SCHIST-HOSTED EMERALDS Q07

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Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYMS: Emerald deposits commonly described as “suture zone-related”, “pegmatite-related schist-hosted” or “exometamorphic”, “exometasomatic”, “biotite schist-type”, “desilicated pegmatite related” and “glimerite-hosted” are covered by this model.

COMMODITIES (BYPRODUCTS): Emerald (industrial grade beryl, other gemstones, such as aquamarine, chrysoberyl, phenakite, tourmaline).

EXAMPLES **(Yukon): Tsa da Glisza (Regal Ridge) (105G 123)**;
(British Columbia - *Canada/International*): *Socoto and Carnaiba deposits (Brazil), Habachtal (Austria), Perwomaisky, Mariinsky, Aulsky, Krupsky, Chitny and Tsheremshansky deposits (Russia), Franqueira (Spain), Gravelotte mine (South Africa), Mingora Mines (Pakistan).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Emerald deposits principally related to mafic and ultramafic schists or unmetamorphosed ultramafic rocks in contact with felsic rocks, either pegmatoid dykes, granitic rocks, paragneisses or orthogneisses. Such contacts may be either intrusive or tectonic.

TECTONIC SETTINGS: Found in cratonic areas as well as in mobile belts. In many cases related to major Phanerozoic or Proterozoic suture zones that may involve island arc-continent or continent-continent collision zones. The lithological assemblages related to suture zones commonly form a “tectonic mélange” and in some areas are described as “ophiolitic melange”.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Mainly in greenstone belts, but also in other areas where Cr-bearing rocks may be adjacent to pegmatites, aplites, granites and other felsic rocks rich in beryllium. Metamorphic grade is variable; however, it typically reaches green-schist to amphibolite facies. **In Yukon, Tsa da Glisza emeralds are associated with mafic volcanic rocks of Yukon-Tanana Terrane intruded by mid-Cretaceous plutonic rocks of Anvil-Cassiar Suite.**

AGE OF MINERALIZATION: The deposits are hosted by Archean age rocks or younger. The age of mineralization is typically linked to either a period of tectonic activity or a time of pegmatoid emplacement. **Tsa da Glisza emeralds are related to mid-Cretaceous intrusive rocks.**

HOST/ASSOCIATED ROCK TYPES: Biotite schists (“biotites”, “phlogopitites” and “glimerites”) are a particularly favourable host. Other favourable hosts are metamorphosed mafic volcanic rocks, such as epidote-chlorite-actinolite-bearing rock, chlorite and chlorite-talc schists, talc and talc-carbonate schists, white mica schists, mafic schists and gneisses and amphibolites. Less

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commonly emeralds occur in unmetamorphosed mafic or ultramafic rocks and possibly listwaenites. Pegmatites or quartz veins in the contact zone between granitic rocks and mafic rocks may in some cases host emeralds. A wide variety of rocks can be associated with schist-hosted emerald deposits, including granite, syenite, tonalite, granodiorite, a variety of orthogneisses, marbles, black phyllites, white mica schists, mylonites, cataclasites and other metasedimentary rocks.

DEPOSIT FORM: Most of the mineralization is hosted by tabular or lenticular mafic schists or “blackwall zones”. Favourable zones are a few metres to tens of metres wide and follow the contacts between felsic and mafic/ultramafic lithologies for distances of tens to hundreds of metres, but economically mineable portions are typically much smaller. For example, mineable bodies in the Urals average 1 metre in thickness and 25 to 50 metres in length. Pegmatoides, where present, may form horizontal to steeply dipping pods, lens-shaped or tabular bodies or anastamosing dykes which may be zoned.

TEXTURE/STRUCTURE: In blackwall or schists, lepidoblastic texture predominates. The individual, discrete emerald-bearing mafic layers within the favourable zones may be complexly folded, especially where the mineralization is not spatially associated with pegmatites. Emeralds are commonly zoned. They may form porphyroblasts, with sigmoidal orientation of the inclusion trails; beryl may form the rims separating phenakite form the surrounding biotite schist; or emerald crystals may be embedded in quartz lenses within the biotite schist. Chrysoberyl may appear as subhedral porphyroblasts or skeletal intergrowths with emerald, phenakite or apatite. Where disseminated beryl crystals also occur within pegmatites, they are short, commonly fractured, prismatic to tabular with poor terminations; but may be up to 2 metres in length and 1 metre in cross section. Long, prismatic, unfractured crystals occur mainly in miarolitic cavities.

