بسم الله الرحمن الرحيم
GREETING FROM EGYPT
Emerald and other beryls in Egypt; a review

Khaleal, F. M.
Periodic Table of the Elements

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* Lanthanide Series

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Types and occurrences of beryl

Although 28 minerals are known, in which beryllium is an essential constituent, only two are found in sufficient quantity and concentration to allow commercial extraction. Those are: Beryl; \( \text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18} \) with 14% BeO & Bertrandite \( \text{Be}_4(\text{OH})_2\text{Si}_2\text{O}_7 \) with 15% BeO.

The beryllium content in beryl is commonly lowered by the presence of Na, Rb, Li and Cs. \( \text{H}_2\text{O}, \text{CO}_2 \) and fluorine.

Deep green, transparent beryl is an extremely valuable gemstone (emerald). In emerald, up to 2% \( \text{Cr} + \text{V} \) replace Al in the crystal lattice. The pale, greenish-blue color of aquamarine is due to content of 0.1–0.3% \( \text{Fe}^{+2} \). Bertrandite occurs like beryl in miarolitic granites, greisen and pegmatites, where it is commonly formed by alteration of beryl. Frequent impurities in bertrandite include Al, Fe and Ca. Its main commercial source is tuffites in the USA (Walter 2011).
Emerald refers to green beryl, colored by trace amounts of chromium and sometimes vanadium. Emeralds in antiquity were mined by the Egyptians and in Austria, as well as Swat in northern Pakistan.

Price: 4176$/6.8ct   ... 1g= 5 ct
Aquamarine and maxixe

Aquamarine (from Latin: *aqua marina*, "water of the sea") is a blue variety of beryl. It occurs at most localities which yield ordinary beryl. The deep blue version of aquamarine is called *maxixe*. Maxixe is commonly found in the country of Madagascar.

The pale blue color of aquamarine is attributed to Fe$^{2+}$. The Fe$^{3+}$ ions produce golden-yellow color, and when both Fe$^{2+}$ and Fe$^{3+}$ are present, the color is a darker blue as in maxixe.

Price: 874.7$/1ct  ... 1g= 5 c

The largest aquamarine of gemstone quality ever mined was found in Marambaia, Minas Gerais, Brazil, in 1910. It weighed over 110 kg, and its dimensions were 48.5 cm (19 in) long and 42 cm (17 in) in diameter.
Golden beryl and heliodor

*Golden beryl* can range in colors from pale yellow to a brilliant gold. Unlike emerald, golden beryl has very few flaws.

The golden yellow color is attributed to Fe$^{3+}$ ions.

Both golden beryl and heliodor are used as gems. Probably the largest cut golden beryl is the flawless 2054 carat stone on display in the Hall of Gems Washington, D.C., United States.

Price: 157$/6.8ct ... 1g = 5 c
Colorless beryl is called *goshenite*. The name originates from Goshen, Massachusetts where it was originally discovered. Since all these color varieties are caused by impurities and pure beryl is colorless, the gem value of goshenite is relatively low. However, goshenite can be colored yellow, green, pink, blue and in intermediate colors by irradiating it with high-energy particles.

**Price:** 289$/5ct  ...  1g= 5 c
Morganite, also known as "pink beryl", "rose beryl", "pink emerald", and "cesian beryl", is a rare light pink to rose-colored gem-quality variety of beryl. The pink color of morganite is attributed to Mn²⁺ ions.

On October 7, 1989, one of the largest gem morganite specimens ever uncovered, eventually called "The Rose of Maine," was found at the Bennett Quarry in Buckfield, Maine, US. The crystal, originally somewhat orange in hue, was 23 cm (9 in) long and about 30 cm (12 in) across, and weighed (along with its matrix) just over 50 pounds (23 kg).

Price: 300$/5.4ct  ... 1g= 5 c
Red beryl (also known as "red emerald" or "scarlet emerald") is a red variety of beryl. The dark red color is attributed to Mn$^{3+}$ ions.

Red beryl is very rare and has only been reported from a handful of locations. While gem beryls are ordinarily found in pegmatites and certain metamorphic stones, red beryl occurs in topaz-bearing rhyolites.

