Ministry of Energy, Mines and Petroleum Resources

POTENTIAL FOR GEM BERYL AND SCHIST HOSTED EMERALD IN BRITISH COLUMBIA

By Andrew S. Legun, P. Geo.

GEOFILE 2005-19

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Cover photo by Brad Wilson - Aquamarine from Slocan Area

INTRODUCTION

This article reviews the gem varieties of beryl, the associations of beryl with granitic rocks, and the particular association of emerald with ultramafic wallrocks affected by volatile-rich fluids. The article includes an emerald potential map for the province and a general description of areas of gem beryl potential.

There has been little systematic work on transparent gemstones in British Columbia in spite of a number of gem discoveries in the last fifteen years. These discoveries include iolite (gem cordierite), peridot (gem olivine), topaz and aquamarine (Simandl *et al.*, 2000), (Domville, 1998). Discoveries of chromium rich emerald at Regal Ridge in south-central Yukon, vanadium rich emerald at Lened near the Yukon/Northwest Territories border (Groat *et al.*, 2002) has raised interest in the emerald potential of British Columbia. In B.C. poorly formed crystals of emerald are known (Wilson, 1997).

Beryl $Be_3Al_2(Si0_3)_6$ is the most common mineral of beryllium and aquamarine the most abundant gem variety of beryl. Emerald is gem beryl with traces of chromium or vanadium as the coloring agent. Other beryllium bearing minerals that may have sufficient clarity to form gems include chrysoberyl ($BeAl_2O_4$**)**, euclase ($BeAlSiO_4OH$**)** and phenakite (Be_2SiO_4).

Beryllium is associated with other lithophile metals (W, Sn, Mo, U, Nb and Li). These metals, with the exception of lithium and perhaps tin, are well represented by showings, prospects and deposits of B.C. This association suggests more beryllium prospects, including gem beryl, will be found and their paucity is probably due to a lack of careful exploration. The juxtaposition of beryllium bearing granitic rocks with ultramafic rocks in B.C. is a geologic setting generally conducive to emerald formation.

Emerald is traditionally found in small volume deposits, such as wallrock zones of pegmatites. Mineable widths may only be a metre or so. However there may be many producing pegmatites in an area and the total volume of emerald-bearing rock may be significant. The artisan miner or small co-operative has historically exploited individual high value but small volume emerald deposits.

The range in value of emerald varies tremendously, from a few dollars, to tens of thousands of dollars per carat (a fifth of a gram). The value of gold at 400 dollars a troy ounce translates to about 2.57 dollars per carat. Emerald is more valuable than gold but quality of material in small volume deposits is of paramount importance.

PHYSICAL PROPERTIES AND ASPECTS OF VALUATION OF GEM BERYL

COLOR AND CHEMISTRY

Beryl or beryllium aluminum silicate is colorless in its pure form. In common form it is white and opaque due to inclusions or alkali content. The appeal of gem beryl is in its transparency and wide variety in color. The color variations include:

Emerald: leaf green to deep bluish green;

Morganite: pink, apricot;

Goshenite: colorless;

Heliodor: pale yellow to yellow-orange to yellow-green;

Aquamarine: watery blue, bluish-green to greenish yellow;

Bixbite: an informal name to a very rare variety of red beryl.

The particular hue of emerald is the result of trace amounts of chromium or vanadium that substitute for $Al3^+$ in the beryl ring silicate structure. Iron is responsible for hues in the less valuable but more widely distributed aquamarine. The color variations of aquamarine depend on the oxidation state of the iron (Fe^{3+} or Fe^{2+}) and whether the ion occupies a channel position in silicate rings or substitutes for aluminum in octahedral sites. The yellow of heliodor is a result of Fe^{3+} substituting for aluminum in the octahedral site. Manganese is responsible for violet-pink hues in morganite and probably the red of bixbite.

Gem crystals of beryl may also be color zoned, either normal or parallel to the c-axis of the crystal. The result is color banding along the length of the crystal, or crystals with a visibly paler core.

Natural irradiation may lead to color effects. The intense blue of a rare "Maxixe" beryl is due to natural radiation and it fades with time. Artificial gamma radiation is applied on some colorless beryl to induce color with temporary or permanent effect.

OPTICAL QUALITIES

The optical qualities of emerald (refractive index = 1.57-1.59, dispersion = 0.014) represent only modest brilliance and sparkle (fire). The saturated tones of “leafy green” in quality stones nevertheless translate into a value per carat that may exceed diamond (Hall, 2004).

Inclusions are common in gem beryl and emerald in particular. In schist-hosted emerald it may be needles of actinolite or tremolite. Trains of bubbles of gas and fluid may form inclusions and internal fractures are sometimes described as inclusions. Flawless, inclusion-free crystals of emerald are not known. The emerald clarity scale begins at very, very slightly included (class i1):

http://www.esmerald.com/clarity.shtml

DURABILITY

Emeralds and other gem beryls are not as durable as either diamond or sapphire. The hardness of beryl at 7.5 to 8 is less than that of sapphire (9) or diamond (10). The presence of inclusions makes gem beryl more susceptible to abrasion and disintegration during transport. Alluvial placers of emerald are rare.

VALUATION

Many aspects govern valuation of a transparent gem deposit. This includes ease of extraction of the crystals, weight and size of crystals, clarity, color hue and saturation, fractures and inclusions, and the chemical nature of the coloring agent. In most deposits only a portion of the crystalline material is worth cutting and a further portion is lost in the faceting process. It is thus difficult to assign a net value to a deposit. In Canada's climate abundant fractures in elluvial emeralds reduce the available size for cutting and are a concern in deposit development (*ibid*). In the individual stone value escalates rapidly with faceted size.

The value of vanadium-bearing emerald is less than that of chrome-bearing variety though the color is very comparable. Inclusions may add value and character to emerald (a natural birthmark) but value is diminished if inclusions mark the surface. Valuation of gemstones requires consideration of competing stones. Heat-treated topaz provides competition for aquamarine of the same color.

FORMATION AND DISTRIBUTION OF BERYL IN THE GRANITIC ENVIRONMENT

BERYL AND VOLATILE GRANITES

Beryl is associated with volatile-bearing phases of leucocratic granites and syenites. According to Pell and Hora (1990) volatile granites may form anywhere the Sr87/86 ratio exceeds 0.704. The granites can be either orogenic, resulting from compression, crustal thickening and melting of metasediments (S-type granites) or related to rifting (anorogenic/anhydrous A-type granites).

Concentrations as low as 4-8 ppm beryllium in the parent magma may lead to beryl bearing pegmatite through fractionation (London and Evensen, 2001). As temperatures decline beryl becomes insoluble in the melt. Volatiles facilitate this process via fluxing - i.e. reducing the temperature of crystallization. The volatile components (besides water) may include CO_2, F, B, Li, P, and Cl.

The crystallization of pegmatite from such magmas may be followed by development of coarse micaceous aggregates rich in tourmaline, topaz, fluorite, rutile, cassiterite, wolframite, beryl and lithium mica. The mica rich aggregates are known as greisen and form from high temperature volatile-rich (particularly fluorine rich) aqueous solutions. Thus more than one generation of beryl may form as temperatures fall and physiochemical conditions change - a first generation in pegmatite, and a second at lower temperature when greisen fluids affect pegmatite (Markl and Schumacher, 1997).

Beryl may also crystallize from late liquid and gas-rich pockets or miaroles within the essentially solidified host intrusive.

Volatile granites are often geochemically distinct and characterized by names such as "tin granites" or "topaz granites". However simple granites may be local enriched in beryllium and beryl due to volatile activity (Rainer, 2001). Many granites in B.C. are simple but crystallized in the presence of active volatile components - shown in presence of tourmaline, fluorite and apatite.

