INDUSTRIAL MINERAL ENDOWMENT AND DEVELOPMENT OPPORTUNITIES, NORTHEAST-CENTRAL BRITISH COLUMBIA

By Bob Lane, Ken MacDonald, Mining Operations Branch, British Columbia Ministry of Energy and Mines, Prince George, BC, Canada,
Brian McGrath, Cumberland Resources Ltd., Vancouver, BC, Canada
Nicole Robinson and George J. Simandl, British Columbia Ministry of Energy and Mines, Victoria, BC, Canada

INTRODUCTION

The industrial mineral endowment of northeast-central British Columbia is rich and varied. There are 390 industrial mineral occurrences in MINFILE, the Ministry of Energy and Mines electronic database (www.em.gov.bc.ca/Mining/Geolsurv/Minfile/default.htm) that are located within the administrative boundary of the region (Figure 1). These occurrences are reviewed with respect to physiography, tectonic terrane, deposit type, character and resource potential (Table 1).

Commodities of interest include sand and gravel, diatomite, limestone, clay and shale, rare earth elements, volcanic material, silica, barite, dimension stone, and jade. Glaciated areas of central British Columbia make sand and gravel (aggregate), the most abundant and economically important commodity in the region. Primary aggregate sources include terraces along the Nechako and Fraser Rivers, major meltwater channels, raised shorelines of former glacial lakes and, to a lesser extent, esker systems. Sand and gravel generally have a structural end use and are not discussed further here.

The region is serviced by a well-developed road and rail network. The city of Prince George (Figure 1) is central to the region, and is the transportation hub for the northern two-thirds of the province. Major transport routes radiate east to markets in Alberta, south through the province to markets in the Lower Mainland and the United States, and west to the port of Prince Rupert. Other routes extend northward and provide access to resource-rich areas. Most industrial mineral development is close to transportation corridors, such as highways 16 and 97, and a large number of logging arteries that span the region. Summaries of selected mineral commodities highlight the economic significance of past producers and introduce the importance of potential deposits. MINFILE reference numbers follow deposit names where applicable.

REGIONAL GEOLOGIC SETTING

The Canadian Cordillera can be divided into five, orogen-parallel belts of either continental or oceanic affinity (Monger and Nokleberg, 1996). Three of the belts – the Foreland, Omineca and Intermontane - trend north-westerly across northeast-central British Columbia (Figure 1). The Foreland Belt is comprised of folded and thrusted sedimentary rocks derived from the North American craton. The Omineca Belt is made up of complexly deformed and metamorphosed sedimentary, volcanic and granitic rocks of the pericratonic Kootenay (Barkerville and Cariboo subterranes) and Cassiar terranes, and the oceanic Slide Mountain terrane. The Intermontane Belt is an amalgamation of two major island arc assemblages, the Quesnel and Stikine terranes, that sandwich the Cache Creek terrane accretionary (or subduction) complex. The Overlap Assemblage, a package of younger sedimentary and volcanic rocks, covered all the major terranes. The wide range in depositional environments resulted in potential for diverse industrial mineral commodities, many of which are underexplored. Some industrial mineral commodities are restricted to, or concentrated in, particular terranes (Table 1). Selected industrial mineral occurrences and deposits are shown in Figure 2.

DIATOMITE

There are a number of recorded diatomite occurrences in the region (Hora and Hancock, 1995), including four past producers: Crownite (093B 023), Buck Ridge (093B 042), Quesnel (093B 059) and Big Bend (093G 039). Most are concentrated in the Quesnel area. The occurrences are mainly stratiform lacustrine deposits that formed within Tertiary volcanic and sedimentary sequences that crop out along a 40 kilometre belt that parallels the Fraser River from Big Bend (12 kilometres north of Quesnel) to Alexandria. The diatomite ranges in colour from white to grey to buff and consists mainly of Melosira granulata diatoms; most are very small, with variable amounts of clay, silt and volcanic ash.

Diatomite at the Crownite deposit (Hora and Hancock, 1995) 3 kilometres southwest of Quesnel occurs in beds up to 31 metres thick with interbeds of