ORE MINERALOGY [Principal and *subordinate*]: Emerald and *other beryls (in some cases aquamarine or morganite),* ± *chrysoberyl and industrial grade beryl. Spodumene gems (in some cases kunzite) may be found in related pegmatites.*

GANGUE MINERALOGY [Principal and *subordinate*]: In the schist: biotite and/or phlogopite, talc, actinolite, plagioclase, serpentine, ± fuchsite, ± quartz, ± carbonates, ± chlorite, ± muscovite, ± pyrite, *epidote, ± phenakite, ± milarite and other beryllium species, ± molybdenite, ± apatite, ± garnet, ± magnetite, ± ilmenite, ± chromite, ± tourmaline, ± cassiterite.*
In the pegmatoids: feldspars (commonly albite), quartz, micas; ± *topaz,* ± *phenakite* , ± *molybdenite,* ± *Sn and W-bearing minerals,* ± *bazzite,* ± *xenotime,* ± *allanite, ± monazite, ± phosphates, ± pollucite, ± columbite-tantalite, ± kyanite, zircon, ± beryllonite, ± milarite and other beryllium species.* Emerald crystals may contain actinolite-tremolite, apatite, biotite, bityite, chlorite, chromite, columbite-tantalite, feldspar, epidote, fuchsite, garnet, hematite, phlogopite, pyrrhotite, rutile, talc, titanite and tourmaline inclusions.

ALTERATION MINERALOGY: Limonitization and pyritization are reported in the host rocks. Kaolinite, muscovite, chlorite, margarite, bavenite, phenakite, epidimyte, milarite, bityite, bertrandite, euclase are reported as alteration products of beryl.

WEATHERING: Weathering contributes to the economic viability of the deposits by softening the matrix, and concentrating the beryl crystals in the overlying soil or regolith.

ORE CONTROLS: 1) The principal control is the juxtaposition of beryllium and chromium-bearing lithologies along deep suture zones. Emerald crystals are present mainly within the mafic schists and in some cases so called “blackwall zones” as described ultramafic-hosted talc deposits (M07). In this setting it may be associated with limonite zones. 2) This commonly occurs near the contacts of pegmatoids with mafic schists. Emerald crystals are present mainly within the mafic schists, although in some cases some of the mineralization may be hosted by pegmatoids. 3) Another prospective setting is along fracture-controlled glimerite zones. 4) Mineralization may be concentrated along the planes of regional metamorphic foliation, especially in cores of the folds where the relatively high permeability favours chemical exchange and the development of synmetamorphic reaction zones between chromium and beryllium-bearing lithologies.
5) Serpentinite roof pendants in granites are prospective.

GENETIC MODELS: The origin of schist-hosted emerald deposits is controversial as is the case with many deposits hosted by metamorphic rocks. All emerald deposits require special geological conditions where chromium (± vanadium) and beryllium coexist. Where pegmatoids or plagioclase-rich lenses occur within ultramafic rocks, the crystallization of emeralds is commonly explained by interaction of pegmatites or pneumatolytic-hydrothermal, Be-bearing fluids with Cr-bearing mafic/ultramafic rocks. In other cases, emeralds in schists form by syn- or post-tectonic regional metamorphic chemical exchange (metasomatism) between felsic rocks, such as felsic gneisses, garnet mica schists or pre-metamorphic pegmatoids, with the adjacent Cr-bearing rocks such as schists, gneisses or serpentinites. Contacts between Cr- and Be-bearing source rocks may be tectonic, as is the case for "suture zone-related" deposits.

ASSOCIATED DEPOSIT TYPES: Feldspar-quartz and muscovite pegmatites (O03, O04). Mo and W mineralization may be associated with emeralds. Some porphyry W deposits (L07) have associated beryl. Tin-bearing granites are in some cases associated with emeralds. Gold was mined at Gravelotte Emerald Mines (no information about the gold mineralization is available).

