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Geochemical characteristics of beryl from pegmatites of the Erongo Volcanic Complex, Namibia

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The granite-hosted pegmatites of the Erongo Volcanic Complex in central Namibia, are well known for the occurrence of a number of mineral types, of much interest to collectors. A variety of beryl types with colours ranging from green, yellow (heliodor), colorless (goshenite) and blue/greenish blue (aquamarine) are found in mariolitic cavities within the pegmatites. This contribution serves to document and discuss their physical appearance, inclusion content, and their major and trace element chemistry. To this extent, 25 blue beryls, as well as two green beryls and one colourless beryl were investigated using SEM, EMPA and LA-ICP-MS in order to gain insight into chemical differences between the various beryl types, their chromophores, and their similarities or differences to other beryls worldwide. The beryls from Erongo are generally subhedral to euhedral with a well-formed prismatic habit. Idiomorphic crystals, characterized by well-developed hexagonal prisms, are common. Common associated minerals include schorl, quartz, muscovite, alkali feldspar, plagioclase feldspar, iron oxides, foitite, rossmanite and cassiterite.

Aquamarines range from pale blue to deep blue, or greenish blue, with pronounced colour zoning. The two green specimens vary in colour from pale green to pale yellowish green. One green beryl is medium green and heavily included whereas the other specimen has a pale yellowish green colour. Transparency is heavily influenced by cracks, often filled with secondary iron oxides. Common mineral inclusions include schorl, quartz, muscovite, feldspar, iron oxides and cassiterite; clearly reflective of the host pegmatite mineralogy.

Aquamarine and green beryl contain iron as the main chromophore while goshenite is devoid of chromophores. Increasing colour saturation correlates with increasing Fe, consistent with the known chromatic effects of Fe in blue, yellow and green beryl. Although optically and chemically homogeneous specimens are common, colour-zoned, optically heterogeneous crystals are also encountered. These are characterised by variable Fe_{tot} (0.79-3.19 wt% FeO), Na (0.09-0.35 wt% Na_2O), and Al (15.99-18.18 wt% Al_2O_3). Zoning patterns range from simple core-to-rim transitions to more complex sector and/or oscillatory zoning, with chemical trends which correspond to previously documented substitutions for beryl worldwide.

Octahedral cation substitution is the dominant mechanism for the incorporation of a variety of minor and trace elements and Na is mainly incorporated (over Cs) at the channels (to maintain charge balance). Based on charge balance arguments, some tetrahedral Be-Li substitution is also indicated. Trace element concentrations, as determined through LA-ICP-MS analysis, are variable, with highest concentrations encountered in the aquamarines. Cs, Sc, Ga and Mn are positively correlated with Rb, consistent with the incorporation of these elements at the octahedral site (Sc, Mn and minor Ga) or the channel site (Cs, Rb), in order to preserve charge balance. In contrast, Ca, Zn and Ti do not correlate with Rb, nor with Cs. This is unexpected, as Ti and Ca are known to substitute at the octahedral site in beryl, while Ca may also enter the 2a channel site of beryl. Consistently low Cr contents in all the samples examined concur with Cr not being a chromophore element for the green beryl examined in the present study. Overall, major and trace element contents are similar to that of other beryls (aquamarines) worldwide, with no distinctive locality-specific chemistries observed, when compared to the worldwide database.