TABLE 1. DISTRIBUTION OR SELECT INDUSTRIAL MINERAL OCCURRENCES IN NORTHEAST-CENTRAL BRITISH COLUMBIA

COMMODITY	STATUS & NUMBER OF OCCURRENCES		COMMODITY/DEPOSIT TYPE		DEPOSIT CHARACTER		TECTONIC BELT		TERRANE	
									Cache Creek	8
					Vein	9	Intermontane	9	Barkerville	1
Asbestos	Showing	10	Ultramafic-hosted	10	Stockwork	1	Omineca	1	Slide Mtn.	1
			Sediment-hosted	13	Stratiform	23			Ancestral NA	43
			Carbonate-hosted	12	Stratabound	11			Barkerville	2
	Developed Prospect	3	Other/Unknown	10	Vein	7	Foreland	43	Cariboo	1
	Prospect	5	Vein	5	Massive	5	Omineca	4	Cassiar	1
Barite	Showing	40	Sedex Zn-Pb-Ag	8	Other	2	Intermontane	1	Slide Mtn.	1
									Ancestral NA	2
							Foreland	3	Overlap Assemblage	1
Bentonite	Showing	4	Unknown	4	Stratiform	4	Omineca	1	Slide Mtn.	1
			Sandstone	2					Ancestral NA	2
Building Stone	Developed Prospect	2	Marble	2			Omineca	3	Cache Creek	1
Dimension Stone	Prospect	1	Granite	1			Foreland	2	Cassiar	1
Granite/Marble	Past Producer	2	Flagstone	1	Massive	4	Intermontane	1	Cariboo	1
Slate	Showing	2	Unknown	1	Stratiform	3	Unknown	1	Other	2
									Overlap Assemblage	8
	Prospect	1	Fireclay	18					Quesnel	7
Clay	Past Producer	4	Expanding Clay	1	Stratiform	21	Intermontane	17	Ancestral NA	4
Shale	Showing	17	Unknown	3	Unknown	1	Foreland	5	Other	3
			Lacustrine	7					Overlap Assemblage	5
	Past Producer	4	Volcanic Ash	1	Stratiform	8			Cache Creek	4
Diatomite	Showing	6	Unknown	2	Stratabound	2	Intermontane	10	Stikine	1
	Past Producer	1	Dolomite	2			Foreland	3		
Dolomite	Showing	3	Limestone	2	Stratiform	4	Omineca	1	Ancestral NA	4
					Stratabound	10				
	Developed Prospect	1	Carbonate-hosted	16	Vein	4				
	Prospect	6	Barite-fluorite vein	2	Stratiform	3				
Fluorite	Showing	12	Unknown	1	Other	2	Foreland	19	Ancestral NA	19
			Crystalline flake	2	Disseminated	2	Omineca	3	Cassiar	2
Graphite	Showing	4	Unknown	2	Other	2	Intermontane	1	Other	2
	Developed Prospect	1			Layered	1	Foreland	1	Ancestral NA	1
Gypsum	Showing	1	Bedded	2	Unknown	1	Intermontane	1	Quesnel	1

TABLE 1 (CONTINUED)

COMMODITY	STATUS & NUMBER OF OCCURRENCES		COMMODITY/DEPOSIT TYPE		DEPOSIT CHARACTER		TECTONIC BELT		TERRANE	
					Podiform	3				
	Past Producer	6			Massive	2			Cache Creek	4
Jade/Nephrite	Showing	1	Jade	7	Unconsolidated	2	Intermontane	7	Plutonic Rocks	3
							Omineca	2		
Kyanite	Showing	3	Kyanite-sillimanite schists	3	Layered	3	Foreland	1	Ancestral NA	3
									Ancestral NA	17
	Producer	2							Cache Creek	13
	Developed Prospect	5							Cariboo	10
	Prospect	6			Stratiform	47	Omineca	25	Slide Mtn.	6
	Past Producer	10			Stratabound	4	Intermontane	17	Cassiar	3
Limestone	Showing	29	Limestone	52	Massive	1	Foreland	10	Quesnel	3
					Stratiform	1				
			Umafic-host Talc-Magnesite	2	Stratabound	1	Intermontane	2	Cache Creek	2
Magnesite	Showing	3	Unknown	1	Vein	1	Foreland	1	Ancestral NA	1
	Prospect	1	Magmatic Oxide	1			Foreland	1	Ancestral NA	1
Magnetite	Showing	1	Unknown	1	Massive	2	Intermontane	1	Quesnel	1
					Vein	2			Cache Creek	5
			Mn/Vein Replacements	3	Layered	1	Intermontane	6	Cariboo	1
Manganese	Showing	7	Unknown	4	Unknown	4	Omineca	1	Stikine	1
					Vein	6				
			Pegmatite	10	Concordant	3	Omineca	14	Cassiar	9
	Past Producer	3	Kyanite/Sillimanite schists	2	Massive	3	Foreland	1	Kootenay	5
Mica	Showing	13	Unknown/Other	4	Unknown	4	Intermontane	1	Other	2
Perlite	Showing	1	Volcanic Glass		Stratabound		Intermontane		Overlap Assemblage	
	Prospect	1	Upwelling-type	17						
Phosphate	Showing	17	Unknown	1	Stratabound	18	Foreland	18	Ancestral NA	18
	Developed Prospect	2								
	Prospect	1	Silica Sandstone	4	Stratiform	5	Foreland	4	Ancestral NA	4
	Past Producer	1	Silica Veins	3	Vein	4	Intermontane	4	Barkerville	3
Silica	Showing	6	Other	3	Other	1	Omineca	2	Other	3
					Stratiform	2				
Sulphur	Showing	4	Gypsum-hosted	4	Massive	2	Foreland	4	Ancestral NA	4
	Developed Prospect	1	Umafic-host Talc-Magnesite	2	Massive	2				
Talc	Showing	2	Other	1	Vein	1	Intermontane	3	Other	3
	Past Producer	1								
Travertine	Showing	1	Unknown	2	Massive	2	Foreland	2	Ancestral NA	2
Vermiculite	Prospect	2	Vermiculite	2	Disseminated	2	Intermontane	2	Stikine	2