COMMENTS: Recently, microprobe studies have shown that the green color of some beryls is due to vanadium rather than chrome. In most cases both Cr and V were detected in the beryl crystal structure. There are two schools of gemmologists; the first believes that strictly-speaking the vanadium-rich beryls are not emeralds. The second school believes that gem quality beryls should be named based on their physical, and more particularly, colour properties. It is possible that pegmatoid-related or suture zone-related emerald deposits hosted by black shales or other chromium and/or vanadium-bearing rocks will be discovered. In those cases it will be difficult to decide if these deposits are schist-hosted or Columbia-type (Q06) emeralds.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: The presence of beryl in eluvial and alluvial deposits is good pathfinder. The distribution of beryllium in stream sediments proved to be useful in Norway when coupled with identification of the individual drainage basins and knowledge of the geological environment.

GEOPHYSICAL SIGNATURE: A portable field detector that uses ^{124}Sb as a gamma radiation source, the berylometer, is used to detect Be in outcrop. The instrument should be held less than 4 cm from the sample. Radiometric surveys may be useful in detecting associated radioactive minerals where pegmatites are involved. Magnetic and electromagnetic surveys may be useful in tracing suture zones where ultramafic rocks and felsic rocks are faulted against each other.

OTHER EXPLORATION GUIDES: Any Be occurrences in a favourable geological setting should be considered as positive indicators. If green, chromium and/or vanadium-bearing beryls are the main subject of the search then ultramafic rocks, black shales or their metamorphic equivalents represent the most favourable host rocks. If exploration is focused on a variety of gem-quality beryls (not restricted to emerald), or if the targeted area is not mapped in detail, then Be occurrences without known spatial association with Cr- or V-bearing lithologies should be carefully considered. Minerals associated with emeralds in the ores may be considered as indirect indicators. A wide variety of field-tests based on fluorescence, alkalinity, staining, density and refractive index have been used in the past to distinguish beryl.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: The grade and tonnage of these deposits is difficult to estimate due to erratic emerald contents (gram/tonne), episodic nature of the mining activity which often results in high grading, and variability in the quality of gemstones (value/carat). For example, at the Mingora mines in Islamia Trench two, 15 to 30 centimetres thick layers of talc-rich rock surrounding quartz lenses contained 1000 to 5000 carats of good stones up to 30 carats in size. Some of the individual pits in the area produced less than 1000 carats. The cumulative production of the Mingora emerald mines was reported between 20 000 to over 50 000 carats/year between 1979 and 1988. At Gravelotte Emerald Mine, at least 23 000 kg of emeralds of varying grades have been produced since 1929 from several zones. For the same mine promotional literature states that " conservative estimates" of ore within the Cobra pit are 1.69 million tonnes that could result in production of 17 000 kg of emeralds (approximately 1gram /tonne). It is estimated that about 30% of the emeralds could be sold, but only 2-3% of these are believed to be gem quality. In the Urals the Mariinsky deposit was explored to an average depth of 500 metres by boreholes and underground workings. To determine emerald content, bulk samples as large as 200 tonnes are taken systematically at 100 metres interval along the favourable zone. No grade and tonnage are available.

ECONOMIC LIMITATIONS: Mining of precious stones in underdeveloped countries and smaller deposits is done using pick and shovel with limited use of jackhammers and bulldozers. Larger schist-hosted emerald deposits may be successfully exploited by a combination of surface and underground mining. The Mariinsky deposit was mined by open pit to the depth of 100 metres and is exploited to the depth of 250 metres by underground methods. “Low impact” explosives, expanding plastics or hydraulic wedging are used to break the ore. The ore is milled, screened and manually sorted.

END USES: Transparent and coloured beryl varieties, such as emerald, morganite and aquamarine, are highly valued gemstones. Industrial grade beryls commonly recovered as by-products are a source of Be oxide, Be metal alloys used in aerospatial and defence applications, Be oxide ceramics, large diameter beryllium-copper drill rods for oil and gas, fusion reactors, electrical and electronic components. Berylium metal and oxides are strategic substances, and may be substituted for by steel, titanium and graphite composites in certain applications. Phosphor bronze may replace beryllium-copper alloys. However, all known substitutes offer lower performance than Be-based materials.

