain mostly by Takla Group sedimentary and volcanoclastic rocks. At the Fran prospect en-echelon shear zones host quartz-sulphide veins, stockworks and replacement mineralization. Fran East is a new target east of Fran. In 2017, three boreholes totalling 112.6 m were drilled to depths ranging from 20.4 to 67.1 m. Most of the drilling intersected Quaternary glacial drift and varved clay, but one hole bottomed in magnetite-bearing Takla Group volcanic rocks containing quartz-calcite veins and sulphide mineralization. The company plans to return to the site with equipment that can penetrate to greater depths.

7.2.5. Pinnacle Reef (ML Gold Corp., Pacific Empire Minerals Corp.)

Pinnacle Reef (formerly referred to as Later) is accessible by resource road about 100 km north of Fort St. James. The prospect is near a fault contact between intermediate volcanic units of the Chuchi Lake succession and the Hogem intrusive complex, where a northeast-trending lineament intersects a discontinuity in the regional fabric. Drilling in 2015 and 2016 targeted a possible gold-rich alkali porphyry coincident with a large IP geophysical anomaly, and encountered gold mineralization in a zone of volcanic rocks with phyllic alteration. Work in 2017, included 12 line km of ground geophysics and drilling of five boreholes at three sites, totalling 1079.6 m.

7.2.6. Kwanika (Serengeti Resources Inc.)

The **Kwanika** project is about 140 km northwest of Fort St. James and can be accessed by resource roads. From work spanning more than a decade, Serengeti has defined two principal porphyry deposits, referred to as the Central (copper-gold-silver) and South (copper-molybdenum-gold-silver) zones. Both are hosted by potassic-altered mostly monzonitic rocks of the Hogem batholith.

In April 2017, Serengeti released a NI 43-101 report and preliminary economic assessment on Kwanika. The report

posits a combined open pit and underground operation with an estimated mineral resource of 131.2 Mt Measured + Indicated, and 73.1 Mt Inferred. The projected mine life is 15 years, with a milling rate of 15,000 tpd. The **Central Zone** is projected to be a combined open pit and underground operation. The open pit Indicated resource is 101.5 Mt grading 0.31% Cu, 0.32 g/t Ag and 0.96 g/t Au, containing 697,200 Mlb Cu, 1040 Moz Au, and 3120 Moz Ag. The underground mine has an Indicated resource of 29.7 Mt grading 0.34% Cu, 0.36 g/t Au, and 1.05 g/t Ag, containing 222,300 Mlb Cu, 350 Moz Au, and 1010 Moz Ag. The proposed **South Zone**, proposed as an open pit, contains an Inferred resource of 33,300 Mt, grading 0.26% Cu, 0.08 g/t Au, 1.64 g/t Ag, and 0.01 % Mo, containing 191,400 Mlb Cu, 80 Moz Au, 1760 Moz Ag, and 7470 Mlb Mo.

In October, Serengeti completed an agreement with POSCO Daewoo and Daewoo Minerals Canada (DMC) to form a joint venture company, the Kwanika Copper Corporation (65% Serengeti, 35% Daewoo), to pursue development. Under the agreement, DMC will contribute \$7 million and its 5% interest in Serengeti, and Serengeti will contribute the balance of its interest in the project. Serengeti will continue as project operator.

7.2.7. UDS (Serengeti Resources Inc.)

The **UDS** prospect is about 7 km south of the former Kemess South mine. The district contains both vein-type epithermal precious metal occurrences and porphyry gold-copper deposits, and the UDS has a geological setting similar to that of Kemess (see section 6.1.1.). An IP program in 2016 defined a target area about 1500 x 900 m that was investigated in 2017 by 1140 m of drilling in three holes 330-650 m apart. Additional work was considered warranted.

7.2.8. Kemess East (AuRico Metals Inc.)

Subject to shareholder approval, AuRico Metals was sold to Centerra Gold Inc. in 2017. The **Kemess East** (KE) deposit is about 1 km east of Kemess Underground (KUG; see section 6.1.1.).

