ROLL OUT THE BERYL

Lara Lewis, Craig Hart and Don Murphy

Yukon Geological Survey

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Yukon Energy, Mines and Resources

he Regal Ridge emerald occurrence is Yukon's most famous beryl locality; its discovery has catalyzed >$3.5M in exploration activity in 2003. Extensive beryl and beryllium data for the Yukon is lacking, which makes target identification difficult. Only fifteen or so beryl occurrences are officially documented in the Yukon, however, many more are suspected to exist.

Beryl commonly occurs in highly fractionated granitic rocks and pegmatites. It also occurs in hydrothermal quartz veins, greisens, miarolitic cavities and within metasomatized contact zones between schist and pegmatites. Trace elements (e.g., iron, chromium, vanadium) within the crystal structure of beryl are responsible for colouring the mineral and turning a worthless beryl into a precious or semi-precious gemstone.

Beryllium-rich granites or hydrothermal fluids intruding chromium- and/or vanadium-rich rocks (usually mafic or ultramafic) may crystallize emerald within, or at the margins of, pegmatites and hydrothermal veins.

In the absence of chromium or vanadium, beryl will crystallize either as non-gem beryl or as semi-precious gem beryl such as aquamarine.

beryl occurrence

Beryl-prospective plutonic suites

- Alkalic-Potassic granites - Prospector Mountain, Tombstone Suite, Mississippian alkaline intrusions
- Peraluminous - two-mica granites - Anvil, Cassiar, Tungsten suites
- Highly Fractionated metaluminous intrusive rocks - Nisling Range Alaskites

Other plutonic suites

- Kluane granites
- Dawson Range granites, Whitehorse intrusive suite, Teslin intrusive suite
- Early Tertiary granites

MINFILE occurrences

- tungsten and tin
- tungsten
- tin
- fluorite, topaz, greisen, tourmaline
- molybdenum

Selwyn Basin whole rock granite geochemistry (3047 sample dataset)

- 11-15 ppm beryllium (96th percentile)
- 15-20 ppm beryllium (99th percentile)

Potential sources of chromium and vanadium

- Intermediate to mafic volcanic and metamorphic rocks

Potential hosts for Black Shale Model deposits

- Earn and Road River Group shales and sedimentary rocks

COLUMBIA BLACK SHALE MODEL

Early Paleozoic shales in the Yukon have the potential to host Columbia-type emeralds. Prospective units include Cambro-Ordovician Road River shales and Devono-Mississippian Earn Group Shales.

Columbia - Black Shale Model
Emeralds occur in fissures and in vugs (with calcite, pyrite, and albite) within brecciated back arc black shales. During extensional deformation, two high salinity brines formed. Be, V, Cr was pulled out of the shales by circulating fluids and precipitated emerald and fluorite.

Aquamarine

Trace iron (Fe^{2+} and Fe^{3+}) in the beryl crystal structure is responsible for the blue colour of aquamarine.

Photo: Steve Cott

Pluto - quartz veins with aquamarine, pyrite, molybdenite, wolframite, galena, bismuthite and muscovite crosscut altered quartz feldspar porphyry. Scheelite, tourmaline and fluorite mineralization are also present.

Beryl is a hexagonal mineral (formula $Be_3Al_2Si_6O_{18}$)