BERYL AND PEGMATITES

Cerny (1991) classified pegmatites according to their metamorphic depth environment of formation. The abyssal and muscovite class represent melts that have not migrated far from source and crystallise in high-grade metamorphic environments of amphibolite and granulite grade. They tend to form poor gemstock.

The rare element class represents melts that have migrated to shallower levels and fractionated en route. They are subdivided into the LCT (Li-Cs-Ta) and NYF (Nb-Y-F) families. Enrichment in beryllium is common to both families. The LCT type is derived from orogenic plutonic suites that tend to be peraluminous and potassic (e.g. Bayonne suite in B.C.) while the NYF type is anorogenic, related to rifting or post orogen reactivation, and derived from source rocks affected by deep mantle-related metasomatism (e.g. Surprise Lake suite in B.C.). NYF magma tends to be peralkaline to metaluminous.

Both LCT and NYF pegmatites may form good gemstock depending on whether gem minerals are free growing or in interlocking texture with other minerals.

The subvolcanic miarolitic class offers the best potential for extractable gems. High quality crystals from open space fillings or weakly bonded matrix are available in symmetrically zoned "fissure fill" pegmatites in this class. Such pegmatites tend to form at shallow levels within crustal blocks undergoing uplift. The uplift may relate to cordilleran tectonics or arching of roofs above subvolcanic intrusions.

In contrast to aquamarine, emerald is not commonly found in pegmatite. It is found in wallrock to pegmatite. Most pegmatites are crystalline at the time aqueous fluids are expelled into wallrock (Morgan and London, 1987). Thus there is little opportunity for element exchange in the pegmatite with trace elements such as chromium in wallrock. There are only a few (rather intriguing) geologic references to emerald in pegmatite (e.g. Brown, 2004).

BERYL IN B.C.

In the mid 1990's there were approximately 23 documented showings of beryl in the province (Minfile records) and 2 of the beryllium mineral danalite-helvite. Presently there are 40 showings of beryl and 3 of other beryllium minerals that are discussed in this article (see table 1). By comparison there are only 10 officially documented occurrences of beryl in the Yukon (Lewis, Hart and Murphy, 2003).

Most beryl in B.C. is found in pegmatites associated with leucocratic granites (alaskites, quartz monzonites), and in late quartz veins that cut the host intrusion or country rock. Beryl has also been tentatively identified in skarn (Bohme, 1984) and in quartz veins cutting skarn at Mt. Haskin (Gower *et al.*, 1985).

Beryl bearing pegmatites in B.C. are usually in border phases or close to the periphery of a large intrusive body (White Creek batholith) but they are found internally as well (Laib claims). The pegmatites vary from massive and homogenous to zoned bodies. Holland (1956) described a zoned beryl-bearing dike in the Horseranch Range area. It had a 2-inch marginal zone of muscovite, a 2-inch intermediate zone rich in tourmaline and garnet, and a 4-inch centre of coarsely crystalline feldspar and quartz with beryl. Stockscheider fabric often accompanies zoning. This is mineral layering with unidirectional crystal growth resulting from heat loss to walls during crystallisation. Such fabric is often seen in smaller pegmatite sills and dikes of the Hellroaring Creek body. Accessory minerals in B.C. beryl-bearing pegmatites may include fluorite, tourmaline, garnet, magnetite, scheelite, and molybdenite.

Cretaceous to Eocene ages of intrusion is typical but the Hellroaring and Greenland Creek suites in the Cranbrook area represent pegmatite of Proterozoic age. There is little info on pegmatites of other ages.

Known beryl-bearing pegmatites have been tentatively placed in the LCT class under Minfile. The Hellroaring pegmatite is probably a good example of the beryl-columbite subtype of the LCT class (Brown, 2004). Beryl bearing NYF pegmatites have not been formally documented in B.C. though granites parental to that type are known.

It appears B.C. has a lack of lithium-rich pegmatites that give rise to polychrome beryl (see Pezzotta and Williams, 2001; Sinkankas and Read, 1986). Mt. Begbie (Minfile 082LNE015) is the only documented locale of lithium bearing pegmatite in B.C. However intrusives with elevated trace amounts of lithium suggest potential for this type of pegmatite. They include Logtung at 180 ppm (Kirkham and Sinclair, 1985, table 2).

To date most beryl gemstone has been extracted from miarolitic cavities within pegmatites or epizonal granitic bodies. Aquamarine crystals on the B.Q. claims near Salmo are found in a pegmatite ascribed to the Eocene Ladybird suite (Gauthier and Dixon, 1997). The aquamarine locale named "Mt. Foster" (Wilson, 1997) may be related to Eocene leucocratic granite of the Bennet Lake cauldron complex, and the locality described as "East of Atlin" by Wilson (*ibid*) may be associated with a topaz bearing satellite body of the nearby Late Cretaceous Surprise Lake batholith. The geologic settings are guesses by the writer as true location is proprietary info. Smaller aquamarine gemstones have also been extracted from pegmatites where the beryl is in intergranular texture with other minerals (e.g. the Eocene pegmatites in the Horseranch Range).

Prospectors have found new showings in the mature exploration ground of the Kootenay region of southeastern B.C. This includes the Laib Creek, Blue Hammer and Topaz Creek showings (Brown, 2004). Most crystals are translucent but occasionally a transparent gem quality crystal is found:

(http://www.creamminerals.com/cream/cma_aquamarine_details.htm)

Wilson (19997) provides cursory documentation of the single vanadium emerald occurrence. It is described as occurring in narrow quartz-calcite-pyrite veins cutting volcaniclastic rocks adjacent to the quartz monzonite intrusive on Red Mountain near Stewart.

Rb-Ba-Sr relations derived from whole-rock geochemical data points to beryl-bearing plutons in B.C. Values near the Rb apex in triangular plots suggest plutons that are more evolved and fractionated. Plutons with high Rb/Sr or Rb/Ba ratios include Logtung and Storie in B.C. and Seagull, Pluto in the Yukon (see figures 8,14 in Sinclair, 1983). All these plutons have associated beryl showings. Data from Horseranch Range pegmatites (Simandl, 1998) also follow the Rb rich trend. Such triangular plots may assist in choosing plutons of interest in B.C.

Figure 1. Faceted crystals of aquamarine from undisclosed locale near Bennet B.C. (NTS 104M14). Photo is courtesy of Brad Wilson.

EMERALD DEPOSIT MODELS

In general the geologic settings for emerald can be categorized by how the incompatible elements beryllium and chrome (or vanadium) are brought together (Schwarz and Guilani, 2001). The most famous (and probably rarest setting), is the shale-hosted deposits of Columbia. The hydrothermally altered shales are a source of both beryllium and chromium. Elsewhere a fault-related hydrothermal plumbing system may bring these elements together from distant sources. Most commonly separate beryl and chrome-bearing source rocks are juxtaposed and affected by fluids. Emeralds in the wallrocks of volatile granites and related pegmatites intruding ultramafics are the focus of an exploration model for emeralds in B.C. Not only is this the most common setting for emerald worldwide it is also the easiest to target in a reconnaissance exploration program.

EMERALD IN WALLROCK

The classic model for emerald formation is the contact zone of beryllium-bearing volatile granites, pegmatites with chrome-bearing ultramafics. Adjacent to the pegmatite contact are monomineralic schists formed as a result of alkali and fluorine metasomatism. Simandl *et al.* (1999) provides an overview of these "schist hosted" emerald deposits also known also as "glimmerites" or "phlogopitites".

The Franqueira pegmatite in the province of Galicia in northwest Spain is a typical example of the classic model. An inner phlogopite zone with imbedded emeralds passes through a tremolite rich zone to an outer zone of anthophyllite in contact with dunite (Fuertes-Fuente *et al*., 2000). Other minerals in this zone include talc and actinolite. Veins of quartz-albite-muscovite-fluorite are common. The metasomatic alteration zone bordering the pegmatite is surprisingly wide in relation to the width of the pegmatite (almost threefold).