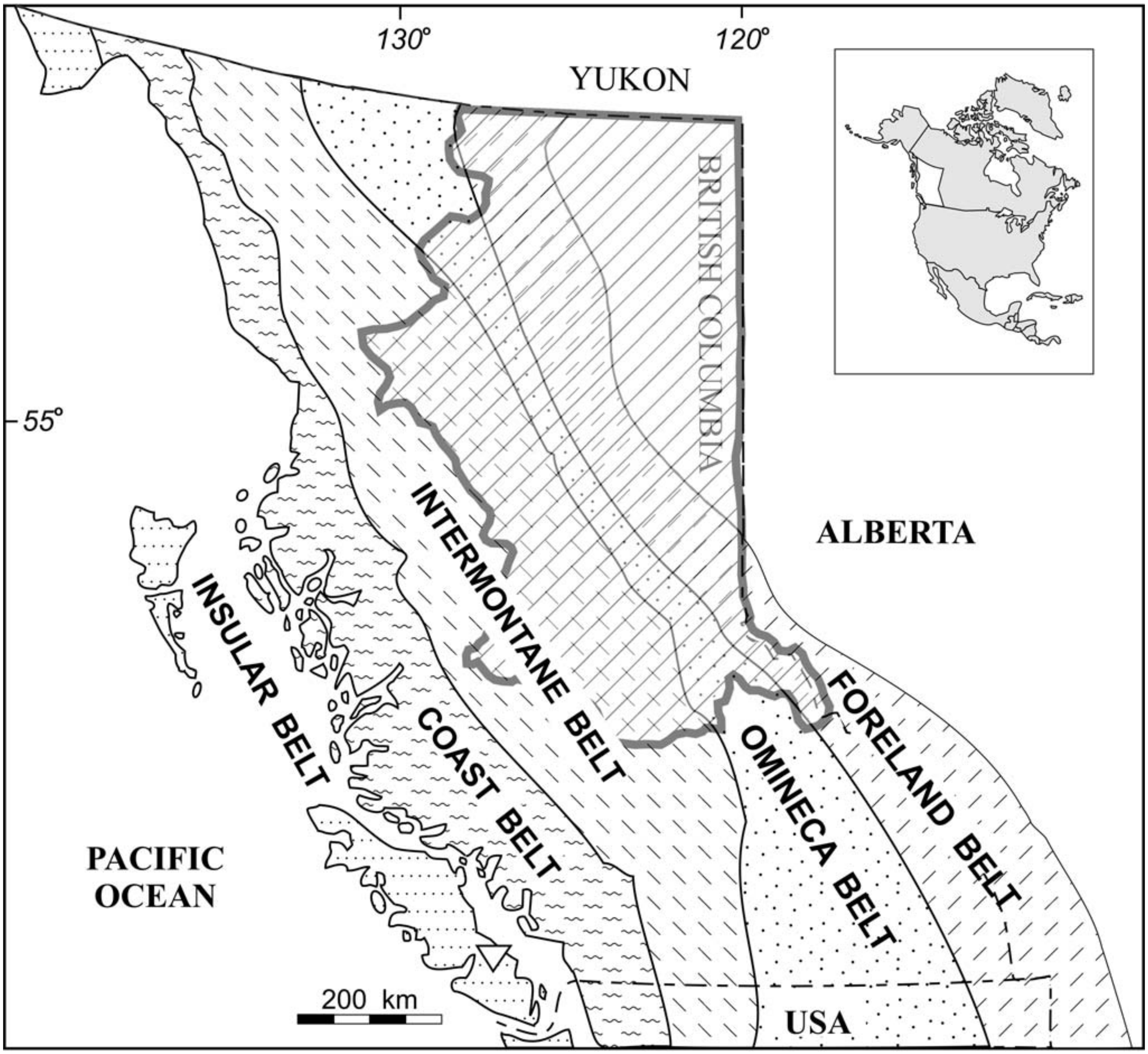

Figure 1. The tectonic belts of British Columbia. The cross-hatched area indicates the administrative region of Northeast-Central British Columbia.

clay, silt and ash. Recorded production has been 22 074 tonnes, and proven and probable reserves were estimated at a conservative 750 000 tonnes. The Buck Ridge deposit is located on the west side of the Fraser River, 27 kilometres south of Quesnel. It encompasses a number of separate diatomite showings that crop out over a distance of about 6 kilometres along the west bank of the Fraser River. At the Quesnel occurrence (Hora and Hancock, 1995), 2 kilometres north of Buck Ridge, recorded diatomite production for 1987 to 1993 totaled 15.2 tonnes. The Big Bend deposit is located along the east side of the Fraser River, 13 kilometres north of Quesnel. Three major exposures of diatomite occur close to water level at the downstream end of the big bend. Diatomite was mined in limited batches and periodically shipments made to Vancouver. A 3 to 6 metre bed of white stoneware clay underlies the diatomite. The Upper Blackwater area of the southern Nechako Plateau is also prospective for diatomite, but few occurrences are reported. The Tsacha showing (093F 041) occurs within volcanic and intercalated sedimentary rocks of the Eocene Ootsa Lake Group. Diatomite and pumice may have accumulated and been preserved in a fault depression. Another diatomite locality of note is reported near Chilako (MINFILE 093G 034) on the Canadian National Railway.

LIMESTONE

The MINFILE database records 52 limestone occurrences, including 2 producers and 5 developed prospects, for the region. The occurrences are mainly stratiform deposits in Ancestral North American rocks,