KE is a copper-gold-silver-molybdenum calc-alkaline porphyry deposit hosted mostly by potassic-altered Black Lake plutonic rocks, with mineralization extending from about 900 m below surface to 1500 m below surface. In July 2017, a NI 43-101 report identified an Indicated resource of 113.12 Mt grading 0.38% Cu, 0.46 g/t Au, and 1.94 g/t Ag, containing 954 Mlb Cu, 1680 Koz Au, and 7066 Koz Ag. Since its discovery in about 2007, Kemess East has been explored by 91 boreholes, including ten holes in 2017. Of the 13,923 m drilled in 2017, eight holes tested the deposit's northern and southern extents, and two tested the northern extent of the Kemess Offset Zone (KOZ). On Kemess East itself, hole KE: KH-17-05 intersected 338 m of 0.64 g/t Au and 0.45% Cu, including 120 m of 1.05 g/t Au and 0.60% Cu. KH-17-08B intersected 846.5 m of 0.25 g/t Au and 0.28% Cu, including 208 m of 0.37 g/t Au and 0.41% Cu. KH-17-09 intersected 853.8 m of 0.24 g/t Au and 0.25% Cu, including 147.5 m of 0.40 g/t Au and 0.42% Cu. On KOZ,

KH-17-10 intersected 461.9 m of 0.27 g/t Au and 0.22% Cu, including 75 m of 0.61 g/t Au and 0.41% Cu.

7.2.9. Joy (Amarc Resources Ltd., Hudbay Minerals Inc.)

Amarc's **Joy** project is a copper+/-molybdenum+/-gold porphyry target. Based primarily on soil surveys, Deposit Target 1 was outlined in 2016, with a core area of 4.5 km² within a larger cluster extending across approximately 9 km². The extensive coincident copper-molybdenum-gold-silver-lead-zinc soil anomalies at Joy are interpreted to represent a potential shallowly buried copper-gold porphyry deposit.

In August 2017, Amarc completed a farm-in agreement with Hudbay Minerals, with Hudbay to spend \$15 million on the property by the end of 2020, including \$1.9 million in 2017. Drilling was undertaken, consisting of three boreholes totalling 1527 m, to test coincident IP and geochemical anomalies. Amarc also completed an airborne magnetometer survey, 49 line km of IP, geological mapping, and a geochemical survey that included 638 fine-grained talus samples.

7.2.10. Pil (Finlay Minerals Ltd.)

The **Pil** property is about 34 km northwest of AuRico Metals' Kemess project, and is accessible by resource roads from Mackenzie. Pil has been extensively explored for alkali copper-silver porphyry mineralization and epithermal gold-silver. The property encompasses several areas of mineralization, with the Pillar East and Atlas Zones being of greatest current interest. Pillar East is a north-northeast oriented quartz breccia epithermal system spatially and temporally associated with an alkalic copper-silver monzonite porphyry. In 2017, the company completed an airborne magnetometer survey over the Pillar East zone, and was permitted to begin a helicopter-supported drill program.

7.2.11. Orbit (Jonathan Rempel)

The **Orbit** project is about 15 km northeast of the Endako Mine (now on care and maintenance). In 2017, the proponent followed up on a 2016 program to sample basal till and near-surface bedrock, with mechanical till sampling. A low-level copper and iron anomaly and a small molybdenum anomaly were identified.

7.3. Selected polymetallic base and precious metal projects

Polymetallic base and precious metal projects in the North Central region include SEDEX and Mississippi Valley-type lead-zinc deposits. Although the **Akie** SEDEX project (Canada Zinc Metals) at Cardiac Creek saw significant exploration activity, the geologically related Cirque, Cirque East, Pie and Yuen prospects were idle, apart from being included in a regional structural analysis. Minfocus Exploration Corp.'s Coral Mississippi Valley-type lead-zinc prospect was idle except for completion of a LiDAR survey.