Larger wallrock targets are feasible in emerald exploration. Intrusive bodies, such as tin granites, tourmaline and/or fluorite bearing granites, syenites, and the more silicic porphyries (Quartz monzonite and Climax type) may have beryl-bearing vein halos. The Carnaiba emerald deposits of Brazil are in fracture quartz veins above a molybdenum porphyry intruding serpentinites (Guiliani *et al*., 1990). Associated minerals include molybdenite, pyrite, apatite, scheelite, phenakite, alexandrite and tourmaline. Such emerald deposits may provide an analogue for exploration in B.C.

There is very little direct information regarding large-scale fluid interactions between tourmaline and fluorine-bearing granites, pegmatites, and their ultramafic host rocks in B.C. There is no documentation of any phlogopite schist reaction zones about pegmatites. There are however suggestive descriptions of potassic alteration halos and fluorine rich greisen in ultramafic rocks (see Bradford and Godwin, 1988 in particular).

Large-scale tourmaline alteration zones in ultramafic rocks appear to be prospective for emerald even in the absence of pegmatites or nearby intrusives. The Swat emerald deposits of Pakistan (Arif *et al.*, 1996) may provide an instructive example. Host rocks at Swat are an altered tectonic mélange that includes talc carbonate, quartz carbonate, dolomite-magnesite schist, quartz fuchsite and thrust faulted lenses of serpentinite. At Swat the mélange was affected by boron metasomatism of uncertain origin. Emerald is associated with chrome tourmaline in dilation zones.

In B.C. both listwanitic mélange and tourmaline bearing granites are proximal to each other in some areas and offer scope for reconnaissance work.

The presence of skarns in the vicinity of volatile granites and ultramafics may be a lead to emerald. In B.C. chrome garnet is noted in some skarns near ultramafic bodies (Ray *et al*., 2000). Other reports indicate the presence of beryllium bearing idocrase (vesuvianite) in skarn. Clearly chromium and beryllium are mobile in the skarn environment.

Kwak (1987) describes several greisenized skarns that include beryl as well as topaz. Late quartz veins crosscutting skarns carry well-formed crystals of near gem quality beryl in the Lened (and JC?) prospects in the Yukon.

SIGNIFICANCE OF YUKON DISCOVERIES TO B.C. EMERALD POTENTIAL

The significance of the Regal Ridge discovery to B.C. is probably twofold. First the Regal Ridge emeralds lie just above the roof of tourmaline-bearing Cretaceous granite that has intruded an ultramafic sill (Murphy *et al.*, 2003). Altered ultramafic roof rocks above volatile-bearing intrusions are clearly of interest in B.C. Secondly the host rocks to emerald-bearing quartz veins at Regal Ridge are schists of the Upper Devonian Fire Lake metavolcanic unit. An early period of metamorphism and deformation may have resulted in chromium migrating into micas and the resulting schist becoming more permeable to invading fluids. Thus older, previously metamorphosed ultramafics may have higher potential for emerald where cut by volatile-rich intrusions in B.C.

Such ultramafic rocks might include the base of accretionary complexes where chrome mica is commonly mentioned (see Atlin accretionary complex in Ash, 2001). Also of interest would be "Siliceous tectonite" in the Cry Lake area of B.C. (Gabrielse, 1998). The tectonite consists of interweaves of oceanic sediments, basalt and ultramafics of Late Devonian to Permian age affected by an early period of metamorphism and deformation (ibid, p.99).

Both Regal Ridge and Lened emeralds are also associated with tungsten mineralization. However it remains to be seen whether this is characteristic of emeralds in the Canadian cordillera (Groat *et al.*, 2002). It is not characteristic of emeralds worldwide but it is an important metal (after molybdenum) in the emerald deposits of the Carnaiba district of Brazil (Guilani *et al.*, 1990).

EMERALD AND GEM BERYL POTENTIAL MAP

Elements of the map include the following pathfinders and constraining elements:

- Showings of beryl and other Be-bearing minerals compiled from various sources.
- The principal lithophile elements associated with beryllium: niobium, tin and tungsten as per **MINFILE Search by Commodity**
- Minerals indicative of volatiles in magma: fluorite, topaz, tourmaline, fluorapatite as per **MINFILE Search by Mineralogy**
- Deposits associated with greisen. These are not well documented in **MINFILE**.
- Areas underlain by ultramafic rocks derived from the G.S.C. tectonic assemblage map.
- The distribution of pegmatites as per **MINFILE Search by Rock Type/Lithology**
- The "volatile granite" line defined by Sr^{87}/Sr^{86} ratio equal to 0.704. (Pell and Hora, 1990).
- The distribution of Cretaceous and younger age intrusives from the tectonic assemblage map.
- The boundaries of the Omineca belt. Plutons within the belt are derived from underlying continental crust. Many are potassic and peraluminous, geochemically "fertile" for the generation of rare element pegmatites.

COMMENTS ON GENERAL AREAS OF POTENTIAL

A large area of emerald potential exists in the general juxtaposition of Slide Mt. (Cache Creek) ultramafics and mid-Cretaceous granites in the Omineca belt. The volatile granite line suggests potential extends west of the Omineca/Intermontane boundary and includes areas where Alaskan-type ultramafic complexes are cut by pegmatites.

There are significant juxtapositions of ultramafic rocks and younger granites in the northern part of the province. This includes the Surprise Lake area (NTS 104N), the Sylvester allocthon near Cassiar (NTS 104O,P), and the Cry Lake area (NTS 104I). Juxtapositions of ultramafic and granitic rocks are limited in the southern part of the province but include the Eagle Bay assemblage at its contact with the Baldy batholith.

Local geologic conditions need to be carefully scrutinized to focus prospecting and exploration. Favorable conditions include small high level intrusions, alkali metasomatism of wallrock, hydrous conditions in ultramafic wallrock, volatile mineralogy, geochemical presence of beryllium, open space fillings.

DESCRIPTIONS OF SPECIFIC AREAS OF POTENTIAL

ATLIN AND JENNINGS RIVER AREA

SURPRISE LAKE SUITE

The Late Cretaceous (high silica low alumina) Surprise Lake plutonic arc extends from the Atlin to Cassiar area. The Surprise Lake suite is a fluorine rich biotite granite-quartz monzonite. It is described as the sole example of "specialty" or tin granites in B.C. (Pell and Hora, 1990). According to Anderson (1985) it also falls into the category of anorogenic A-type granites. The Surprise Lake batholith near Atlin (NTS 104N) has received the most study and includes the alaskitic Mt. Leonard boss. The Klinkit, Parallel Creek, Tuya and Glundebery batholiths within NTS 104O represent the eastern members of the suite. Watson and Matthews (1944) and Gabrielse (1969) describe the eastern suite.

The suite is fluorine rich with topaz impregnated wallrock noted at the southern margin (Minfile 104N 086). A number of peripheral Sn-W-F vein systems are known. Anderson (2003) notes cavities up to a decimeter width lined with alkali feldspar, quartz and tourmaline. The Glundebery batholith is reported to have a pink miarolitic granite phase with miaroles to .75 inches that may include fluorite.

The Surprise Lake batholith cuts several ultramafic bodies of the Cache Creek Group along its western and northern borders (see figure 2 of Ray *et al.*, 2000). Some ultramafic bodies are also preserved as roof pendants of Cache Creek rocks within the Surprise Lake batholith (see open File 1989-15a, Bloodgood *et al.*, 1989). Ballantyne and Littlejohn (1982) suggest fluids deposited quartz, fluorite, Li-mica, beryl, cassiterite in small pods in the roof zone near Mt. Weir.