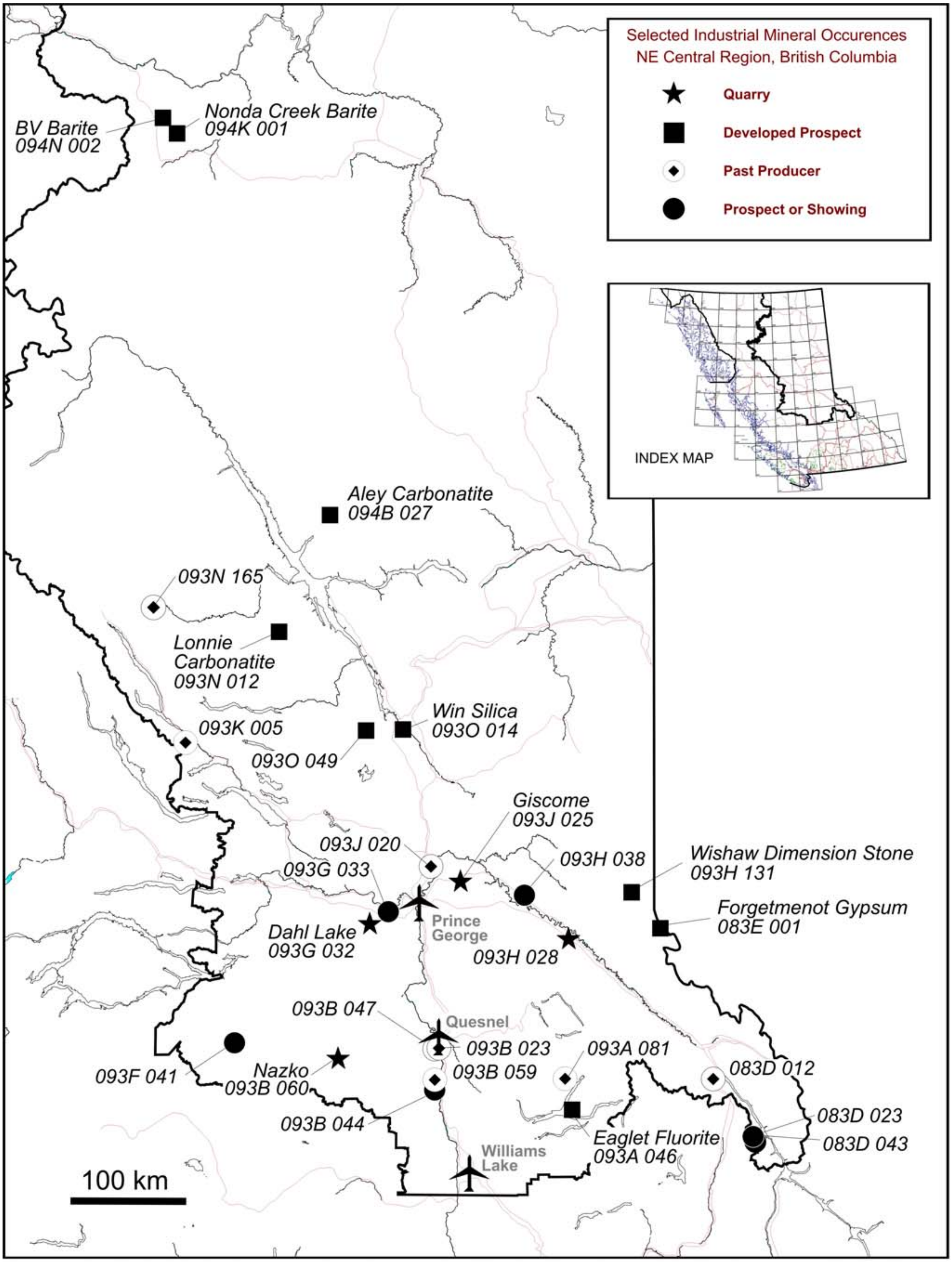

Figure 2. Selected industrial mineral occurrences in northeast-central British Columbia. Producers and developed prospects are identified by name; all others are identified by Minfile number.

and in rocks of the Cariboo and Cache Creek terranes of the Foreland, Omineca, and Intermontane Belts, respectively. The large number of deposits of various types and characteristics will make limestone a key asset in the future. Most of these occurrences are described by Fishl (1992).

The Giscome limestone quarry (093J 025) is located 90 kilometre northeast of Prince George near the BC Rail facilities. Dark grey fossiliferous limestone of the Mississippian to Triassic Slide Mountain Group, which crops out over a 100 by 200 metre area, grades 98% $CaCO_3$. Intermittent quarrying since 1990 produced calcium-rich limestone, primarily for Interior pulp mills.

The Dahl Lake quarry (093G 032), which lies 35 kilometres southwest of Prince George, processes Upper Permian fossiliferous limestone of the Carboniferous to Jurassic Cache Creek complex. Since 1968, about 550 000 tonnes of limestone have been extracted for local pulp mills, and recently 20 000 tonnes of decorative aggregate was extracted from waste rock.

CLAY AND SHALE

A total of 22 clay and shale occurrences are recorded in Quesnel Terrane rocks or in overlap assemblages on the Cache Creek Terrane. Most are stratiform fireclay deposits. Kaolinitic claystones were derived by weathering of crystalline feldspar-rich rocks and deposited in low-energy, freshwater basins. Kaolin clay is mainly used in the paper industry, although some is used in the ceramic and refractory industries. There are 4 reported occurrences of stratiform bentonite deposits in terranes of the Foreland Belt. The most prospective areas are within Upper Cretaceous to Eocene sedimentary basins along the Fraser River from Williams Lake to Prince George. Bentonite or montmorillonite clay forms when volcanic ash is deposited in low-energy shallow marine or lacustrine environments. Bentonite has a wide variety of applications and end uses, including foundry sands, drilling mud and absorbents (Moore, 2003; Crossley, 2003).

The Burnt Shale deposit (093B 047), near Quesnel has seen limited quarrying and is thought to have originally been a clay that was baked. The material is predominantly pale beige, hard, vitreous to porcelaneous, and is regarded as a pozzolan. In the past, it was used as natural pozzolan (Hora and Hancock, 1995) and currently it is currently being mined by Canada Pumice Corporation.

The Giscome Rapids deposit (093J 020) is located on the west bank of the Fraser River. The deposit has a variety of clay-types within a thick Tertiary bed that is exposed for about 800 metres of strike length. Development work in the 1940s included the extraction of 18 tonnes of clay.

A showing of bentonitic clay also occurs near Bednesti (093G 033) adjacent to the Canadian National Railway facilities. The showing consists of cream to grey bentonite of unknown age that is exposed in 3 to 4 metre thick exposures along cutslopes.