Price: 10.000$/1ct   ... 1g= 5 c
Importance of beryl

Beryl (BeAl$_2$Si$_8$O$_{16}$) is the main source of beryllium:

1- In reactors

Mix of Be and Ra acts as a source for Neutrons where “Ra” acts as a source of alpha particles, while “Be” acts as a goal to these particles. Then neutrons shoot the enriched uranium$^{235}$ or Plutonium 239 to start the chain reaction.

\[
_{4}\text{Be}^{9} + _{2}\text{He}^{4} \rightarrow _{6}\text{C}^{12} + _{0}\text{n}^{1}
\]

\[
_{92}\text{U}^{235} + _{0}\text{n}^{1} \rightarrow _{56}\text{Ba}^{141} + _{39}\text{Kr}^{92} + 3\ _{0}\text{n}^{1} + \text{Energy}
\]

2- In Alloys

About 65% of beryllium consumption is in the form of beryllium-copper or other master alloys, about 15% in the oxide form, and the remainder in the metal form.
Emerald and Other Beryls In Egypt
- The oldest emerald mine in the world is Sikait emerald mine since pharos time.
- Hume (1937) and Basta and Zaki (1961) presented detailed studies on Sikait area and believed that the source of Be is the granitoids that injected talc-tremolite and phlogopite-actinolite schists.
- Surour (1993) and El-Dougoudeg et al. (1997) classified the emerald deposits of Sikait, Zabara and Umm Kabu as vein-type deposits at the ophiolitic ultramafics-intrusive granite contact. Similar occurrence at the vicinity of Igla cassiterite mine was also described by Awad (1993).
- El-Assy et al. (1993) recorded white and green beryl in quartz pockets enveloped by phlogopite, for the first time in the Sinai Peninsula, at Wadi Ghazala.
- Omar (2001) studied the characterization and evaluation of some beryl occurrences in the Eastern Desert and mentioned that in W. Al Gemal-Zabara district the beryl is confined to the contact between ophiolitic ultramafics and within-plate granitic rocks.
-Oraby et al., (2002) studied the delimitation and evaluation of beryllium resources in the Eastern Desert, Egypt.

-Sherif et. al., (2005) considered the second record of beryl in south Sinai where beryl occurs as hexagonal prismatic green crystals associated with post tectonic quartz vein cutting through the orthogneisses of Wadi Sedri to the north of the famous Wadi Feiran, south Sinai, Egypt.

Beryl (white and blue varieties) occurs as disseminated crystals and occasionally in veinlets and pockets in the granite itself especially along zones of greisenization and albitization like those of Homret Mikpid, Homr Akarem, Nuweibi, Mueilha and abu Dabbab (El-Shatoury et al., 1970a&b; Hassan and El-Shatoury, 1976; Soliman, 1982&1986; Abdalla and Mohammed, 1999).
Beryl ores of Egypt occur in two geologic environments. In the first environment, beryl occurs in micaceous rocks and other schistose rocks in close proximity to contacts with psammitic gneiss in W. El Gemal – Zabara belt (Hassan and El-Shatoury, 1976; Hassan, 1972! 1973; and Basta and Zaki, 1961). Their spatial distribution depicts their alignment in a fairly well defined zone of an approximate NW-SE trend extending about 45 km. This zone coincides with one of the "deep-seated tectonic zone" in the south Eastern Desert of Egypt, which is characterized by anomalous radioactivity and intense metamorphism, as well as metasomatism and mineralization, caused by acidic intrusions. In the second geologic environment, beryl occurs in pegmatite veins, pegmatoidal lenses and veins and in disseminated form in orthoclase -rich pink granites in Homret Akarem and Homret Mukpid areas (El-Shatoury, 1970 a&b and Hassan and El Shatoury, 1976).

Abdalla and Mohamed (1999) mentioned that two favourable environments are suggested for the localization of beryl mineralizations in the Precambrian rocks of Egypt namely; 1) emerald-schist and 2) beryl specialized granitoid associations. Emerald occurs within the mica-schists and is typically confined to the Nugrus major shear zone. The beryl associated with granitoids occurs in pegmatite veins, greissen bodies and cassiterite quartz veins. The authors (op. cit) concluded that the emerald is though to be formed as the result of epitactic nucleation of Be, Al and alkali-rich solutions on the mica of the schist country rocks.
Fig. 1: Location map of the beryl and emerald deposits, Egypt:
1- Wadi Ghazala; 2- Wadi Sedri; 3- Abu Dabbab; 4- Nuweibi; 5-Igla; 6-Mueilha 7- Zabara- Um Addebaa belt; 8- Homr Akarem; 9- Homr Mikpid; 10, Qash Amir.
1- Emerald and Beryl In Zbara-Wadi Um Addebaa Belt
Geologic map of Sikait-Um Addebaa belt; modified after (Omar, 2001)
Sikait Temple
Location of ancient beryl tunnels in W. Abu Rusheid, SED, Egypt
Location of ancient beryl tunnels in Khore Abalea, W. Abu Rusheid, SED, Egypt.
Location of ancient beryl tunnels in W. Nugrus, SED, Egypt.
Location of ancient beryl tunnels in W. Um Selimate, SED, Egypt.
Location of ancient beryl tunnels in W. Sikait, SED, Egypt.
Location of ancient beryl tunnels in W. Um Kabu, SED, Egypt.
Location of ancient beryl tunnels in W. Um Addebaa, SED, Egypt.
Detecting and Plotting of ancient tunnels in (UTM)