Beryl is found in quartz veins near Zenazie Creek northwest of Mt. Weir (Minfile 104N 066) with several other locations shown in maps of Aspinall (1971). Beryl with fluorite (in mafic dikes?) occurs on the CY8 claim southeast of Mt. Weir at Caribou Creek (Geology, Exploration and Mining 1977-81, p. 182). Danalite is also found in mafic dikes on the northeast flank together with sphalerite, galena, magnetite and hematite (ibid). The genetic relationship of the mafic dikes to the intrusion is not stated.

Aquamarines are found in miarolitic cavities of a quartz monzonite stock east of Atlin (Wilson, 1997). The relationship of this stock to the Surprise Lake suite is not known and its exact location is not revealed

There is emerald potential in altered ultramafics of the Cache Creek Group where present as roof rocks to small satellite stocks of this batholith. One satellite is postulated (from aeromagnetic data) to lie near the intersection of Boulder Creek and Surprise Lake road (Kikauka, 2002). Another is shown near Mt. Dixie (Aitken, 1959).

Beryl is present in the eastern part of the suite near Ash Mountain (Wilson, 1997). According to Wilson (personal communication) this showing is not the tungsten skarn of the same name (Minfile 104O 021). Several skarns are present in the area with the Parallel Creek intrusion underlying the area at shallow depths (Watson and Matthews, 1944). As well miarolitic granite with some pegmatite is noted in a cirque about four and a half miles to the north.

According to Ballantyne and Littlejohn (1982) the Surprise Lake suite lacks pegmatites. However some pegmatitic bands (alternating with aplite) have been noted on the west side of the Trout Lake graben (Geology, Exploration and Mining 1977-81, p. 183). Pegmatite is also present in some abundance south of Klinkit Lake in screens of metasediments at the margin of the Klinkit batholith (Gabrielse, 1969). Prospecting efforts may yet reveal pegmatites (NYF type?) external to the batholith cutting ultramafics of Cache Creek terrain. Any wallrock schists associated with such pegmatites should be prospected for emerald.

Fluorine-garnet-pyroxene tin and tungsten skarns peripheral to the Surprise Lake suite indicate metasomatic activity of interest. Geochemical beryllium has been noted in the Daybreak wrigglite skarn (Ray *et al.*, 2000). It appears to be lacking in Silver Diamond multielement skarn (Kikauka, 2002). The Day wrigglite is encouraging for emerald potential given the presence of chrome bearing garnet. According to Ray *et al.* (2000) this indicates a "tectonic history that enabled mineralizing fluids from the Surprise Lake batholith to interact with ultramafic and oceanic rocks of the Cache Creek terrane".

In summary the Surprise Lake suite does offer leads to pursue gem beryl related to skarns, contact zones of pegmatites, small satellite bodies and miarolitic cavities. Little work appears to have been done in this plutonic suite outside the immediate Atlin area.

SEAGULL BATHOLITH

The 100 Ma old Seagull batholith, part of the Thirtymile suite lies immediately north of the B.C.-Yukon border and the Logtung deposit. The main body does not extend into B.C. but its description is relevant here due to petrologic similarity with the Surprise Lake suite (Ray *et al.*, 2000).

Blue beryl and danalite are found with quartz, blue tourmaline, fluorite, and green Fe biotite in a peripheral skarn (JC prospect Yukon MINFILE 105B 040). Though the skarn is some distance from the contact a lobe of the intrusion is intersected at depth in a diamond drillhole on the property. The Seagull batholith is fluorine rich, tin bearing and carries lithium micas (zinnwaldite and lepidolite) as well as tourmaline nodules. The nodules are of gemological relevance as some contain cavities lined with coarse crystals (Sinclair, 1983). Upper parts of the body show a well-developed greisen (Noble and Spooner, 1986). The Seagull batholith is a highly fractionated intrusive with a high Rb/Sr ratio and plots near the apex of Rb-Sr-Ba ternary diagram. Liverton and Alderton (1994) provide considerable info on the evolved nature of this pluton. Groat and Eric (1996) identify it as a pluton of interest for rare element pegmatites.

LOGTUNG

Beryl is present at the Logtung Mo-W porphyry deposit; both in the main vein stockwork, and in beryl-bearing quartz wolframite veins located a few kilometres to the south in B.C. The wolframite veins are near a fluoritic monzogranite body. A few beryl showings appear to fall within the monzogranite body when separate figures are compared (Wengzynowski, 1999). It is unclear if pegmatites in the monzogranite have been evaluated. Interestingly the descriptions of beryl mineralization suggest more than one generation of beryl has formed. Most beryl is bluish and opaque but mention is also made of a transparent variety (ibid).

The presence of beryl at Logtung suggests other alkali granite and quartz monzonite porphyries with moly/tungsten/tin mineralisation may carry beryl in wallrock veins some distance from the main body. The vein systems at the Anticlimax porphyry (Minfile 092P 014) are similar to that at Logtung. Both comprise quartz-molybdenite or wolframite with bismuthinite and fluorite. The Anticlimax porphyry has been related to the beryl prospective Bayonne suite of the Kootenay region.

Figure 2. Logtung beryl is illustrated in the poster of Lewis and Hart (2004).

CASSIAR AND CRY LAKE AREA

CASSIAR BATHOLITH

Groat *et al.* (1996) examined granitic pegmatites at the northern end of the Cassiar batholith within the Yukon. They identified an area of beryl-bearing pegmatites about two kilometres long and up to half a kilometre wide in the Ice Lakes area (figure 7, ibid). Beryl ranges to 5 cm in length but concentrations are low, and there is no mention of gem quality crystals. On the south side of the border in British Columbia references are made to pegmatite bodies in batholithic rocks at Cottonwood Creek, Blue River (Gabrielse 1963, p.88) but there is no mention of beryl. However beryl in pegmatite is noted at Toozaza Creek (Kyba, 1978).

South of the Yukon border beryl is recognized in late phases or younger stock-like intrusions within the Cassiar batholith. Showings include quartz-beryl-molybdenite veins at Toozaza Creek associated with two mica granites at Central and Southwest stocks (Kyba ibid), and vuggy quartz veins at the Storie molybdenum prospect associated with the Late Cretaceous Troutline Creek stock (Panteleyev, 1979). Both stocks display minor development of muscovite-fluorite greisen.

Other satellite plutons of Late Cretaceous age on the east margin of the batholith may be prospective for beryl. They include the Windy (Lamb) stock, Contact, Kuhn and other small mapped bodies (Nelson, 1993), (Cooke and Godwin, 1981).

Beryl with fluorite occurs in pegmatite dikes near the Blue Light skarn (Minfile 104O 005) on the west margin of the batholith. The dikes are associated with an Eocene granitic body. The surrounding area, from Toozaza Creek to Little Rancheria River on the west flank of the batholith, comprises a fluorine rich phase of the Cassiar batholith (Gabrielse, 1963). Mulligan and Jambor (1968) report pegmatite dikes are abundant and beryl is fairly common in some. According to Joanne Nelson (personal communication) crystals of beryl are small and a very pale blue color. The showing is not noted in Mulligan (1968).

Also of immediate prospecting interest is the greisenised and tourmaline-bearing Amy granite near Midway (Bradford and Godwin, 1988).

SYLVESTER ALLOCTHON

The Sylvester allocthon, a large slice of displaced oceanic rocks, lies immediately east of the Cassiar batholith. Chrome bearing ultramafic rocks form part of the oceanic sequence. Northwest of Blue River the allocthon is cut by the batholith. The contact aureole is up to a kilometre wide and has affected the mineralogy of ultramafic bodies. Ultramafic bodies contain regenerated olivine plus talc, tremolite and enstatite (Nelson and Bradford, 1993).

