Yukon Geological Survey

ROLL OUT THE BERYL

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Yukon Geological Survey

Yukon Energy, Mines and Resources

The Regal Ridge emerald occurrence is Yukon's most famous beryl locality; its discovery 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 is a hexagonal mineral ($Be_3Al_2Si_6O_{18}$)

Aquamarine

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

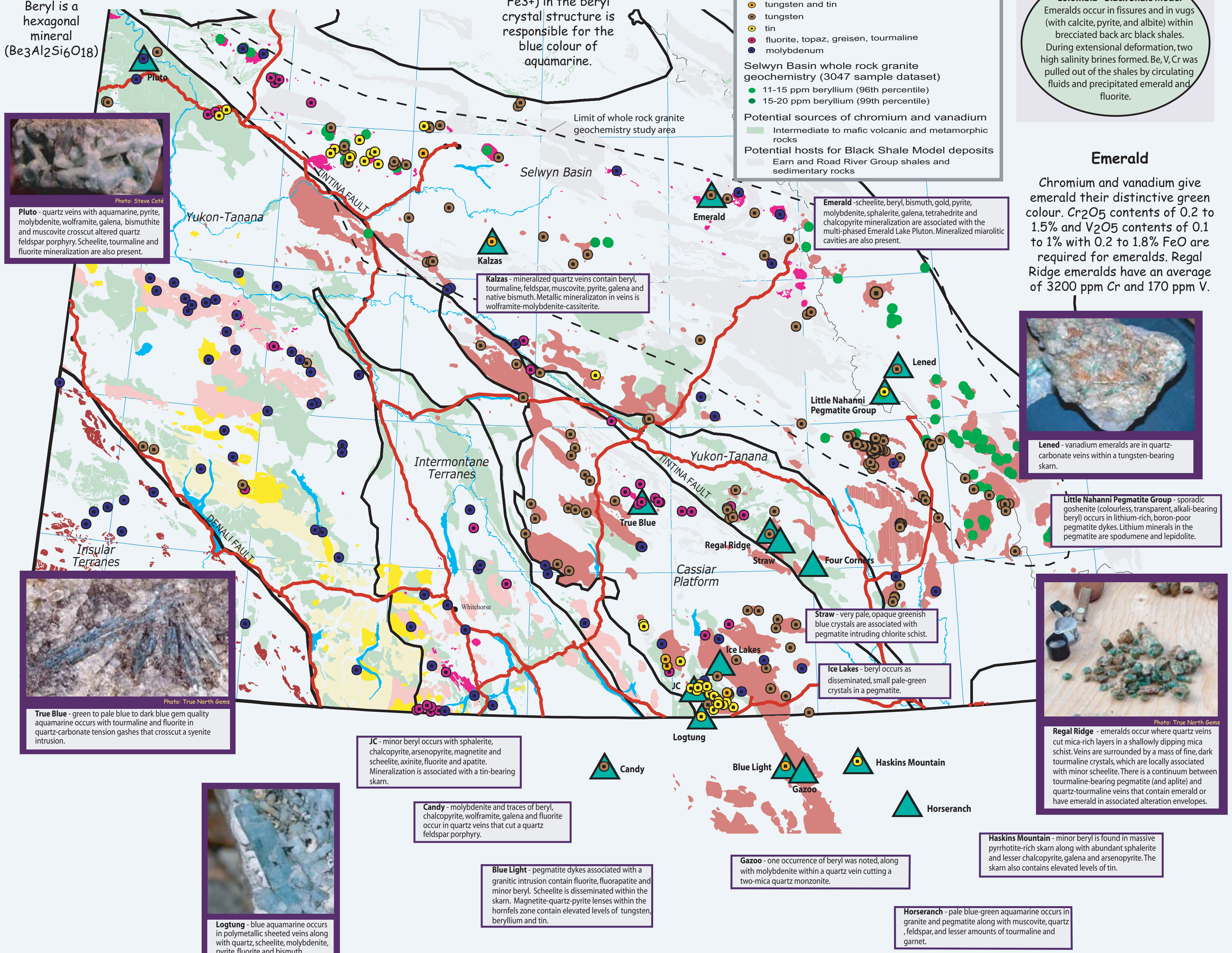
COLOMBIA BLACK SHALE MODEL

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

Colombia - 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.