RARE EARTH AND HIGH-TECH ELEMENTS

Niobium, rare-earth elements (REE) and yttrium are commonly associated with carbonatites and alkaline rocks (Pell, 1996 and Birkett and Simandl 1999; deposit models). Such rocks are found in the Foreland and Omineca Belts in northeast-central British Columbia. The presence of several notable occurrences makes the region highly prospective.

The Aley property (094B 027), located 140 kilometres north-northwest of Mackenzie, has an extensive exploration history. A Mississippian alkaline-carbonatite complex intrudes miogeoclinal rocks of the Foreland Belt. Exploration identified possible open-pit niobium-bearing zones that grade from 0.66 to 0.75% Nb (Pride, 1987).

The Mount Bisson alkaline complex is situated 64 kilometres northwest of the town of Mackenzie. Within it, light REE are enriched in allanite pegmatites and syenite dykes within the Wolverine metamorphic suite of the Omineca Belt.

A group of tantalum- and niobium-enriched carbonatites also occur in the Monashee Mountains north of Blue River. The Howard Creek (083D 023 and 043), Paradise (083D 006 and 022) and Verity (083D 005) prospects occur along sills that intrude mainly amphibolite-grade rocks of the Hadrynian Horsethief Creek Group. Fir deposits are unusual because of their high tantalum content (Simandl *et al.*, 2002; Dahrouge, 2002).

Carbonatite-syenite complexes and volatile-rich granites are also good exploration targets for many high tech metals and non-metals (Table 2). Regionally, these rocks occur along the western edge of the Foreland Belt, and east of the Rocky Mountain Trench. Specialty metals, such as gallium and germanium, are present in highly anomalous amounts in carbonate-hosted lead-zinc deposits such as Cay (094G 017) in the Robb Lake Belt.

The REE market is currently dominated by China and REE prices are depressed (O'Driscoll, 2003). The tantalum market was described by Simandl (2002) who noted that it is impossible to predict the market for rare earth elements in ten or twenty years.

TABLE 2. SELECT SPECIALTY MINERAL OCCURRENCES IN NORTHEAST-CENTRAL BRITISH COLUMBIA

MINFILE	NAME	STATUS	COMMODITY	HOST ROCK	CHARACTER	TECTONIC BELT	TERRANE
094B 027	ALEY	Developed Pros.	Nb, Pp, Rs	Carbonatite-hosted	Disseminated	Foreland	Ancestral NA
094B 028	ALEY DYKES	Showing	Rs, Ce, Nd, La, Th, Sr	Carbonatite-hosted	Disseminated	Foreland	Ancestral NA
093J 014	PRINCE	Showing	Nb, Rs, La, Ce, Pp	Carbonatite-hosted	Disseminated	Foreland	Plutonic Rocks
093N 012	LONNIE	Developed Pros.	Nb, Zr, Ti, Ur, Th, Rs	Carbonatite-hosted	Podiform	Omineca	Cassiar
093N 174	VIRGIL	Prospect	Nb, Zr, Ti, Ur, La, Nd	Carbonatite-hosted	Podiform	Omineca	Cassiar
083D 023	HOWARD CK. SYENITE	Showing	Ns, Sx, Nb, Ta, Ur	Carbonatite-hosted	Stratiform	Omineca	Kootenay
083D 043	HOWARD CK. CARBONATITE	Showing	Sr, Ph, Pp, Ta, La, Ce	Carbonatite-hosted	Stratiform	Omineca	Kootenay
094D 114	MCCONNELL BERYL	Showing	Be	REE pegmatite	Concordant	Intermontane	Quesnel
093O 021	LAURA	Showing	Th, Rs, La, Ce, Pr, Nd	REE pegmatite	Disseminated	Omineca	Ancestral NA
093N 201	WILL	Showing	Th, La, Ce, Nd, Yr, Ta	REE pegmatite	Layered	Omineca	Cassiar
093O 041	URSA	Showing	Th, Rs, La, Ce, Pr, Nd	REE pegmatite	Disseminated	Omineca	Cassiar
094M 022	LIARD HOTSPRINGS	Showing	Rd, Rn, Hs	Travertine	Unconsolidated	Foreland	Ancestral NA
094N 001	WISHING WELL	Showing	Rd, Ra, U, Rn, Hs	Travertine	Unconsolidated	Foreland	Ancestral NA
094E 038	TOR	Showing	Hf	Unknown	Disseminated	Omineca	Cassiar
083D 06E	FIR	Showing	Ta and Nb	Carbonatite-hosted	Layered	Omineca	Kootenay
083D 005	VERITY	Developed Pros.	Ta and Nb	Carbonatite-hosted	Stratiform	Omineca	Kootenay

VOLCANIC MATERIAL

Pleistocene lava, and associated tuffs and breccia overlie till in the south-central part of the region.

Canada Pumice Corporation mines tephra seasonally from the Nazko lava rock quarry (093B 060), 90 kilometres west of Quesnel. The company was recently acquired by Crystal Graphite Corporation. Each year the company produces between 15 000 and 25 000 cubic metres of scoriaceous lava for the agricultural, horticultural, landscaping and lightweight aggregate uses. Perlite and volcanic glass occurrences crop out primarily in the Nechako Plateau. This low-lying area is underlain by Eocene Ootsa Lake rhyolitic and dacitic flows, tuffs and breccias, with lesser andesites, basalts and conglomerates. Several recorded occurrences in the region (White, 2002) include: Uncha Lake (093F 026), Ootsa Lake (093F 028) and Cheslatta Lake (093F 028). All perlite now being used in British Columbia is imported from the United States, but ongoing development of resource roads may lead to discovery of new perlite deposits in the Nechako Plateau (Rotella and Simandl, 1999).