7.3.1. Akie (Canada Zinc Metals Corp.)

The **Akie** property, which contains the Cardiac Creek SEDEX

deposit, is underlain by siliciclastic and carbonate rocks of the Kechika, Road River and Earn groups near the western margin of ancestral North America. The property is accessible by resource roads, although a washout complicated access for much of the field season. The Cardiac Creek SEDEX deposit is in shales of the Gunsteel Formation (Earn Group). It is a steeply southwest-dipping stratiform baritic zinc-lead-silver body, averaging about 20 m thick. The principal economic minerals are sphalerite and galena. In 2016, the company issued a NI 43-101 report on Akie that defined an Indicated resource of 19.6 Mt grading 8.2% Zn, 1.6% Pb and 13.6 g/t Ag (at a 5% zinc cut-off grade) and an Inferred resource of 8.1 Mt grading 6.8% Zn, 1.2% Pb and 11.2 g/t Ag (at a 5% Zn cut-off grade). In 2017, the company conducted a drilling program on the Cardiac Creek deposit, aimed at extending the resource, completing eight holes totalling 4700 m. All holes intersected the mineralized zone and two expanded the indicated resource (Fig. 9). Noteworthy is borehole A-17-132, which returned 10.38% Zn+Pb and 14.2 g/t Ag over a true thickness of 28.67 m, including 12.39% Zn+Pb and 15.9 g/t Ag over a true thickness of 19.81 m, which further included 14.42% Zn+Pb and 17.2 g/t Ag over a true thickness of 10.16 m. Borehole A-17-133 returned 12.11% Zn+Pb and 16.0 g/t Ag over a true thickness of 9.42 m in a broader mineralized interval of 25.63 m. Borehole A-17-137 intersected 67.79 m grading 11.79% Zn+Pb and 19.1 g/t Ag, including 15.44 m grading 22.61% Zn+Pb and 36.1 g/t Ag. Borehole A-17-142, returned an envelope of mineralization grading 11.15% Zn+Pb and 15.5 g/t Ag over a true thickness of 32.65 m including 23.32% Zn+Pb and 30.9 g/t Ag over a true thickness of 11.31 m from the Footwall Zone. Borehole A-17-143 returned 7.77 % Zn+Pb and 9.8 g/t Ag over a true thickness of 20.49 m, including 10.41% Zn+Pb and 15.0 g/t Ag over a true thickness of 7.90 m. In 2017, Canada Zinc Metals completed a structural interpretation of satellite imagery over the Kechika trough, including Akie. The interpretation identified predominantly northeast-vergent thrust faults, except for a zone along the eastern margin of the area with structures



Fig. 9. Mottled high-grade sphalerite and galena, hole A-17-137, at approximately 529 m depth (courtesy of Canada Zinc Metals Corp.).

that verge southwest, and major transverse faults. Forty-one new exploration targets were identified.

7.4. Selected skarn projects

Exploration was carried out on two skarn projects, both in the North Central Region.

7.4.1. Stardust (Sun Metals Corp.)

The **Stardust** (formerly **Lustdust**) property is a few kilometers to the northwest of Serengeti Resources' Kwanika project. The principal system, the Canyon Creek deposit, consists of copper, gold, and silver mineralization in a limestone, dolomite and dolomitized limestone skarn. A NI 43-101 compliant report, completed in 2010, stated an Indicated resource of 1.253 Mt grading 1.33% Cu, 1.426 g/t Au and 33.0 g/t Ag. An additional 3.124 Mt grading 1.12% Cu, 1.366 g/t Au, and 25.4 g/t Ag was classified as Inferred.

Lorraine Copper acquired the claims in 2016 from ALQ Gold Corp. In June 2017, Lorraine optioned the property to 1124245 B.C. Ltd.; with the numbered company to purchase 100% of its interest by the end of 2017 for cash and \$500,000 property expenditure, and to continue \$6 million in expenditures by the end of 2021. In November 2017, the property was acquired by Sun Metals Corp. In 2017, Lorraine collected 744 soil samples to extend existing grids, ran 28 line km of IP and magnetic surveys, reinterpreted a 2011 ZTEM survey, and completed a 3 borehole drilling program to complete existing holes and to verify the continuity of three known mineralized zones.

7.4.2. Kliyul (AuRico Metals Inc.)

Kliyul (Fig. 10) is a copper-gold prospect hosted by Takla Group volcanic and sedimentary rocks that are cut by small Jurassic mid-Cretaceous diorite plutons. Mineralization comprises gold-bearing quartz veins, magnetite-rich skarn, and mineralized shear zones in altered andesite units. The skarn is most prominent, containing disseminated gold-bearing chalcopyrite and pyrite.

AuRico Metals acquired the property from Kiska Metals Corp. in March 2017, then entered into an agreement with First Quantum to conduct early-stage exploration for one year. AuRico and First Quantum completed a 30-day field program



Fig. 10. Kliyul Camp 2017 (courtesy of AurRico Metals Inc.).

that included sampling bedrock (294), subcrop (28) and soil/talus-fines (60) on a 350 m grid across the entire property. A surface ELF grid was completed across much of the property.

7.5. Selected mafic and ultramafic hosted projects

Zones of tectonically emplaced nickel-bearing ultramafic rock (serpentinite) occur along the Pinchi Fault, which separates the Quesnel and Cache Creek terranes. These serpentinite units host jade deposits and nickel mineralization.