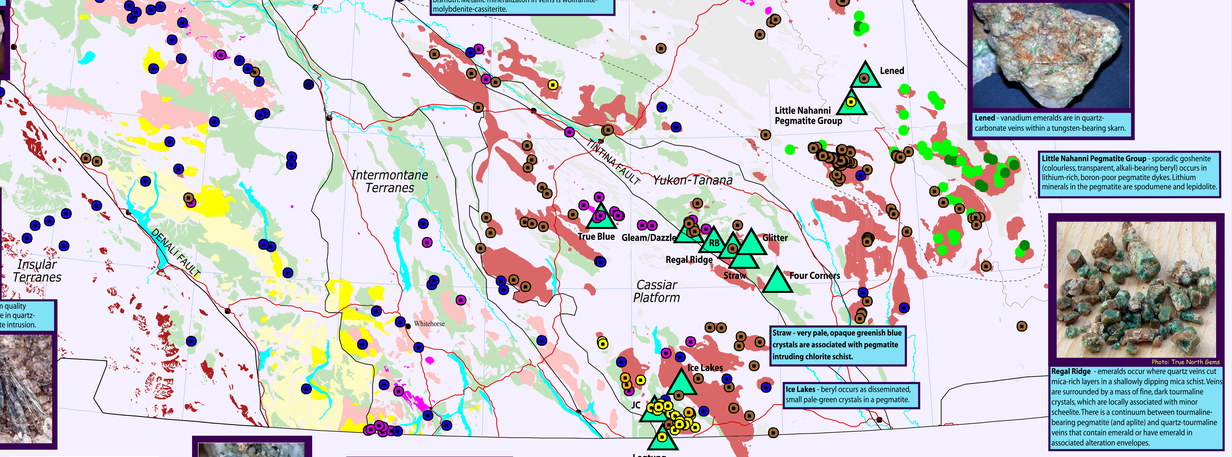
Photo: True North Gems

True Blue - green to pale blue to dark blue gem quality aquamarine occurs with tourmaline and fluorite in quartz-carbonate tension gashes that crosscut a syenite intrusion.

Photo: Brad Wilson

Mount Foster, northern B.C. (near Bennett - precise location unknown) - aquamarine occurs in miarolitic cavities in granitic rocks along with other gem-quality minerals such as topaz and smoky quartz.

Logtung - blue aquamarine occurs in polymetallic sheeted veins along with quartz, scheelite, molybdenite, pyrite, fluorite and bismuth.



Emerald -scheelite, beryl, bismuth, gold, pyrite, molybdenite, sphalerite, galena, tetrahedrite and chalcopyrite mineralization are associated with the multi-phased Emerald Lake Pluton. Mineralized miarolitic cavities are also present.

Kalzas - mineralized quartz veins contain beryl, tourmaline, feldspar, muscovite, pyrite, galena and native bismuth. Metallic mineralizaton in veins is wolframite-molybdenite-cassiterite.

Emerald

Chromium and vanadium give emerald their distinctive green colour. Cr_2O_5 contents of 0.2 to 1.5% and V_2O_5 contents of 0.1 to 1% with 0.2 to 1.8% FeO are required for emeralds. Regal Ridge emeralds have an average of 3200 ppm Cr and 170 ppm V.

Lened - vanadium emeralds are in quartz-carbonate veins within a tungsten-bearing skarn.

Little Nahanni Pegmatite Group - sporadic goshenite (colourless, transparent, alkali-bearing beryl) occurs in lithium-rich, boron-poor pegmatite dykes. Lithium minerals in the pegmatite are spodumene and lepidolite.

Photo: True North Gems

Regal Ridge - emeralds occur where quartz veins cut mica-rich layers in a shallowly dipping mica schist. Veins are surrounded by a mass of fine, dark tourmaline crystals, which are locally associated with minor scheelite. There is a continuum between tourmaline-bearing pegmatite (and aplite) and quartz-tourmaline veins that contain emerald or have emerald in associated alteration envelopes.

Straw - very pale, opaque greenish blue crystals are associated with pegmatite intruding chlorite schist.

Ice Lakes - beryl occurs as disseminated, small pale-green crystals in a pegmatite.

JC - minor beryl occurs with sphalerite, chalcopyrite, arsenopyrite, magnetite and scheelite, axinite, fluorite and apatite. Mineralization is associated with a tin-bearing skarn.

Candy - molybdenite and traces of beryl, chalcopyrite, wolframite, galena and fluorite occur in quartz veins that cut a quartz feldspar porphyry.

