**Geological Significance of Blue Quartz in the United States of America**

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**Abstract**

Blue quartz has been identified in literature dating as far back as 1894. However, few studies have been conducted to discern the geological significance of its occurrence. Although rarely reported in the world, it is not uncommon to find blue quartz in certain regions of the United States. Nine samples of blue quartz were analyzed from localities in: Old Rag Mountain, VA (2); Flint Hill, VA (2); Roseland, VA; Cape Ann, MA (2); Oracle, AZ; and Llano, TX. Scanning electron microscopy images revealed the presence of rutile needles in quartz in all six localities. However, the size of these needles (2-30 μm) makes them unlikely candidates for the Rayleigh scattering of light. Thus, the origin of blue quartz remains unresolved. Thin sections of blue quartz from Old Rag Mountain showed rutile needles predominantly oriented at 60° to each other, which is consistent with the hexagonal crystal system of quartz suggesting rutile exsolved from the quartz. Blue quartz occurs in host rocks of varying composition (quartz monzonite to anorthosite) and as xenoliths in Paleozoic metamorphic rocks. As the size of these rocks is generally much smaller (<1 km) than the wavelength of the light, the wavelength of blue light is 475 nanometers.

**Results**

The nine quartz samples were analyzed under a scanning electron microscope (SEM). Acicular needles (Figure 5) were present in eight of the nine samples. An energy dispersive X-ray spectrometry (EDS) analysis revealed the needles were composed of Ti and O (Figure 6). Thus, these needles are most likely rutile, which is TiO2. The size of the observed needles, however, were on the order of 2-30 μm making them an unlikely candidate for Rayleigh scattering. It is possible, however, that nanometer-sized rutile needles present in the samples were beyond the detection level of the scanning electron microscope (SEM). Consequently, the origin of the blue color in blue quartz remains unresolved.

**Introduction**

Due to the chemical simplicity of quartz, differences in the environmental conditions such as radiation and impurities can greatly influence its color. While some of its varieties are well-known such as rose and smoky quartz, others are less known such as blue quartz. Blue quartz is rarely reported in the world. It is not uncommon to find this mineral in certain regions of the United States (Figure 2). This research study was undertaken to better understand the significance of blue quartz in rocks found in differing geological environments through optical and chemical studies of blue quartz. Nine samples of blue quartz were analyzed from localities in: Old Rag Mountain, VA (2); Flint Hill, VA (2); Roseland, VA; Cape Ann, MA (2); Oracle, AZ; and Llano, TX (Figure 3). The host rocks of blue quartz vary amongst the different localities in both composition and age. In Virginia, the host rocks are the Old Rag Granite (garnetiferous leucogranite, 1065 m.y. old), Flint Hill Gneiss (syenogranite gneiss, 1144 m.y. old), and the Roseland anorthosite (1045 m.y. old). The Cape Ann Granite in MA is a perthitic alkali feldspar granite that is roughly 388 m.y. old (Figure 4). The Oracle Granite in AZ is 1450 m.y. old and is a quartz monzonite. In Llano, blue quartz occurs in mylonitic dikes (also known as laniite) and is 1093 m.y. old.

**Why is Blue Quartz Blue?**

Unlike smoky quartz which derives its color from natural radiation, the origin of the distinctive blue color in blue quartz remains uncertain. Some researchers have hypothesized that the blue color arises from Rayleigh scattering of light by microscopic rutile needles. Rayleigh scattering is the elastic scattering of visible radiation from the sun by particles much smaller (<1100) than the wavelength of the light. The wavelength of blue light is 475 nanometers.

**Orientation of Rutile Needles**

Thin sections of quartz samples from two localities: Old Rag, VA and Roseland, VA were examined in the petrographic microscope. Under transmitted light, the rutile needles are oriented at 60° to each other, consistent with the hexagonal crystal system of quartz (Figure 7). This orientation suggests that the rutile needles exsolved from the quartz after the quartz started crystallizing.

**Variation in Blue Color of Quartz**

Other inclusions identified in the blue quartz samples included ilmenite, titanite, zircon, plagioclase feldspar and apatite. These minerals were typically consistent with the mineralogy of the host rock. In the VA samples, “waxy” strands of ilmenite often darkened areas in the blue quartz (Figure 8).

**Conclusions**

- Origin of blue color in quartz remains unresolved.
- Orientation of observed rutile needles at 60° to each other is consistent with the hexagonal crystal system of quartz. Thus, these rutile needles most likely exsolved from quartz.
- Darker blue quartz regions have a higher density of rutile needles relative to the lighter blue regions.
- Blue quartz found in both igneous and metamorphic rocks is closely associated with anorogenic magmatism.
- Further studies should aim to resolve the genetic conditions at which rutile can exsolve from quartz.
- Recent studies have suggested that titanium substitution in quartz is temperature dependent (Wark and Watson, 2006); thus, attention should be given to the titanium-bearing blue quartz as a potential geothermometer.

**References**


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