Module B. Colour from the Cosmos

Lesson 14: Beryl Mineralogy and Gemology

What is its Chemistry and Crystal Structure?

The ideal chemical formula for beryl is Be3Al2Si6O18 - an aluminous beryllium cyclosilicate. The dominant crystal sites are the tetrahedral sites of Si and Be, the octahedral site of Al, and a distinct channel located along the length of the *c*-axis within the six-membered rings comprising SiO4 tetrahedra.

With respect to gem beryl, substitutions in the octahedral Al site are the most important because they give rise to the most vivid colours. Almost all beryl crystals contain at least minor substitutions that result in the variety of colours displayed by this single mineral.

Crystal structure of beryl looking just off the *c* axis, along the orientation of the channels. In this model, red triangles represent the Si tetrahedron (1 silicon atom surrounded by 4 oxygen atoms) arranged in rings, purple Be tetrahedrons (1 beryllium atom surrounded by 4 oxygen atoms), green Al octahedra (1 aluminum atom surrounded by 6 oxygen atoms), and blue spheres are usually Na or water residing in the channel site.

Crystal structure of beryl looking perpendicular to the *c* axis, note the sequential stacking of Be and Al polyhedra with Si polyhedra that gives rise to the basal cleavage of beryl.

Beryl adheres to the constraints of the hexagonal crystal system (see page 100 in your text), giving it one primary *c* axis, and three secondary *a* axes on a single plane, all separated by 120 degrees. This figure shows a depiction of the hexagonal crystal system, how a simple prism would be represented in this system, and that simple hexagonal prism superimposed on a real beryl crystal.

Although beryl ideally consists of only four elements and its elemental substitutions can be relatively straightforward, a comprehensive understanding of this mineral remains elusive. Historically it has been difficult to develop conclusive statements regarding exactly what element exchanges are occurring because it is difficult to obtain accurate measurements of Li and Be (These elements are simply just tricky to work with.) Furthermore, the similarities between the Si and Be tetrahedral sites makes it difficult to determine where exactly substituting cations are going.