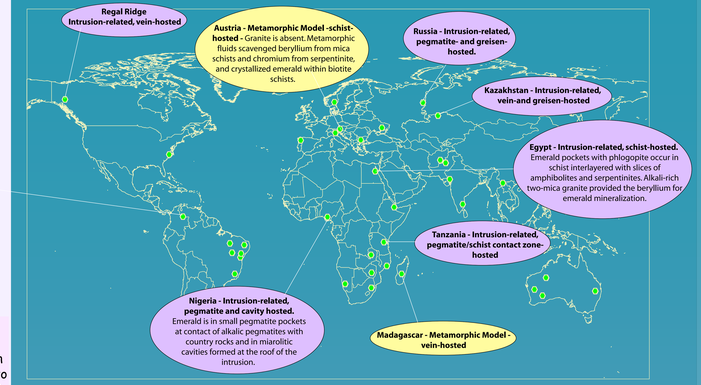
Blue Light - pegmatite dykes associated with a granitic intrusion contain fluorite, fluoroapatite and minor beryl. Scheelite is disseminated within the skarn. Magnetite-quartz-pyrite lenses within the hornfels zone contain elevated levels of tungsten, beryllium and tin.

Gazoo - one occurrence of beryl was noted, along with molybdenite within a quartz vein cutting a two-mica quartz monzonite.

Haskins Mountain - minor beryl is found in massive pyrrhotite-rich skarn along with abundant sphalerite and lesser chalcopyrite, galena and arsenopyrite. The skarn also contains elevated levels of tin.

Horseranch - pale blue-green aquamarine occurs in granite and pegmatite along with muscovite, quartz , feldspar, and lesser amounts of tourmaline and garnet.

EMERALDS OF THE WORLD



WHERE IS THE BERYLLIUM?

The beryllium content of most rocks and rock-forming minerals is low. Mica-rich sedimentary rocks, which are considered fertile sources of beryllium, generally contain less than 5 ppm beryllium.

Typical granites associated with beryl and emerald mineralization contain between 12 and 20 ppm beryllium. In pegmatites, this number may increase into the 100s of ppm.

Beryllium is generally in low concentration within magma, and is not easily incorporated into crystals. Therefore, it is considered to be incompatible, and tends to enrich and crystallize late from highly fractionated magmas.

Beryllium concentrated in the residual magma may crystallize in pegmatites, aplites or (more prospective) hydrothermal veins. This partitioning of beryllium into a fluid phase allows the beryllium concentration to reach saturation levels so that beryl can precipitate in veins.

PLACER BERYL OCCURRENCES

Beryl occurrences have not been officially recorded in placer deposits. Although beryl is hard (Hardness=7.5-8) it has a specific gravity similar to quartz (2.63-2.68), and is not typically recovered in heavy mineral concentrates.

Emerald is commonly full of inclusions and does not survive weathering. Semi-precious gem beryl and non-gem beryl are more resistant to weathering and may occur as larger, resistant minerals within sediments.

EXPLORATION CRITERIA FOR GEM BERYL

INTRUSION-RELATED

- **Highly-Fractionated Granites** - Leucocratic, very felsic, and typically muscovite-bearing quartz-rich granites. Tourmaline is often present.
- **Lithophile Element Enrichments** - Prospective granitoids typically have associated tungsten, tin, molybdenum or uranium mineralization.
- **Fluorine** - Fluorine may act to transport beryllium in the fluid or vapour. Look for fluorite gangue in quartz veins, fluorine-enriched granites, greisens or topaz mineralization.
- **Vugs, miarolitic cavities and brain rock** - These indicate that potentially mineralizing fluids have been exsolved from the magma and were concentrated, likely in the apex of the intrusion.
- **Pegmatites and aplites** - Presence of these rocks indicates the formation of a fluid phase; they typically have associated quartz veins and may have associated tourmaline or enrichments of Be, Li, Sn, Ta and/or U.
- **Moderate to shallow granite emplacement depth** - shallow to mid-crustal granitoids more easily exsolve the fluid phase needed to form beryl in veins (greater gem potential); beryl that stays in the melt crystallizes within granite or in pegmatite and has lower gem potential.

PROSPECTIVE PLUTONIC SUITES

Cassiar, Tungsten, Anvil, and Nisling Range plutonic suites contain phases of highly fractionated granite. Other prospective granites include parts of the Coffee Creek, Prospector Mountain and Tombstone suite granites.