The allocthon is probably underlain by volatile-rich intrusions of Late Cretaceous age at Gum Mountain and Brinco Hill near the Midway deposit in the north (Bradford and Godwin, 1988). This is supported by the presence of fluorine rich dikes with topaz at the deeper levels of the deposit and an aeromagnetic anomaly. The Midway area should be prospected for beryl not only in altered Sylvester rocks but also in nearby Earn Group shales that form the footwall of the Sylvester allocthon.

Further to the south and east of Cassiar the local presence of granitic clasts in lamprophyre dikes suggests shallow granitic bodies underlie the allocthon locally (Nelson and Bradford, 1993).

Tourmaline pegmatites of the Cassiar suite are present near ultramafic bodies of the allocthon west of Blue River (Gabrielse, 1963). These pegmatites are an obvious target for further evaluation.

HORSERANCH RANGE

Prospector Einar Hagen discovered beryl crystals in the area in 1953 and Holland (1956) subsequently described beryl at source in pegmatite. Much later Simandl *et al.* (1998) and Wilson (1998) described the gem potential of the area. During their visits additional showings were found in the Harvey Lake area some distance away from the initial discovery (Minfile 104P 024). Beryl is found with tourmaline in pegmatites cutting ultramafics. Some of the pegmatites are zoned. Some of the beryl is of gem quality and small bluish aquamarines have been cut. Simandl (ibid) noted the ultramafics in the area are unaltered and anhydrous and suggested this reduced potential for emeralds. The area is however incompletely prospected. Though the main areas of ultramafic rock have undergone scrutiny, other large areas of the Horseranch Range have not been assessed. For example there are skarns that carry brown tourmaline with quartz and calcite, a bit of scheelite and these lie adjacent to other pegmatite bodies (Sis tungsten, Sellmer and McGill, 1981). The skarns hint that fluids to alter ultramafics are locally available.

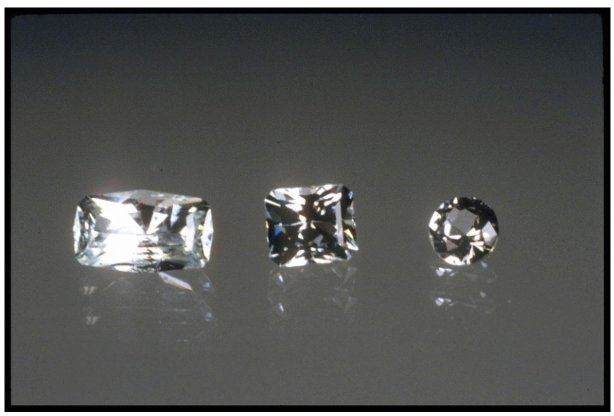

Figure 3. Small pale aquamarines from pegmatites in Horseranch range east of Cassiar. Photo is courtesy of Brad Wilson.

MOUNT HASKIN

Mount Haskin and the nearby Mt. Reed are small plug-like intrusions of Eocene age cutting platformal carbonates of the Atan Group. Associated with them are multi-stage skarns with Mo (W) mineralisation. Beryl, occasionally with a bit of fluorite, is mentioned as a minor component in associated quartz veins cutting hornfels and skarn at the northern contact of the Mount Haskin intrusion (Gower *et al.*, 1985). Ludwigite (a magnesian iron borate) is found in the skarn. Some pegmatoid phases are mentioned in border phases of the intrusions. The country rocks should be prospected for pegmatites.

WEST WILLISTON

A large belt of pegmatites (Wolverine complex) intrudes extensive areas of metamorphosed Ingenika Group rocks on the west side of Williston Lake. Sizable pegmatite bodies are present, up to 250 metres width (Ferri and Melville, 1994). Individual areas, up to 60 square kilometres in size, are underlain by granodiorite and pegmatite. The pegmatites are described as very uniform and non-descript. In the northwest part of the belt, beryl-bearing pegmatite is noted at the Family Farm showing (Minfile 94C 034) together with occasional tourmaline in pegmatite. The belt has received little geologic documentation since descriptions of quarrying in the 1920's and 1930's for mica (Dolmage, 1928).

In 1986 rare-earth element pegmatites (NYF type) were discovered in the Mount Bisson/Munroe Creek area in the southern part of this belt (Minfile 93O 021, Halleran and Russell, 1990). These allanite bearing pegmatites carry up to 0.8 per cent niobium. The associated alkalic bodies range from aegirine monzonites/syenites to quartz pegmatites.

There are likely more surprises to be found in the pegmatites of the extensive Wolverine complex. In such a large pegmatite belt some geochemical zonation is likely. This is a candidate area to discover beryl-bearing NYF pegmatites.

BAYONNE MAGMATIC ARC, KOOTENAY REGION

The southern Omineca belt contains an eighty to one hundred kilometer wide belt of mid to late Cretaceous batholiths and stocks of granodioritic, monzonitic and quartz monzonitic compositions. This north-south trending belt of intrusives, known as the Bayonne magmatic arc, carries related W-Mo-Bi mineralization. Most of the plutonic bodies are post-metamorphic and discordant to trends in country rock. They are mostly peraluminous, subalkalic, hornblende-biotite granite as well as highly fractionated two mica granites, aplites and pegmatites. Many of the granites are derived at least in part from melting of underlying Proterozoic metasediments. These metasediments are also exposed as horst-like gneiss domes.

The batholiths are generally mesozonal with emplacement depths generally deeper than mid-Cretaceous plutonic suites in the Yukon (Logan 2002a, 2002). Shallower emplacement depths are postulated at the northern and southern ends of the Bayonne arc.

NORTHERN BAYONNE SUITE AND SHUSWAP COMPLEX

Some intrusives in the high-grade metamorphic Shuswap complex have high initial Sr^{87}/Sr^{86} ratios, are peraluminous, and may be parental to rare element pegmatites. An example with beryl potential is the Northern Monashee leucogranite listed in Logan's (2002) dataset of the Bayonne suite and described in Kyser *et al.* (1994).

The Battle Range batholith looks promising for beryl mineralization. It is a highly fractionated two-mica granite pluton with related pegmatites and known tin, tungsten, fluorite and tourmaline showings. Beryl has not been recognized in outcrop but tentatively identified in thin section as a component of a fluorite-scheelite skarn (Bohme, 1984, p. 11).

The Baldy batholith is reported to carry beryl near Dunn Peak (Wilson, 1997). The area however now lies in a park and mineral extraction is not allowed.

SOUTHERN BAYONNE SUITE AND VALHALLA COMPLEX

There are at least five geologic settings of interest with known showings. They include:

- Late pegmatitic phases of the Bayonne batholith near Kootenay Lake;
- The periphery of the White Creek batholith west of Skookumchuk;
- The Proterozoic Hellroaring Creek stock southwest of Kimberley and related bodies (Matthew Creek stock, satellitic dikes and sills). Also the Greenland Creek intrusions of similar age west of Skookumchuk;
- Pegmatites in the Valhalla complex near Salmo;
- Pegmatites of the Nelson batholith.

Details are not provided here as J. Brown (2004) has reported on these occurrences while Legun (2004) provides an updated map on the Hellroaring Creek body.

The Valhalla complex in the Salmo area is of particular interest due to high-level vuggy pegmatites intruded during the period of uplift of the gneiss complex in the Eocene. The aquamarine-bearing pegmatite at the BQ claims (Brown, 2004) has been related to the to Eocene Ladybird suite (Gauthier, G. and Dixon, K., 1997).

Church (1998) mentions aquamarine in fragments of pink pegmatitic host rock in dump material at the Ottawa mine. The pegmatite is probably derived from small pegmatitic masses within Nelson porphyritic quartz monzonite. Other coarse pegmatites in the area have been noted (Chapleau property) and are worth further scrutiny.