SILICA

Hardrock silica occurrences in British Columbia are divided into quartzite, vein and pegmatite deposits (Foye, 1987). Quartzite within the Lower Silurian Nonda quartzite is the best potential source in the region. This unit occurs east of the Rocky Mountain Trench in Ancestral North American rocks.

A folded sequence of sedimentary and volcanic rocks host the Longworth prospect (093H 038), located 80 kilometres east of Prince George. The quartzite is essentially correlative with the Lower Silurian equivalent to the Nonda Formation, and is fine-grained, massive and well-sorted. During 1985, a property evaluation produced 28 samples grading 98.84% to 99.80% SiO_2 (Foye, 1987).

The Win quartzite occurrence (093O 014) at Mount Chingee correlates with the Lower Cambrian Gog Group or the Upper Proterozoic Misinchinka Group. The unit contains a drill inferred resource of 4.5 million tonnes grading 98.03% SiO_2. Further to the southeast near Mount Kinney, the An quartzite prospect (093O 013) occurs in equivalent strata. Limited drilling suggests that there is potential for a large tonnage of high grade silica.

Alroy is an early stage silica prospect located 160 kilometres east of Prince George. Several prominent exposures of quartzite that are probably of the Cambrian Yanks Peak Formation crop out in the Fraser River valley immediately north of Highway 16. Most of these silica deposits are described by Foye (1987).

BARITE

Barite occurrences, including 3 developed prospects, are found principally in Ancestral North American rocks. Occurrences are mainly stratiform or stratabound within carbonate or fine-grained sediment sequences as described in the corresponding deposit model by Paradis *et al.* (1999). Barite is widely used as oil-drilling mud, and as filler for paper and cloth (Brobst, 1994).

The BV prospect (94N 002) is a large carbonate-hosted, high grade stratiform deposit in the Sentinel Range near Muncho Lake on the Alaska Highway. The region is underlain by Proterozoic to Middle Devonian sedimentary rocks of Ancestral North American affinity. The basal barite deposit is hosted in the Stone Formation. The inferred resource potential of the BV is 100 million tonnes grading 65% $BaSO_4$.

The Nonda Creek developed prospect (094K 001) is situated 14 kilometres east-northeast of the settlement of Muncho Lake. The upper section of the deposit, measures 120 metres long, 45 metres wide and 30 metres thick, and comprises 92% barite. It is considered as one of the British Columbia's highest-grade deposits.

DIMENSION STONE

Although only seven dimension stone occurrences are recorded in northeast-central British Columbia, the development potential is good, especially in the eastern region where quartzite and marble are abundant. Stone from several granite, marble, slate and quartzite prospects have physical characteristics comparable to material now being mined in southern British Columbia.

The Wishaw quartzite prospect (093H 131) near McGregor is underlain by 300 to 350 metres of pale grey, beige, pink and maroon quartzite beds of the Mahto Formation (Hora and Kwong, 1984). The unit displays intricate cross-bedding, banding and swirled patterns, making it a potentially desirable dimension stone.

The Dome Creek slate prospect (093H 028) straddles highway 16 and lies within the Hadrynian Yankee Belle Formation of the Cariboo Group. The slate is marketable because of its green color, good cleavage and strength properties. The near surface deposit covers an area of approximately 3 square kilometres.

Marble was briefly quarried at Maeford Lake (093A 081) located 100 kilometres east-southeast of Quesnel. The area is underlain by continental margin sediments of the Cunningham Formation of the Cariboo Group. During 1990, about 150 tonnes of the medium grained milky white marble were extracted and sold locally as dimension stone.

The Aspen claims (093O 049), located west of Mackenzie, cover pale pink, coarse-grained granite of an Early Tertiary pluton. This is one of a number of small post-accretionary plutons that are attractive dimension stone targets in the Omineca Belt.

JADE (AND OTHER SEMI-PRECIOUS COMMODITIES)

The region has demonstrated potential for jade, semi-precious gemstones, like rhodonite, opal, jasper, agate. In addition, favourable areas for soapstone deposits exist southwest of Hixon, at the Trust prospect, and near Fort St. James in the Stuart Lake - Trembleur Lake and Fleming areas.

Jade (nephrite) deposits are hosted by metamorphosed mafic and ultramafic rocks associated with ancient volcanic arcs. 'Jade' may be jadeite or nephrite. Jadeite is a rock that consists essentially of the mineral jadeite, a sodium-rich, high-pressure pyroxene. Nephrite consists of acicular amphiboles of the tremolite-actinolite series that form bundles of randomly oriented and interlocking crystals. Although all commercial jade deposits in British Columbia are of the nephrite variety (Simandl *et al.*, 2000), jadeite may have formed in high-pressure eclogite-grade metamorphic rocks that crop out in the Pinchi Lake area (Simandl *et al.*, 2000). There are several recorded nephrite occurrences in the region, located mainly in the Mount Ogden and Mount Sidney Williams areas.

The Ogden Mountain (093N 165) occurrence is approximately 40 kilometres north-northeast of Takla Landing (Simandl *et al.*, 2000). Variably metamorphosed sedimentary and volcanic rocks of the Carboniferous to Jurassic Cache Creek Group are intruded by sill-like serpentinite bodies of Mississippian to Triassic oceanic ultramafites. Total production of nephrite up to 1992 was about 1441 tonnes; estimated reserves are 472 tonnes.

The Genesis deposit (093K 005) is located on O'Ne-ell Creek. The pre-Upper Triassic Trembleur ultramafic intrusions are of probable ophiolitic affinity and are related to the Cache Creek Group. The jade deposit occurs at the contact between serpentinite and a quartz monzonite intrusion. A total of 34.2 tonnes were mined in 1968. Present data suggests that about 2800 tonnes of nephrite jade and tremolite remain.