7.5.1. Decar (FPX Nickel Corp.)

FPX Nickel Corp. (formerly First Point Minerals Corp.) continued exploration on the **Decar** project west of Fort St. James, with the technical support of Equity Exploration Consultants. The site is readily accessible by resource roads. The host rocks are tectonically emplaced serpentinized ultramafic rocks that are mineralized by disseminated awaruite (Ni_3Fe ; Fig. 11). In 2017, the company drilled eight boreholes totalling 1197 m at the **Baptiste** deposit. Near-surface mineralization was extended 500 m beyond previous drill coverage, and supported possible extension of the mineralized zone by 650 m to the southeast.

Borehole 67 intersected 96 m grading 0.167% Ni, starting at an approximate vertical depth of 42 m below surface, representing the second-highest grade, near-surface interval intersected at the deposit. Borehole 68 intersected 124 m grading 0.133% Ni, starting at an approximate vertical depth of 20 m below surface. To date, drilling in the southeast part of the Baptiste deposit has defined a zone of near-surface mineralization approximately 1000 m long and 200 to 600 m wide.

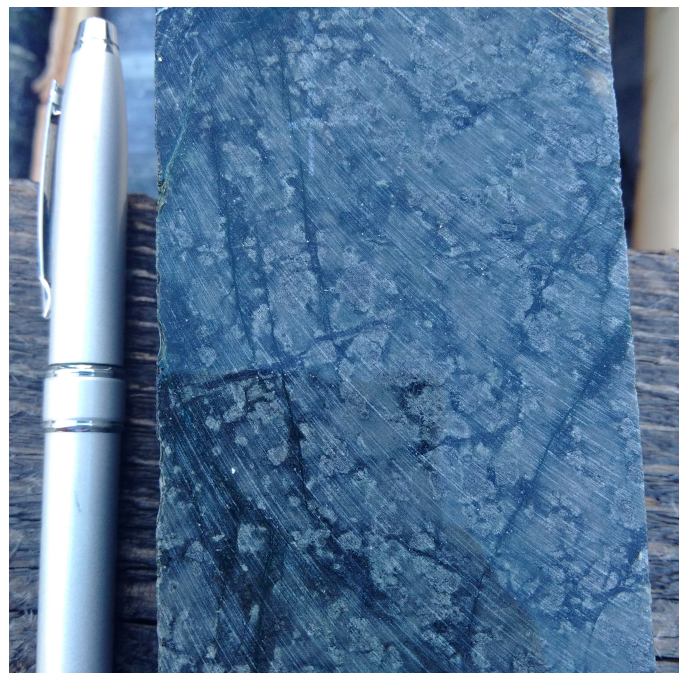


Fig. 11. Awaruite-bearing serpentinite in pseudobreccia, hole 17-BAP-063, at approximately 184 m depth.

7.5.2. BT (Porpoise Bay Minerals Ltd.)

Porpoise Bay Minerals' **BT** property is a nickel-copper-gold in serpentinite deposit about 60 km southwest of Prince George. Detailed sampling and prospecting over several years returned rock samples that averaged 16.98% Mg and 0.195% Ni. The occurrences have been extensively prospected but await detailed investigation. In 2017, outcrops were explored by backpack drilling, and samples were collected for analysis.

7.6. Selected specialty metal projects

The Western margin of continental platformal rocks is host to at least two carbonatite deposits. Taseko Mines Ltd.'s Aley project (described above), and a new discovery by Arctic Star Exploration Corp.

7.6.1. CAP Claims (Arctic Star Exploration Corp.)

In 2017, Arctic Star drilled four holes totalling 647.5 m to test coincident geochemical and geophysical anomalies on its **CAP** (formerly Carbo) property. A carbonatite-syenite (Fig. 12) was discovered in outcrop and in one of the boreholes. Between surface exposures and drilling, the deposit has a strike length of up to 3 km. In the borehole, at least 138.5 m of carbonatite was intersected: 0.35% Nb_2O_5 across 10.42 m (including 2.26 m of 0.63% Nb_2O_5); 19.63 m of 9.94% P_2O_5 (including 2.55 m of 20.97% P_2O_5); and 2.4 m of 0.81% TREOs (total rare earth element oxides).



