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Etch pits on natural Beryls

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Beryl, a cyclo-silicate, with the ideal chemical composition Be3Al2Si6O18, space group P6/mcc, is the most important accessory mineral and an ore of the strategic material beryllium. It is mainly found in pegmatites, in some highly evolved granites and in some metamorphic rocks. In many cases, the beryl-forming process extends over a wide range of P-T conditions, and freely grown crystals from pegmatitic-hydrothermal environments often show characteristic etch pits. These etch pits can provide valuable information in deciphering growth or dissolution history experienced by a crystal, the dissolution behaviour and could also be used as a diagnostic tool to distinguish natural beryls from synthetic ones, in provenance studies and in petrogenetic modeling.

Surface etch pits of twentyone natural beryl crystals from different sources were studied by scanning electron microscopy. The samples were characterized by electron microprobe, infrared spectroscopy (transmission method), and x-ray powder diffraction (Rietveld).

The EMP analysis of all samples show a composition close to ideal stoichiometry with a low degree of substitution except in two samples of tabular habit viz., from China and Brazil, showing their miarolitic-granitic pegmatitic origin. The wt.% of SiO_2, Al2O_3 and FeO are between 64.17-67.37, 17.69-19.33 and 0.17-o.54, respectively. Their alkali content is comparatively higher than in the other samples and the wt.% of Na2O + Cs2O is 2.00 and 2.21, respectively. A negative trend in Si-Al (apfu) of all the samples shows substitution of Si4+ by Al3+.

The ratio between the lattice constants c and a of all beryls was found 0.997-0.998 (unsubstituted normal beryl) except in the two alkali-rich samples, which show a c/a ratio higher than 0.999, pointing to tetrahedrally substituted beryls.

The IR spectra of powdered beryl samples in the finger print region showed Si-O bands at wave number 1206 cm-1 in unsubstituted beryl, shifted to lower frequency at 1175 cm-1 in alkali rich tetrahedrally substituted beryls. In alkali rich beryls the Si-O band at 1018 cm-1 in normal beryls splits at 1020 cm-1 and 1060 cm-1. All beryls are hydrated, as indicated by the presence of either type I (normal beryls) or type I and type II water molecules (alkali rich beryls), corresponding to the absorption bands at 3699, 3602 and 3589 cm-1.

SEM studies showed polygonal etch pits on samples; their morphology is determined by the symmetry and growth environment of crystals. Two kinds of etch pits were observed on first order prism viz., (i) flat and shallow (F-type etch pits) and (ii) deep and pointed rectangular etch pits, with or without steps (P-type etch pits). Diamond-shaped and canoe-shaped etch pits are also characteristics of prism faces. The pyramid and basal pinacoid are characterized by the presence of triangular and hexagonal shaped etch pits. Long edges of the rectangular etch pits on prism face are straight and shorter edges are curved indicating their alignment to stronger and weaker bonds in the crystal structure. The curved edges are found to be parallel to C- axis corresponding to the channels in beryl.