Common opal and agate occur in Triassic and younger volcanic sequences in the northern Chilcotin and southern Nechako Plateau areas. Precious opal is typically associated with Miocene volcanic sequences where porous, pyroclastic or lacustrine rocks are interbedded with lava flows. For more information regarding this type of deposit, consult Paradis *et al.* (1999).

MISCELLANEOUS MINERALS

The area has a number of known industrial commodities, including asbestos, magnesite, graphite, phosphate, fluorite, gypsum, and mica.

Fluorite occurs mainly as stratabound carbonate-hosted deposits within the Ancestral North American rocks of the Foreland Belt. The Eaglet developed prospect (093A 046) is located near Quesnel Lake. There mineralization is contained in quartz-feldspar-mica gneiss of the Hadrynian-Paleozoic Snowshoe Group of the Barkerville terrane. The mineralized zone measures 1500 by 900 metres and has indicated probable reserves of 24 million tonnes grading 11.5% CaF_2 (Pell, 1992).

The Forgetmenot gypsum prospect (083E 001), near McBride, is hosted in Ancestral North American rocks. It is described by Butrenchuk (1987). Gypsum is intercalated with dolomite and minor limestone in the Upper Triassic Starlight Evaporite member of the Whitehorse Formation. The tabular gypsum body measures 100 by 500 metres and is up to 26 m thick. The deposit has a grade of 75 to 90% gypsum.

Mica (muscovite) occurrences are principally hosted in pegmatite veins cutting Cassiar or Kootenay terrane rocks. However, two former producers recovered mica from kyanite-sillimanite schists of the Upper Proterozoic Windermere Supergroup of the Cariboo terrane. For the geological setting of this type of deposit, see Simandl *et al* (1999). The Canoe North Mica deposit near Valemount (083D 012) is on the northwestern margin of the Shuswap Metamorphic Complex. It is underlain by pelitic schists of the Hadrynian Lower Kaza Group. A total of 225 tonnes of mica product was extracted in 1960 and 1961. An estimated resource of 2.29 million tonnes grading 60.5% mica remains.

Cache Creek Group rocks host eight ultramafic-hosted asbestos and two magnesite showings. Deposit models for asbestos and magnesite describing the general setting were prepared by Hora (1998) and Simandl and Ogden (1999). Crystalline flake graphite showings are recorded from highly metamorphosed Cassiar terrane rocks. Detailed information is missing; however, these deposits are believed to belong to the deposit model provided by Simandl and Keenan (1998). Phosphate occurrences are stratabound, upwelling-type deposits in miogeoclinal rocks of the Ancestral North American terrane.

SUMMARY

Northeast-central British Columbia is host to a large number of industrial mineral occurrences with a wide range of deposit types and in varied geologic settings. The deposits with the best development potential are strategically located aggregate resources and barite deposits. Markets for these commodities exist in northeast British Columbia and Alberta, particularly in support of the expanding oil and gas sector. The main factor limiting the development of traditional low-cost industrial mineral deposits is the lack of a significant local market. Mining and marketing of scoria from the Nazko quarry is an example of a successful niche market development. Production of high-priced products such as jade, precious opal and emeralds is affected to a lesser extent by a limited market. In the future, with exploration resolve, technological advances and improvements in the area's diverse infrastructure network, more discoveries and expanded industrial mineral mining are anticipated.

REFERENCES

Birkett, T.C. and Simandl, G.J. (1999): Carbonatite-associated Deposits; *In* G.J. Simandl, Z.D. Hora and D.V. Lefebure, Editors, Selected British Columbia Mineral Deposit Profiles, Volume 3, Industrial Minerals and Gemstones, *British Columbia Ministry of Energy and Mines*, pages 73-76.

Brobst, D.A. (1994): Barium Minerals, *In* D.D. Carr, Editor, Industrial Minerals and Rocks, 6th edition, *Society for Mining, Metallurgy, and Exploration, Inc*. Littleton, Colorado, pages 125-134.

Butrenchuk, S.B. (1991): Gypsum in British Columbia. *British Columbia Ministry of Energy and Mines* Open File 1991-15, 48 pages.

Crossley, P. (2003): Bent on success, *Industrial Minerals*, June 2003, pages 32-37.

Dahrouge, J. (2002): The Fir Carbonatite A Potential Tantalum – Niobium Resource. Exploration and Mining in BC, *British Columbia Ministry of Energy and Mines*, pages 83-88.

Fishl, P.S. (1992): Limestone and Dolomite Resources of British Columbia. *British Columbia Ministry of Energy and Mines* Open File 1992-18. 150 pages.

Foye, G. (1987): Silica Occurrences in British Columbia. *British Columbia Ministry of Energy and Mines* Open File 1987-15. 55 pages.

Hancock, K.D. and Simandl, G.J. (1993): Geology of the Anzak Magnesite Deposit. Geological Fieldwork 1992, *British Columbia Ministry of Mines and Petroleum Resources*, Paper 1993-1, pages 381-387.

Hora, Z.D. (1998): Ultramafic-hosted Chrysotile Asbestos, *In* Geological Fieldwork 1997, *British Columbia Ministry of Employment and Investment*, Paper 1998-1, pages 24K-1 to 24K-4.

Hora, Z.D. and Hancock, K.D. (1997): Some new dimension stone properties in British Columbia, Part III. Geological Fieldwork 1996, *British Columbia Ministry of Energy and Mines*, Paper 1997-1, pages 301-306.

Hora, Z.D. and Hancock, K.D. (1995): Quesnel Area – Industrial Minerals Assessment. Geological Fieldwork 1994, *British Columbia Ministry of Energy and Mines* Paper 1995-1, pages 395-404.