Fig. 12. Boudin-like feature in limestone (above) intruded by carbonatite (below), CAP claims.

7.7. Selected coal projects

Coal exploration in the Northeast Region remained at a low level, with only one significant project near the Trend Mine (now on care and maintenance). In the Klappan coalfield north of Smithers, Atrum Coal continued work on its Groundhog and Panorama North projects.

7.7.1. Flatbed and Huguenot (Colonial Coal International Corp.)

Colonial Coal's **Flatbed** project is adjacent to Anglo American's Trend Mine. The project targets flat-lying coal in the Gates Formation (Middle Cretaceous) at depth. In 2017, the company drilled five vertical holes on 1800 m centres totalling 2830 m (Fig. 13). The holes encountered flat-lying coal units, with common shaly interbeds, at depths of about 700 m. Downhole geophysical logs were completed, and core sampled. The core was stored frozen in the company's facility near Tumbler Ridge until sampling was complete. An NI 43-101 report on the project released in late November 2017 outlined an underground mineable Inferred resource of 298 Mt of bituminous coal that were referred to as having "coking properties after beneficiation." Colonial continued environmental monitoring studies on its **Huguenot** project south of the Trend Mine. The property contains combined Measured and Indicated surface resources of 131.95 Mt, and combined underground resources of 145.73 Mt.



Fig. 13. Coarse sandstone with pebbles overlying Gates Formation D seam, 726 m.

7.7.2. Groundhog North (Atrum Coal Ltd.)

The Groundhog coalfield consists of an estimated 1.57 Bt in total Measured, Indicated and Inferred categories of high- and ultra high-grade anthracite in the Groundhog unit of the Upper Bowser Lake Group (Jurassic-Lower Cretaceous). The host rocks are folded in an open northwest-trending synclinorium within which the target seams are about 2 m thick at a depth of 72 m, and about 3 m thick at a depth of 265 m.

7.7.3. Panorama North (Atrum Coal Ltd., JOGMEC (Japan Oil, Gas, and Metals National Corporation))

The **Panorama North** project is about 15 km west of the Groundhog coalfield and, similar to Groundhog, it hosts anthracitic coal seams. In 2016, Atrum entered a farm-in agreement in which JOGMEC agreed to contribute \$5 million

in cash or in-kind support for three years to earn a 35% interest in the project. During the initial program (2016), multiple shallow coal seams were encountered, including a 2.3 m thick seam at only 12 m depth. In 2017, extensive surface mapping was undertaken to identify and trace coal seams, and five wide-spaced boreholes were completed, totalling 1227.5 m.

7.8. Jade project: Ogden Mountain (Green Mountain Jade)

Ogden Mountain, in the North Central Region, was the only active Jade project in 2017. Green Mountain Jade Inc. continued mining and exploring on the property.

7.9. Selected industrial mineral projects

7.9.1. Longworth (MGX Minerals Inc.)

The **Longworth** quartzite project is in the North Central Region about 82 km east of Prince George, adjacent to the northern Rocky Mountain trench. It is hosted by Silurian greenstone, carbonate, and quartzite units of the Nonda Formation, in a steeply northeast-dipping, northwest-trending synform. Ridges of white quartzite are exposed intermittently for 6 km. Each of four high-purity zones (Snow, Rain, Long and Doll) extend along strike for 300 to 800 m and are about 400 m thick. The quartzite is massive and homogeneous; it contains muscovite, limonite and calcite as minor impurities. In 2017, the company completed three boreholes to depths ranging from 51.5 to 69 m, for a total of 186.1 m. Results indicated an average of 99.5% SiO₂ in the Snow Zone, which compares closely with surface samples.

8. Geological research

As part of a British Columbia Geological Survey project to better understand ultramafic rocks in the Cache Creek terrane, Milidragovic et al. (2018) undertook a mapping project near FPX Nickel's Decar property (see section 7.5.1.) to update existing maps, establish the petrological evolution of the mantle tectonites that host prospective awaruite mineralization, and develop a chemostratigraphic framework for Permo-Triassic volcanic and related intrusive rocks. Buckingham et al. (2017) integrated a set of gravity maps to help delineate subsurface faults in a part of Geoscience BC's TREK (Targeting Resources for Exploration and Knowledge) project area that includes the Blackwater gold deposit (see section 6.1.2.), and Angen et al. (2017) released a geological compilation map of the same area.

