Physical characteristics and origin of emerald

Emerald is a green variety of beryl, found in Afghanistan, Brazil, Columbia, Madagascar, Pakistan, Russia, Zambia, and Zimbabwe, in either mineral or gem quality.

Emeralds are priced for their colour – their vivid greens, blue-greens and yellow-greens – and have for centuries been some of the most sought after gems in the world. In 2000 a 10. 11 ct Columbian emerald was sold for $1, 149, 850. (Zachovay, 2002).

To understand Emerald we need to first understand the physical and chemical structure of Beryl, $Be_3Al_2Si_6O_{18}$. Emerald colour is caused by trace element of Chromium (Cr) and /or Vanadium (V) replacing the Aluminium (A)l in the crystal structure. Fig. 1 shows the crystal lattice of emerald in 2D, " the dark grey shows the tetrahedral formation BeO_4, the medium grey shows the octahedral formation AlO_6, the light grey shows the tetrahedral formation SiO_4."(Groat, L. A. 2007).

Emerald can form as a crystal or as an impurity in a host mineral depending on the amount of Be present and environmental factors like temperature, pressure, and space in which the beryl crystals (Be3Al2Si6O18) have to grow.

Physical Characteristics:

Emerald varieties of Beryl have a hexagonal prismatic habit with pinacoid termination, sometimes with bypyramidal faces and imperfect basal cleavage. Rectangular etch pits occur on the prism faces and hexagonal etch pits occur on pinacoids shown respectively in Fig. 2 and Fig. 3. The hardness is 7 . 5-8 on Moh`s scale, the specific gravity is between 2. 65-2. 80. Well formed crystals are called euhedral, have recognisable faces and a vitreous lustre.

Its toughness, durability, stability, vitreous lustre, and hardness make Emerald an ideal stone for jewellery. Its liveliness does not fade away or react badly to acid, sweat or daily washing liquids. Precaution is needed however, as emerald is brittle and can fracture on a sharp knock.

Colour in Emerald.

The dispersed metal ion is the colouring mechanism in Emerald. Transitional elements, Cr and V are impurities in beryl structure and cause the red fluorescence that enhances the luminosity of the blue-green colour. This effect is suppressed if Fe3+ is present in the emerald crystal. (Nassau. 1983). Cr and / V also give emerald its unique absorption bands in the red area of the electromagnetic spectrum.

Origin:

Emerald formation necessitates Be. According to Groat L. A., the process of Be formation can be divided into stages as follows:

1. Be bearing rock needs to find right condition for phase change (e. g. liquid or vapour) and
2. Needs a transportation mechanism for mobilisation (otherwise the Be will solidify and the whole process starts again).

3. If the silicate melts in an environment rich with Fluorine (F), Lithium (Li), Boron (B), Phosphorous (P), it can retain the changed phase of Be for transportation (Evensen et al. 1999, London & Evensen 2002).
4. To crystallize, the Be, together with Al (aluminium), Si (silicon) and O (oxygen), needs an open space, crack or cavity in pegmatic rock.

“ Be tends to concentrate itself in pegmatites, granites, black shale and their metamorphic equivalent and Cr and / Vare concentrated in dunite, peridotite, and basalt of the oceanic crust and upper mantle, and their metamorphic equivalents. However, high concentrations can also occur in sedimentary rocks, particularly black shale.” (Schwarz et al. 2002)

Be is the 47th most abundant element in the earth’s crust (Emsley, 2001). The introduction of Cr and / V (respectively 92 and 97 ppm in the earth’s crust) to Be (1. 4ppm in lower crust, 2. 29 ppm in middle crust, 2. 1 ppm in the upper continental crust) requires unusual geological and geochemical metasomatic processes such as the intrusion of Be rich magmatic fluids or the fusion of Be-rich pegmatite minerals with the surrounding Cr / V sedimentary rock. (Rudnick & Gao 2003) This is how Emerald is formed.

Other Variables to consider:

According to Barton & Young (2002) Be is necessary to beryl formation. “ The stability field of temperature is relatively wide between 300-6000 with Al2O3 as intermediate. But with very high Al2O3 and very low Al2O3, environments, can lead to precipitation of Chrysoberyl (BeAl2O4) or Euclase (BeAl [SiO4] OH) and Phenakite (Be2 [SiO4]) or Bertrandite (Be4 [Si2O7] (OH) 2). In contrast if the activity for SiO2 is low, other minerals like Chrysoberyl, Phenakite and Bromellite will precipitate”.

Conclusion:

1. Beryllium is scarce.
2. Because of beryllium's small mass highly sophisticated machines like Scanning Electron Microprobes struggle to analyze it accurately. " Even with Laser ablation ICP-MS, SIMS (Secondary Ion Mass Spectrometry), there is so much Be in the structure that the analysis can be suspected."(Groat L. A. 2007)
3. Be interacting with Cr / V, and Cr / V acting as a chromophore makes the whole process interesting and rare, thus making an Emerald a valuable rare gem.

Technological advancements are still needed to better understand, the chemical composition, impurities and crystal structure which can lead to earth's fundamental geological and geochemical mechanisms. At present understanding of the classic model of elements and how they interact in geological processes is flawed. This means the concept of Mother Nature acting as an open source, where everything contributes to the one thing or another, is not fully understood.