IMPORTANCE: Schist-hosted deposits are the most common source of emeralds, although the largest and most valuable gemstones are most frequently derived from the Colombia-type deposits. Besides schist-hosted deposits and pegmatites, beryl for industrial applications may be also be present in fertile granite and syenite complexes that may be parent to pegmatites. A major portion of the beryl ore used in the U.S.A. as raw material for beryllium metal is recovered as a byproduct of feldspar and quartz mining from pegmatites.

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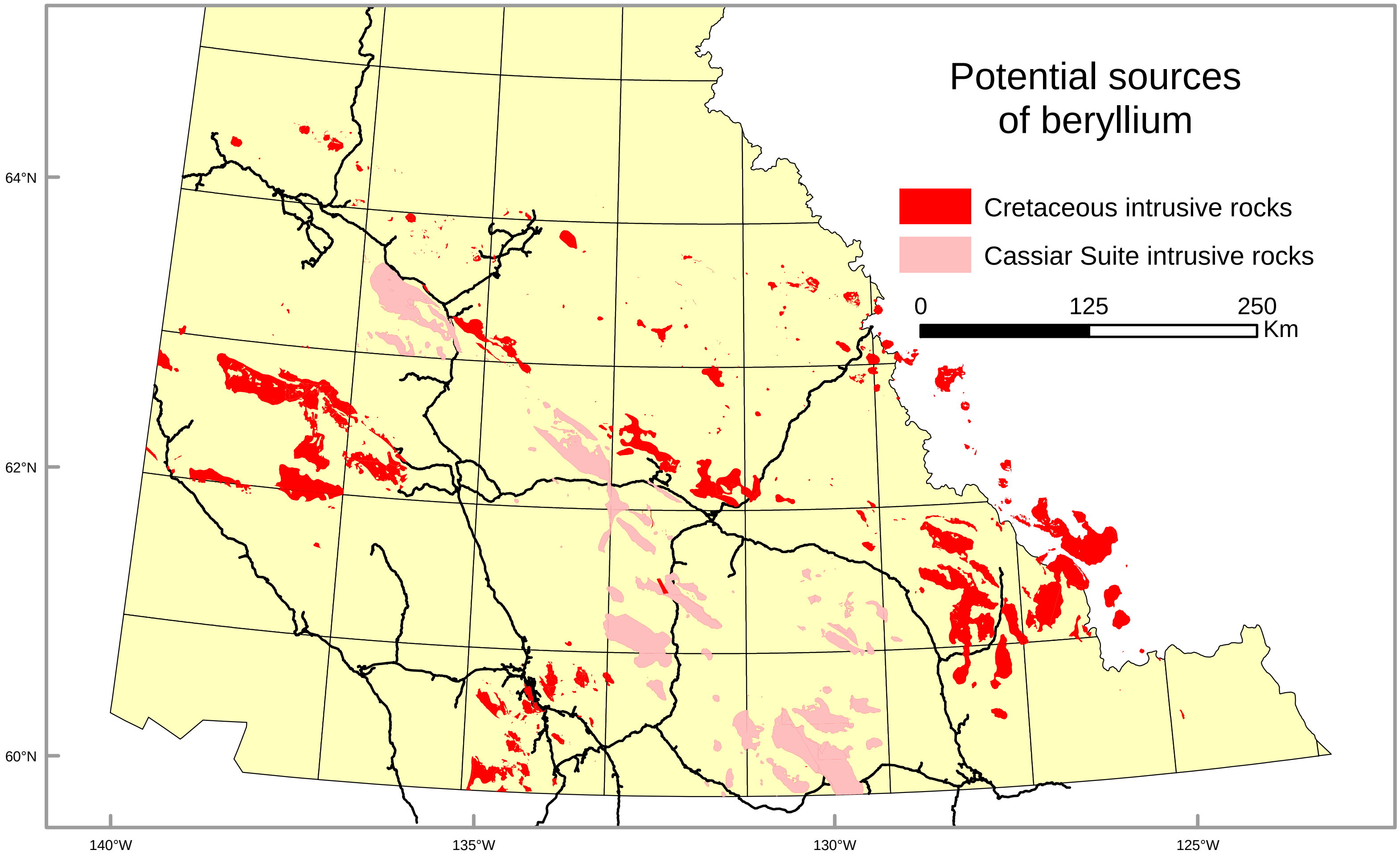
Potential sources
of beryllium
Cretaceous intrusive rocks
Cassiar Suite intrusive rocks
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64°N
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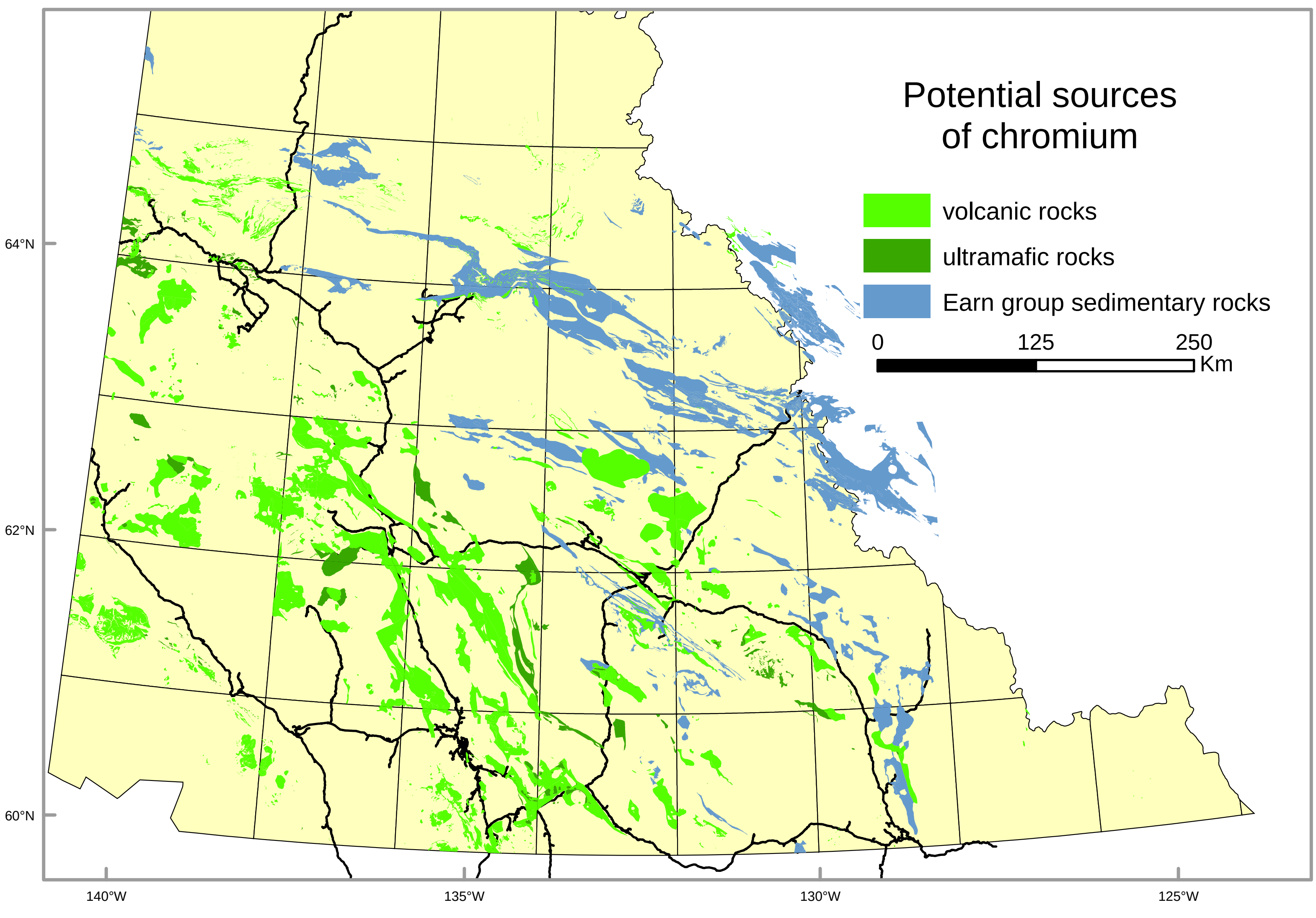
130°W
125°W


Potential sources
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