9. Summary

Relative to previous years, the North Central and Northeast regions saw increased levels of mining and exploration activity in 2017. Two of the coal mines in the Northeast Region that had been on care and maintenance status reopened, and a third is expected to resume in 2018. A major mine application was submitted the North Central region. The pace at which Notices of Work (exploration permits) were being issued increased through the year, and preliminary work began on ground held under multi-year permits. Major highlights in 2017 include the following.

- Re-opening of Brule and Perry Creek (Wolverine Project) metallurgical coal mines by Conuma Coal Resources Ltd.
- Issuance of an Environmental Assessment Decision Statement by the Government of Canada, subject to conditions, in favour of HD Mining International Ltd.'s proposed Murray River underground metallurgical coal mine.
- Submission of a Major Mine Permit application for the Kemess Underground project by AuRico Metals Inc.
- Continued extensive drilling on AurRico's Kemess East project.
- Completion of an agreement between Serengeti Resources Inc. and POSCO Daewoo and Daewoo Minerals Canada (DMC) to form a joint venture company, the Kwanika Copper Corporation, to pursue development of the Kwanika Central and South Zones.
- Reactivation of FPX Nickel Corp's Decar project, and extension of the mineralized zone to the southeast by drilling.
- Discovery of a new carbonatite deposit on the CAP claims by Arctic Star Exploration Corp.

Acknowledgments

The writer acknowledges with thanks the willingness of project proponents to share information about their work, both through online publication and particularly by personal communication. My Regional Geologist colleagues, staff in the Mineral Development Office, the Geological Survey of British Columbia, and the Ministry's Regional Office in Prince George, were unfailingly generous with their time and supportive in their comments.

References cited

- Andrews, P., Berthelsen, D., and Lipiec, I., 2017. Milligan Mine, North Central British Columbia, NI 43-101 Report for Centerra Gold, Inc., 238 p.
- Angen, J.J., Rahimi, M., Westberg, C.J.R., Logan, J.M., and Kim, R., 2017. Bedrock Geology, TREK project area, northern Interior Plateau, central British Columbia. Geoscience BC Map 2017 06-01 and MDRU Map12-2017, scale 1:250,000.
- Buckingham, A.J., Core, D.P., Hart, C.J.R., and Jenkins, S., 2017. TREK project area gravity compilation, enhancement filtering and structure detection, Geoscience BC Report 2017-14, 34 p.
- Clarke, G., Northcote, B., Katay, F., and DeGrace, J.R., 2018. Exploration and Mining in British Columbia, 2017: A summary. In: Provincial Overview of Exploration and Mining in British Columbia, 2017. British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Information Circular 2018-1, pp. 1-33 (this volume).
- Cui, Y., Miller, D., Schirizza, P., and Diakow, L.J., 2017. British Columbia digital geology. British Columbia Ministry of Energy and Mines and Petroleum Resources, British Columbia Geological Survey Open File 2017-8, 9 p.
- Ernst & Young LLP, in press. British Columbia Mineral and Coal Exploration Survey 2017 Report. < <http://www.ey.com/ca/bcminingsurvey> >.
- Hickin, A.S., Ward, B.C., Plouffe, A., and Nelson, J., 2017. Introduction to the geology, physiography, and glacial history of the Canadian Cordillera in British Columbia and Yukon. In: Ferbey, T., Plouffe, A., and Hickin, A.S., (Eds.), Indicator

- Minerals in Till and Stream Sediments of the Canadian Cordillera. Geological Association of Canada Special Paper Volume 50, and Mineralogical Association of Canada Topics in Mineral Sciences Volume 47, pp. 1-25.
- Jago, C. Paul, 2017. Exploration and mining in north central and northeast regions, British Columbia. In: Provincial overview of exploration and mining in British Columbia, 2016. Ministry of Energy and Mines, British Columbia Geological Survey Information Circular 2017-1, pp. 31-72.
- Milidragovic, D., Grundy, R., and Schiarizza, P., 2018. Geology of the Decar area north of Trembleur Lake, NTS 93K/14. In: Geological Fieldwork 2017, British Columbia Ministry of Energy, Mines and Petroleum Resources, British Columbia Geological Survey Paper 2018-1, pp. 129-142.
- Nelson, J.L., Colpron, M., and Israel, S., 2013. The Cordillera of British Columbia, Yukon, and Alaska: Tectonics and metallogeny. In: Colpron, M., Bissing, T., Rusk, B.G., 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, pp. 53-109.