Figure 4. The BQ claims near Salmo have produced fine specimens of gem aquamarine from a miarolitic pegmatite

SUMMARY AND CONCLUSIONS

Beryl is associated with volatile-bearing phases of leucocratic granites and syenites. Pathfinders include fluorite, topaz, tungsten and tin mineralization. Epizonal granites and pegmatites related to uplift present the best opportunity for open space fillings with aquamarine. B.C. compares more than favorably with the Yukon in number of showings of common beryl.

There has been virtually no exploration of small plugs of volatile granites and related pegmatites intruding ultramafic rocks in B.C. This association is a prime target for emerald. Given modest concentrations of beryllium in the host intrusive, emerald may be a byproduct of alkali and fluorine/boron metasomatism of ultramafic roof rocks. Previously metamorphosed ultramafics may enhance potential by way of improved permeability for beryllium bearing fluids or the presence of more mobile forms of chromium. The beryl-bearing vein halo of the Logtung porphyry indicates size potential for emerald deposits in B.C.

ACKNOWLEDGMENTS

The study grew from ideas generated by manager Brian Grant and subsequent support from the Rocks to Riches Program of the BC & Yukon Chamber of Mines. Eric Lalande provided cheerful field assistance to the author in the summer. Jarrod Brown and George Simandl provided useful feedback on the topic of pegmatites. Nick Massey provided data files for the emerald potential map. Constructive comments by Brian Grant, George Simandl, Neil Church and Dave Lefebure assisted the author in revisions to the manuscript.

REFERENCES

Aitken, J.D. (1959): Atlin, British Columbia; *Geological Survey of Canada*, Memoir 307, 89 pages.

Anderson, R.G. (1985): An overview of some Mesozoic and Tertiary plutonic suites and their associated mineralization in the northern Canadian Cordillera *in* Recent Advances in the Geology of Granite-Related Mineral Deposits, edited by R.P. Taylor and D.F. Strong, Special Volume 39, *The Canadian Institute of Mining and Metallurgy*, pages 96-113.

Anderson, R.G., Lowe, C., and Villeneuve, M.E. (2003): Nature, age, setting, and mineral potential of some Mesozoic plutons in central and northwestern Atlin map area (NTS 104N), northwestern B.C.; *Geological Association of Canada 2003 Conference*, abstract.

Arif, M., Fallick, A.E. and Moon, C.J. (1996): The genesis of emeralds and their host rocks from Swat, northwestern Pakistan: a stable-isotope investigation, *Mineralium Deposita*, Vol. 31, pages 255-268.

Ash, C. (2001): Relationships between ophiolites and gold-quartz veins in the North American cordillera; *B.C. Ministry of Energy and Mines*, Bulletin 108, 140 pages.

Aspinall, C. (1971): Geological report on mineral claims Candy 13-18, 23-30, Kel3; *B.C. Ministry of Energy and Mines*, Mineral Assessment Report 3569, 28 pages.

Ballantyne, S.B. and Littlejohn, A.L. (1982): Uranium mineralization and lithogeochemistry of the Surprise Lake batholith, Atlin, British Columbia *in* Uranium in Granites, edited by Y.T. Maurice, *Geological Survey of Canada*, Paper 81-23, pages 145-155.

Barton, Mark D. (1986): Phase equilibria and thermodynamic properties of minerals in the $Be0-AL_20_3-SiO_2-H_2O$ (BASH) system, with petrologic applications; *American Mineralogist*, Vol. 71, pages 277-300.

Bloodgood, M.A., Rees, C.J. and Lefebure, D.V. (1989): Geology of the Atlin Area (104N/11W, 12E); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-15.

Bohme, D.M. (1984): Geological and geochemical report on the Dary claim group, Slocan Mining Division, British Columbia; *B.C. Ministry of Energy and Mines*, Mineral Assessment Report 13473, 59 pages.

Bradford, J.A. and Godwin, C.I. (1988): Midway silver-lead-zinc manto deposit, northern British Columbia (104O/16); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1987, Paper 1988-1, pages 353-360.

Brown, G. (2004): Australia's emerald deposits, URL <http://gem.org.au/gallery/emerald.htm>

Brown, J.A. (2004): Mineralogy and geochemistry of beryl and rare-metal bearing granitic pegmatites in the Kootenay Region of Southeastern BC; *B.C. Ministry of Energy and Mines*, Geological Fieldwork 2003, Paper 2004-1, pages 167-184.

Cerny, P. (1991): Rare-element granitic pegmatites part1: Anatomy and internal evolution of pegmatite deposits; *Geoscience Canada*, Vol. 18, no. 2, pages 49-67.

Church, B.N. (1998): Metallogeny of the Slocan City Mining Camp (082F11/14); Geological Fieldwork 1997, *B.C. Ministry of Employment and Investment*, Paper 1998-1, pages 22-1 - 22-13.

Cooke, B.J. and Godwin, C.I. (1981): Geology of the McDame tungsten skarn project; *B.C. Ministry of Energy and Mines*, Geological Fieldwork 1981, Paper 1982-1, pages 259-270.

Dolmage V. (1928): Finlay River district *in* Summary Report 1927, Part A, *Geological Survey of Canada*, pages 31-35.

Domville, Julie (1998): Gemstones in B.C. have a sparkling outlook, *Mining Review Winter 1998*, pages 33-37.

Ferri, F. and Melville, D.M. (1994): Bedrock geology of the Germansen Landing - Manson Creek area, British Columbia, *B.C. Ministry of Energy and Mines*, Bulletin 91, 148 pages.

Fuertes-Fuente, M. and Martin-Izard, A. *et al.* (2000): P-T path and fluid evolution in the Franqueira granitic pegmatite, Central Galicia, Northwestern Spain; *The Canadian Mineralogist*, Vol. 38, pages 1163-1175.

Gabrielse, H. (1969): Jennings River map-area, British Columbia; *Geological Survey of Canada*, Paper 68-55, 37 pages.

Gabrielse, H. (1998): Geology of Cry Lake and Dease Lake map areas, north-central British Columbia; *Geological Survey Of Canada*, Bulletin 504, 147 pages.

Gabrielse, H. (1963): McDame map area, Cassiar District, British Columbia; *Geological Survey Of Canada*, Memoir 319, 138 pages.

Gauthier, Guylaine and Dixon, Kathleen, P. (1997): Slocan Valley Gem Project; *B.C. Ministry of Energy and Mines*, Mineral assessment report 25032.

Gower, S., Clark, A. and Hodgson, C. (1985): Tungsten-molybdenum skarn and stockwork mineralization, Mount Reed - Mount Haskin district, northern British Columbia, Canada; *Canadian Journal of Earth Sciences*, Vol. 22, pages 728-747.

Groat, L. and Ercit T. (1996): Granitic pegmatites in north-western Canada; *Department of Indian and Northern Affairs*, Open File 1996-3, 37 pages.

Groat, L. et al. (2002): Mineralogical and geochemical study of the Regal Ridge emerald showing, southeastern Yukon; *The Canadian Mineralogist*, Vol. 40, pp.1313-1338.

Giuliani, G., Silva, L. and Couto, P. (1990): Origin of emerald deposits of Brazil; *Mineralium Deposita*, Vol. 25, pp. 57-64.

Hall, Ron (2004): Canadian emeralds; *Canadian Mining Journal*, April 2004.

Halleran, A. and Russell, J. (1990): Geology and description petrology of the Mount Bisson alkaline complex, Munroe Creek, British Columbia (93N/9E, 93O/12W, 5W); *B.C. Ministry of Energy and Mines*, Geological Fieldwork 1989, Paper 1990-1, pages 297-304.

Hawthorne, F. and Cerny, P. (1982): The mica group in Granitic Pegmatites in Science and Industry; *Mineralogical Association of Canada*, Short Course Handbook, Volume 8, pages 63-91.

Holland, S.S. (1956): Cassiar beryl; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Minister of Mines Annual Report - 1955, pages 9-10.