Hora, Z.D. and Kwong, Y.T.J. (1984): Industrial Minerals and Structural Materials. Geological Fieldwork 1983, *British Columbia Ministry of Energy and Mines*, pages 213-217.

Gabrielse, H., Monger, J.W.H., Wheeler, J. O. and Yorath, C. J. (1991): Part A. Morphogeological belts, tectonic assemblages and terranes. *In*: H. Gabrielse, and C.J. Yorath, editors, Geology of the Cordilleran Orogen in Canada, Geology of Canada, *Geological Survey of Canada*. No. 4, pages 15-28.

Moore, P. (2003): Swell times ahead? *Industrial Minerals*, February 2003, pages 42-45.

O'Driscoll, M. (2003): REgeneration in autocatalysts, *Industrial Minerals*, January 2003, pages 24-33.

Paradis, S. and Simandl, G.J. (1999): Volcanic-Hosted Opal; *In* G.J. Simandl, Z.D. Hora and D.V. Lefebure, Editors, Selected British Columbia Mineral Deposit Profiles, Volume 3, Industrial Minerals and Gemstones, *British Columbia Ministry of Energy and Mines*, pages 133-136.

Paradis, S., Simandl, G.J., MacIntyre, D. and Orris, G.J. (1998): Sedimentary-hosted, Stratiform Barite; *In* Geological Fieldwork 1997, *British Columbia Ministry of Energy and Mines*, Paper 1998-1, pages 24F-1 - 24F-3.

Pride, K.R. (1987): 1986 Diamond Drilling, Aley Property, Assessment Report 16484, Cominco Ltd. 50 pages.

Pell, J. (1996): Mineral deposits associated with carbonatites and related alkaline igneous rocks, *In* R.H. Mitchell, editor, Undersaturated Alkaline Rocks: Mineralogy, Petrogenesis, and Economic Potential, Winnipeg, Manitoba, pages 271-310.

Pell, J. (1992): Fluorspar and Fluorine in British Columbia. *British Columbia Ministry of Energy and Mines* Open File 1992-16. 82 pages.

Simandl, G., Jones, P., and Rotella, M. (2002): Blue River Carbonatites, British Columbia – Primary Exploration Targets for Tantalum. Exploration and Mining in BC, *British Columbia Ministry of Energy and Mines*, pages 73-82.

Simandl, G.J. (2002): Tantalum Market and Resources: An Overview. Geological Fieldwork 2001, *British Columbia Ministry of Energy and Mines*, Paper 2002-1, pages 313-318.

Simandl, G.J., Paradis, S. and Nelson, J. (2001): Jade and Rhodonite Deposits, British Columbia, Canada, *In* R.L. Bon, Editor, Proceedings of the 35th Forum on the Geology of Industrial Minerals-Intermountain West Forum, Salt Lake City 1999, pages 163-172.

Simandl, G.J., Riveros, C.P. and Schiarizza, P. (2000): Nephrite (Jade) Deposits, Mount Ogden Area, Central British Columbia, *In* Geological Fieldwork 1999, *British Columbia Ministry of Energy and Mines* Paper 2000-1, pages 339-347.

Simandl, G.J. and Paradis, S. (1999): Carbonate-hosted Talc; *In* G.J. Simandl, Z.D. Hora and D.V. Lefebure, Editors, Selected British Columbia Mineral Deposit Profiles, Volume 3, Industrial Minerals and Gemstones, *British Columbia Ministry of Energy and Mines*, pages 35-38.

Simandl, G.J. and Ogden, D. (1999): Ultramafic-hosted Talc-Magnesite; *In* G.J. Simandl, Z.D. Hora and D.V. Lefebure, Editors, Selected British Columbia Mineral Deposit Profiles, Volume 3, Industrial Minerals and Gemstones, *British Columbia Ministry of Energy and Mines*, pages 65-68.

Simandl, G.J., Paradis, S. McCracken, W.H. and Hancock, K.D. (1999a): Kyanite, Muscovite and Garnet in Metasediments; *In* G.J. Simandl, Z.D. Hora and D.V. Lefebure, Editors, Selected British Columbia Mineral Deposit Profiles, Volume 3, Industrial Minerals and Gemstones, *British Columbia Ministry of Energy and Mines*, pages 89-92.

Simandl, G.J. and Keenan, W.M. (1998): Crystalline Flake Graphite, *In* Geological Fieldwork 1997, *British Columbia Ministry of Energy and Mines* Paper 1998-1, pages 24P-1 - 24P-3.

Simandl, G.J. and Hancock, K.D. (1998): Sparry Magnesite, *In* Geological Fieldwork 1997, *British Columbia Ministry of Energy and Mines* Paper 1998-1, pages 24E-1 - 24E-3.

Simandl, G.J., Hancock, K.D., Callaghan, B., Paradis, S. Yorke-Hardy, R. (1997): Klinker Precious Opal Deposit, South Central British Columbia, Canada - Field and Potential Deposit Scale Controls; *In* Geological Fieldwork 1996, *British Columbia Geological Survey Branch*, Paper 1997-1, pages 321-327.

White, G.V. (2002): Perlite in British Columbia, *In* S. Dunlop and G.J. Simandl, editors, Industrial Minerals in Canada, *Canadian Institute of Mining, Metallurgy and Petroleum*, Special Volume 53, pages 59-65.

Yorke-Hardy, R., Paradis S., Simandl, G.J, Callaghan, B. and Hancock, K.D. (1997): Okanagan Precious Opal Deposit, British Columbia, Canada - An Australian Analogue? Canadian Institute of Mining and Metallurgy; CIM Annual General Meeting, Program with abstracts, page 61.