SHEAR-HOSTED

Deep structures such as faults, shear zones and suture zones can channel fluids through country rocks. Shear zones that cut through imbricated slices of oceanic and continental crust provide potential zones for emerald mineralization.

METAMORPHIC

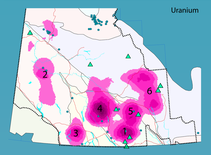
Look for metasomatized greenschist or higher grade, regionally metamorphosed contact zones between sedimentary (Be-source) and mafic (Cr-source) rocks for potential emerald mineralization.

BLACK SHALE-HOSTED - shales with elevated levels of beryllium, vanadium, and chromium may be prospective for Columbia black shale-type emerald deposits. A mix of intrusion-related and black shale models may also occur.

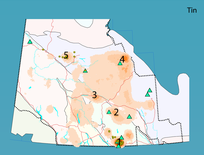
Regional Stream Sediment Geochemistry Density Plots*

Tin, molybdenum, fluorine and uranium mineralization are associated with highly fractionated granites that provide good targets for beryl exploration and are easily located with MINFILE density and regional geochemical density plots.

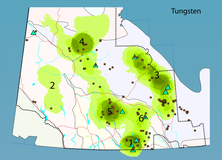
When granitic magma partially crystallizes, certain elements tend to remain in the melt or go into a fluid phase. Incompatibile elements that go into fluid or stay in the melt include beryllium, boron, lithium, rare earth elements and uranium, among others. The residual melt therefore becomes increasing enriched in incompatible elements, water and volatile elements (e.g., fluorine, chlorine). The exsolved fluid phase is less viscous and tends to rise in the magma chamber, and brings with it metallic elements like copper, molybdenum, tin and uranium. These elements may crystallize eventually as pegmatites, hydrothermal quartz veins, skarn or greisen deposits.



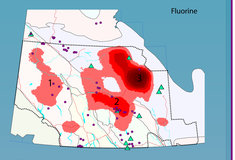
Uranium concentrations are high in areas associated with highly fractionated granitoids: (1) Cassiar Suite intrusions, (2) Nisling Range alaskites, (3) Kusawa area plutons, (4) Nisutlin/Quiet Lake batholiths, (5) Finlayson Lake District plutons and the (6) Tungsten plutonic suite.



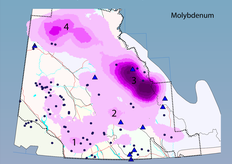
High tin concentrations are associated with highly fractionated granites: (1) Cassiar Suite intrusions, (2) Pelly Mountains area, (3) Glenlyon Batholith, (4) Hess Mountains area and (5) McQuesten area granites



High tungsten concentrations are associated with evolved granites: (1) Cassiar Suite Intrusions, (2) Nisling Range alaskites, (3) Tungsten plutonic suite (4) Mayo area plutons, (5) Nisutlin/Quiet Lake batholiths and (6) Finlayson Lake area plutons



Tin-tungsten and REE-enriched granites and pegmatites commonly have elevated fluorine levels. Regional high fluorine concentrations are associated with (1) Nisling Range alaskites, (2) Anvil Plutonic Suite, and (3) Tungsten plutonic suite or Selwyn black shale.



Molybdenum concentrations are high in the following: (1) Nisling Range alaskites, (2) Finlayson Lake area, (3) associated with the Tungsten Plutonic Suite or early Paleozoic shales and (4) on the North American Platform, associated with early Paleozoic shales. Note that this geochemical data is not a good discriminator for beryl-fertile granites in Selwyn Basin

Note the absence of pathfinder element concentrations in the Dawson area, specifically around the Pluto aquamarine property. This may be due to the lack of glaciation in the area, which gives skewed results for regional geochemistry.

*Triangles denote known beryl occurrences. Circles denote MINFILE occurrence associated with the plotted element. Dotted line indicates limit of regional geochemical coverage. Plots were produced by taking GSC regional geochemical stream sediment data and calculating density by adding the ppm values for each point in the search radius (50 km from a point; 20 km for the tin plot) and dividing by the area of the circle in kilometres.

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