Kikauka, A. (2002): Geological report on the Adanac property; *B.C. Ministry of Energy and Mines*, Mineral Assessment Report 26895, 53 pages.

Kirkham, R.V. and Sinclair W.D. (1985): Comb quartz layers in felsic intrusions and their relationship to porphyry deposits *in* Recent Advances in the Geology of Granite-Related Mineral Deposits, edited by R.P. Taylor and D.F. Strong, Special Volume 39, *The Canadian Institute of Mining and Metallurgy*, pages 50-71.

Kwak, T. (1987): W-Sn skarn deposits and related metamorphic skarns and granitoids; *Elsevier* (Developments in Geology 24), 451 pages.

Kyba, B.W. (1978): Geological and geochemical report 6A200 mineral claims; *B.C. Ministry of Energy and Mines*, Mineral assessment report 7148, 72p.

Kyser, T., Ghent, E. and Sevigny, J. (1994): Petrogenesis of two-mica granites, northern Monashee Mountains, British Columbia: Evidence from oxygen, hydrogen, and strontium isotopic compositions; *Geological Society of America Bulletin*, Vol. 106, pages 1531-1537.

Lefebure, D.V., Fournier, M.A. and Jackaman, W. (1993): Prospective areas for intrusion-related gold-tungsten-bismuth Veins, *B.C. Ministry of Energy and Mines*, Open File 1999-3.

Legun, A. (2004): The potential for emeralds in B.C. - A preliminary overview; *B.C. Ministry of Energy and Mines*, Geological Fieldwork 2003, Paper 2004-1, pages 291-229.

Lewis, L., Hart, C. and Murphy, D. (2003): Roll out the beryl; *Yukon Geological Survey*, Miscellaneous Publications, URL <http://www.geology.gov.yk.ca/publications/miscellaneous/placemats/beryl_placemat.pdf>

Lewis, L., and Hart, C. (2004): Maximizing Beryllium anomalies for successful emerald exploration; *Yukon Geological Survey*, Miscellaneous Publications, URL <http://www.geology.gov.yk.ca/publications/miscellaneous/posters/ beryllium_poster_2004.pdf>

Liverton, T. and Alderton, D.H.M. (1994): Plutonic Rocks of the Thirtymile Range, Dorsey Terrane: ultrafractionated tin granites in the Yukon; *Canadian Journal of Earth Sciences*, Vol. 31, pages 1557-1568.

Logan, J., 2002: Intrusion-related gold mineral occurrences of the Bayonne magmatic belt; *B.C. Ministry of Energy and Mines*, Geological Fieldwork 2001, Paper 2002-1, pages 237-246.

Logan, J., 2002a: Intrusion-related gold mineral occurrences of the Bayonne magmatic belt, southeast British Columbia; *B.C. Ministry of Energy and Mines*, Geoscience Map 2002-1.

London, D. and Evensen, J. (2001): The beryllium cycle from anatexis of metapelites to beryl-bearing pegmatites; Eleventh Annual V.M. Goldschmidt Conference, abstract.

Markl, G. and Schumacher, J. (1997): Beryl stability in local hydrothermal and chemical environments in a mineralized granite; *American Mineralogist*, Vol. 82(1-2), pages 194-202.

Mulligan, R. and Jambor, J.L. (1968): Tin-bearing silicates from skarn in the Cassiar district, northern B.C.; *The Canadian Mineralogist*, v. 9, pages 358-370.

Mulligan, R. (1968): Geology of Canadian Beryllium Deposits; *Geological Survey of Canada*, Economic Geology Report no. 23, 109 pages.

Nelson, J. and Bradford, J. (1989): Geology and mineral deposits of the Cassiar and McDame areas, British Columbia (104P/3,5); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1988, Open File 1989-1, pages 323-338.

Nelson, J. and Bradford, J. (1993): Geology of the Midway-Cassiar area, northern British Columbia (104, 104P); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Bulletin 83, 94 p.

Noble, S.R. and Spooner, E.T.C. (1986): Logtung, A porphyry W-Mo deposit in the southern Yukon *in* Mineral Deposits of Northern Cordillera, *Canadian Institute of Mining and Metallurgy*, Special Volume 37, pages 732-746.

Panteleyev, A. (1979): Cassiar map-area; *B.C. Ministry of Energy and Mines*, Geological Fieldwork 1978, Paper 1979-1, pages 51-60.

Pell, J. and Hora, Z.D. (1990: High-tech metals in British Columbia, *B.C. Ministry of Energy and Mines*, Information Circular 1990-19, 27 pages.

Pezzotta, F. and Williams, W.B. (2001): Field course on the rare element pegmatites of Madagascar, UNESCO-IUGS-IGCP.

Rainer, T. (2001): Characteristics of pegmatitic magma produced by low pressure crystallization of granites in the Erzgebirge, Germany: A melt and fluid inclusion study; *European Union of Geosciences*, Conference XI, Symposium OS07 abstracts.

Ray, G.E. *et al.* (2000): The geochemistry of three tin-bearing skarns and their related plutonic rocks, Atlin, northern

British Columbia; *Economic Geology*, Vol. 95, pp. 1349-1365.

Schwarz, D. and Guilani, G. (2001): Emerald deposits - a review; *The Australian Gemmologist*, Vol. 21, pages 17-23.

Shcherba, G.N. (1970): Greisens: *International Geology Review*, Vol. 12, no. 2, pages 114-150 and v. 12, no. 3, pages 239-254.

Sellmer, H. and McGill, M. (1981): Sis property; *B.C. Ministry of Energy and Mines*, Mineral Exploration Assessment Report 9401.

Simandl, G.J, Payie, G. and Wilson, B. (1998): Blue beryl/aquamarine occurrences in the Horseranch Range, north central British Columbia (NTS 104P07, 10), *B.C. Ministry of Energy and Mines*, Geological Fieldwork 1997, Paper 1998-1, pages 25-1 to 25-9.

Simandl, G.J., Paradis, S. and Birkett, T. (1999): Schist-hosted emeralds; *in* Selected British Columbia Mineral Deposit Profiles, Volume 3, Industrial Minerals, G.J. Simandl, Z.D. Hora and D.V. Lefebure, Editors, *British Columbia Ministry of Energy and Mines*, Open File 1999-10.

Simandl, G.J., Marshall, D. and Laird, J. (2000): Gem-quality Cordierite Deposits, Slocan Valley, British Columbia, *British Columbia Ministry of Energy and Mines*, Geological Fieldwork 1999, Paper 2000-1, pages 349-358.

Sinclair, W.D. (1983): Molybdenum, tungsten and tin deposits and associated granitoid Intrusions in the northern Canadian cordillera and adjacent parts of Alaska in Mineral Deposits of Northern Cordillera, edited by James A. Morin, Special Volume 37, *Canadian Institute of Mining and Metallurgy*, pages 216-233.

Sinkankas, J. and Read, P. (1986): Beryl (Butterworth gem books), *Butterworth-Heinemann*, 225 pages.

Watson, K. de P. and Matthews, W.H. (1944): The Tuya-Teslin area, northern British Columbia; *British Columbia Dept. of Mines*, Bulletin 19, 52 pages.

Wilson, Bradley S. (1997): Gemstone occurrences in British Columbia, *Canadian Gemmologist*, Vol. 18(3), pages 74-86.

Wilson, Bradley S. (1998): Report on the exploration of MRX property, *B.C. Ministry of Energy and Mines*, Mineral assessment report 25453.

Wengzynowski, W.A. (1999): Report on the Northern Dancer claim, *B.C. Ministry of Energy and Mines*, Mineral assessment report 25933.