Ancient beryl tunnels in Khore Abalea, SED, Egypt.
Ancient beryl tunnels in Um Solimat, SED, Egypt.
Ancient beryl tunnels in Um Solimat, SED, Egypt.
Ancient beryl tunnels in W. Sikait, SED, Egypt.
Ancient beryl tunnels in W. Um Addebaa, SED, Egypt.
In general, there are one hundred and fourteen (114) old exploration sites that contain up to two hundred and four (204) tunnel, shafts and trench and distributed as follows: there are seven (7) old mining sits at Wadi Abu Rusheid having NNW-SSE trending. There are four (4) old mining sits at Khore Abaleia having NNW-SSE trending. There are twenty five (25) old mining sits at Wadi Um Solimat having N-s and NNW-SSE trending. There are eighteen (18) old mining sits at Wadi Sikait having NW-SE and NNW-SSE trending. There are twenty one (21) old mining sits at Wadi Um Kabu having NW-SE trending. There are thirty five (35) old mining sits at Wadi Um Addebaa having NNW-SSE trending.
A photograph showing beryl crystals in beryl-bearing quartz vein; Abu Rusheid area.
2- Emerald and Beryl In Rare-Metal granite rocks
Fig. 1: Location map of the beryl and emerald deposits, Egypt; where:
1- Wadi Ghazala; 2- Wadi Sedri; 3- Abu Dabbab; 4- Nuweibi; 5-Igla; 6- Mueilha 7- Zabara- Um Kabu belt; 8- Homr Akarem; 9- Homr Mikpid; 10, Qash Amir.
Geologic maps of Home Akarem (A) and Homr Mikpid (B)
General Petrogenetic implications
There are two categories for emerald and beryl deposits in the world:
1- Schist – hosted deposits due to the interaction between granitic pegmatites or fluid emanations from granitic magma with ultramafic rocks or their derivatives (Sinkankas, 1981).

2- Beryl associated with black wall zones resulted from metasomatic reactions of the contact between ultramafic rocks and Be – bearing mica – rich quartzofeldspathic rocks during regional metamorphism (Grundmann and Morteani, 1989).

**The absence of Be in the schist (El Doudoug et. al., 1997) excludes the formation of beryl by metasomatic alteration during regional metamorphism as that described by (Grundmann and Morteani, 1989).**

3- The distribution of Be in the gneissose granite in the studied area (2.18-4.1ppm; Takla et. al., 2003) and in the peraluminous granite (6ppm; Khaleal, 2014) indicates that they are potential sources of beryllium.
4- Pan-African age of phlogopite bearing beryl mineralization (Surour et al., 2002) and very low content of Be in gneisses (1.9 -2.2; Takla et al; 2003) exclude any genetic relation of studied beryl mineralization to the gneisses (of Pre-Pan African age).

5- In Sikait-Um Addebaa belt, beryl occurs disseminated either in quartz veins, in phlogopite schist and in pegmatites. Beryl that occurs in phlogopite schist is of deeper green color and sometimes becomes of green grass color (gem quality emerald) occurring close to the contact between ultramafic rocks with felsic magma and its derivatives.

6- Beryl and emerald of this belt are believed to be formed by metasomatic interaction between felsic magma and its derivatives with the ultramafic rocks. This felsic magma and its derivatives are enriched in Be, F, Al, Ba, Na and K. Metasomatic reactions responsible for growing phlogopite on the expense of actinolite leading to the release of Cr which is the chief player in green coloration of gem quality emerald.

7- For future exploration of beryl phlogopite schist, closed to the felsic magmas and its derivatives, should be followed.
Application of UNFC 2009 for Emerald and Beryl deposits of Egypt
Geologic Knowledge (G) .... G2
Project feasibility (F) ............ F3
Socio-economic viability (E) .. E3
Recommendations

1- Beryl occurs in Wadi El Gemal – Zabara district in economic amounts but in Homret Mukpid and Homret Akarem is not.
2- The contact between the gneiss and overlying schist is a good place for finding emerald and beryl.
3- Emerald (gem quality of beryl) is usually associated with the phlogopite mica. So a hard work is needed to follow this type of mica in the area.
4- There are huge amounts of beryl particles on the dumps as well as in the stream sediments of Wadis as a result of ancient mining workings. The NMA should work for one season to get a good evaluation for these deposits and then a world company may invest in this direction.
5- The peraluminous granite is the source of mineralization in the area, so a lot of attention should be paid to this type of granite in the mentioned area.
6- Drilling is needed in the schist itself away from the shore contact between the gneiss and the overlying schist. The mineralization is still raw in these contacts.