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.



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.

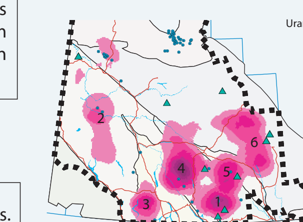
BLACK SHALE-HOSTED

Shales with elevated levels of beryllium, vanadium, and chromium may be prospective for Colombia black shale-type emerald deposits. A mix of intrusion-related and black shale models may also occur.

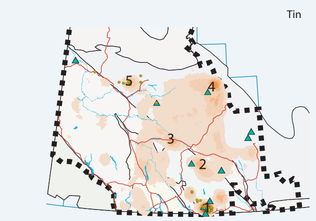
Regional Stream Sediment Geochemistry Density Plots*

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.

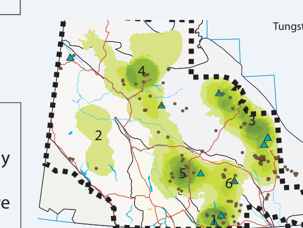
When granitic magma partially crystallizes, certain elements tend to remain in the melt or go into a fluid phase. Incompatibile elements that go into fluid or stay in the melt include beryllium, boron, lithium, rare earth elements and uranium, among others. The residual melt therefore becomes increasing 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.



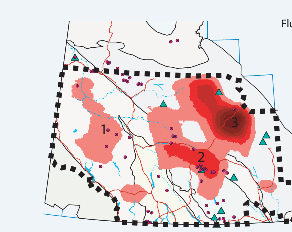
Uranium concentrations are high in areas associated with highly fractionated granitoids: (1) Cassiar Suite intrusions, (2) Nisling Range alaskites, (3) Kusawa area plutons, (4) Nisultin/Quiet Lake batholiths, (5) Finlayson Lake District plutons and the (6) Tungsten plutonic suite.



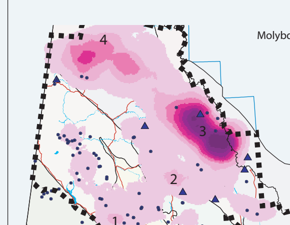
High tin concentrations are associated with highly fractionated granites: (1) Cassiar Suite intrusions, (2) Pelly Mountains area, (3) Glenlyon Batholith, (4) Hess Mountains area and (5) McQuesten area granites.



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 pont 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.

References

Deklerk, R. (compiler), 2002. Yukon MINFILE 2002. Exploration and Geological Services, Indian and Northern Affairs Canada.
Giuliani, G.F., Jarnot, M., Neumeier, G., Ottaway, T., Sinkankas, J. and Staebler, G. (eds.), 2002. Emeralds of the World. ExtraLapis English No.2: The Legendary Green Beryl. Lapis International, LLC, East Hampton, CT, 100 p.
Grew, E.S. (ed.), 2002. Beryllium: Mineralogy, Petrology, and Geochemistry. Reviews in Mineralogy & Geochemistry, vol. 50. Mineralogical Society of America, 691 p.
Groat, L.A., 1996. Granitic Pegmatites in North-western Canada. Exploration and Geological Services, Indian and Northern Affairs Canada, Open File 1996-3(G), 54 p.
Héon, D. (compiler), 2003. Yukon Regional Geochemical Database 2003 - Stream sediment analyses. Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada.
Mulligan, R., 1968. Geology of Canadian Beryllium Deposits. Geological Survey of Canada, Economic Geology Report no.23, 109 p.
Walton, L., 1996. Exploration Criteria for Gemstone Deposits and their Application to Yukon Geology. Exploration and Geological Services, Indian and Northern Affairs Canada, Open File 1996-2(G), 129 p.