TABLE 1 OCCURRENCES OF BERYLLIUM MINERALS IN BRITISH COLUMBIA

MINFILE	NAME	LAT approx deg min sec	LONG approx deg min sec	BERYLLIUM MINERAL	BERYL COLOR	FACETED GEMSTONE
104O 016	LOGTUNG BERYL	59 59 44	131 36 06	beryl	cloudy blue, green, blue-green, white, glassy clear	
104O 028	JENNINGS RIVER	59 59 29	131 36 06	beryl	green	
	MOUNT FOSTER	59 48?	135 30?	beryl, phenakite	colorless to light blue	aquamarine
104N 066	CANDY	59 40 19	132 56 19	beryl		
104N 074	NORTHEAST	59 40 15	132 58 23	danalite		
	EAST OF ATLIN	59 40?	133 25?	beryl		aquamarine
104O 005	BLUE LIGHT	59 38 59	130 28 06	beryl	very pale blue	
	GAZOO NW	59 38 13	130 13 51	beryl	pale green	
104O 045	GAZOO SW	59 36 55	130 13 54	beryl	pale green	
	HARVEY LAKE	59 28 16	122 57 53	beryl	pale-blue	aquamarine
104P 024	CASSIAR BERYL	59 20 59	128 51 26	beryl	pale green, blue	aquamarine
104P 020	HASKINS MOUNTAIN	59 20 29	129 29 36	beryl		
	NEAR ASH MOUNTAIN	59 17 29?	130 31 51?	beryl		aquamarine
104P 069	STORIE	59 14 49	129 52 06	beryl	green	
104P 026	NEEDLEPOINT	59 08 19	129 46 26	danalite		
094C 034	FAMILY FARM	56 33 19	124 44 03	beryl		
094D 114	MCCONNELL	56 25 14	126 06 32	beryl		
103P 086	RED MOUNTAIN	55 58 05	129 41 40	beryl		
	MASSA	54 58	128 10	gadolinite		
093K 006	ENDAKO	54 02 10	125 06 36	beryl		

	MOUNT GEORGE	53 37 26	122 19 22	beryl	green	
083D 019	MICA MOUNTAIN	52 53 56	119 32 48	beryl		
083D 029	SERPENTINE	52 23 00	119 00 04	beryl		
083D 007	YELLOW CREEK	52 00 05	118 18 44	beryl	yellow? &/or blue-green	
	DUNN PEAK	51 26	119 57	beryl		aquamarine
	ADAM'S LAKE	51 24	119 24	beryl	green	
082N 079	INCOMAPPLEUX R.	51 10 57	117 27 08	beryl		
082N 078	WOOLSEY CREEK	51 07 10	117 53 34	beryl?		
082FNW259	MOUNT BEGBIE	50 53 18	118 14 52	beryl	green/opaque	
082KNE071	TIN CITY	50 34 14	116 59 58	beryl		
	BLUE HAMMER	49 59 58	116 09 55	beryl	ice blue, greenish blue, whitish	
082FNE112	GREENLAND CREEK	49 58 24	116 11 09	beryl	pale, glassy/whitish with color tints	
082FNE159	WHITE CREEK	49 54 00	116 20 04	beryl		
082FNW155	OTTAWA MINE	49 47 06	117 23 42	beryl	sky blue	
	MATTHEW CR. (PEG2)	49 38 58	116 05 15	beryl	whitish	
	MATTHEW CR. (PEG1)	49 38 36	116 06 26	beryl	whitish	
082FNE110	HELLROARING CR.	49 34 00	116 10 33	beryl	whitish with color tints	
	RQ CLAIMS	49 33 39	117 38 45	beryl		aquamarine
	LOWER JACK	49 32 56	116 13 26	beryl	whitish	
	BQ CLAIMS	49 32 10	117 42 42	beryl	pale blue-green	aquamarine
	SLOCAN 2	49 31 46	117 39 16	beryl	greenish blue	
082FSE091	MIDGE CREEK	49 22 20	116 49 34	beryl	blue-green	
	LAIB CREEK	49 20 26	116 52 56	beryl	ice blue to greenish blue	
	TOBY	49 10	116 47	beryl	greenish blue	
092B 111	PEG	48 30 37	123 59 23	beryl		

TABLE 1 REFEREMCES

MINFILE	NAME	PRIME REFERENCE (GF = Ministry Geological Fieldwork publication) (ARIS = Mineral Exploration Assessment Report)
104O 016	LOGTUNG BERYL	Wengzynowski, W.A. (1998): ARIS 25933
104O 028	JENNINGS RIVER	MINFILE
	MOUNT FOSTER	Wilson, B. (1997): Can. Gemmologist 18(3), pp. 74-86
104N 066	CANDY	MINFILE
104N 074	NORTHEAST	MINFILE
	EAST OF ATLIN	Wilson, B. (1997): Can. Gemmologist 18(3), pp. 74-86
104O 005	BLUE LIGHT	MINFILE & personal communication Joanne Nelson
	GAZOO NW	Kyba, B. (1978): ARIS 7148
104O 045	GAZOO SW	Kyba, B. (1978): ARIS 7148
	HARVEY LAKE	Simandl, G. (1998): GF 1997, pp. 25-1 to 25-9
104P 024	CASSIAR BERYL	MINFILE
104P 020	HASKINS MOUNTAIN	Gower, S. et al. (1985), CJES 22, p. 739.
	NEAR ASH MOUNTAIN	Wilson, B. (1997): Can. Gemmologist 18(3), pp. 74-86
104P 069	STORIE	Panteleyev, A. (1979): GF 1978, pp. 51-60
104P 026	NEEDLEPOINT	MINFILE
094C 034	FAMILY FARM	MINFILE
094D 114	MCCONNELL	MINFILE
103P 086	RED MOUNTAIN	Wilson, B. (1997): Can. Gemmologist 18(3), pp. 74-86

	MASSA	Tom Schroeter pers comm, ARIS 8467, Map 2
093K 006	ENDAKO	MINFILE
	MOUNT GEORGE	McEwen, B. (1992), ARIS 22365
083D 019	MICA MOUNTAIN	MINFILE
083D 029	SERPENTINE	MINFILE
083D 007	YELLOW CREEK	MINFILE & correspondence in property file
	DUNN PEAK	Wilson, B. (1997): Can. Gemmologist 18(3), pp. 74-86
	ADAM'S LAKE	unnamed contact at Ministry of Environment
082N 079	INCOMAPPLEUX R.	MINFILE
082N 078	WOOLSEY CREEK	MINFILE
082FNW259	MOUNT BEGBIE	MINFILE & personal communication Jarrod Brown
082KNE071	TIN CITY	Bohme, D.M. (1984): ARIS 13473
	BLUE HAMMER	Brown, J. (2004): GF 2003, pp. 167-184
082FNE112	GREENLAND CREEK	MINFILE & Brown, J. (2004): GF 2003, pp. 167-184
082FNE159	WHITE CREEK	MINFILE
082FNW155	OTTAWA MINE	Church, B. N. (1998): GF 1997, pp. 22-1 to 22-13
	MATTHEW CR. (PEG2)	Soloviev, S. (2001): ARIS 26701
	MATTHEW CR. (PEG1)	Chapleau Resources (2001): Peg Property Geology Map
082FNE110	HELLROARING CR.	MINFILE
	RQ CLAIMS	Gauthier, G. and Dixon, K. (1997): ARIS 25032
	LOWER JACK	Chapleau Resources (2000): Pakk property Geology Map
	BQ CLAIMS	Gauthier, G. and Dixon, K. (1997): ARIS 25032
	SLOCAN 2	Gauthier, G. and Dixon, K. (1997): ARIS 25032
082FSE091	MIDGE CREEK	MINFILE
	LAIB CREEK	Addie, L. (2002): ARIS 26966, 26955

	TOBY	Brown, J. (2004): GF 2003, pp.167-184
092B 111	PEG	MINFILE