European Mineralogical Conference
Vol. 1, EMC2012-48, 2012
European Mineralogical Conference 2012

Chemical composition of quartz: insights into the Variscan Altenberg-Teplice caldera evolution (Krušné hory/Erzgebirge Mts, Czech Republic/Germany)

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The internal crystallization/resorption structures and related trace-element contents of quartz crystals were investigated using a hotcatode- and scanning cathodoluminescence analysis (CL) combined with a laser ablation ICP-MS technique. The studied late Variscan volcano-plutonic complex of the Altenberg-Teplice Caldera is located in the eastern Krušné Hory/Erzebirge, along the Czech Republic/Germany border. It is composed of the (i) older basal rhyolite and associated dacite, representing final stage of the late-orogenic peraluminous (S-type) magmatism, and (ii) younger slightly peraluminous post-orogenic (A-type) co-magmatic suite of three eruptive units of the Teplice rhyolite, dykes of granite porphyry and successive intrusions of biotite and zinnwaldite granites.

The concentrations of Al, B, Ba, Be, Cr, Fe, Ge, Li, Mg, Mn, Nb, P, Pb, Rb, Sn, Sr and Ti in the quartz were analyzed. The decreased Ti content and increased Al content (i.e. the increase in the Al/Ti-ratio) is generally accepted as one of the most revealing indicators of granitic magma fractionation. The quartz crystals from rhyolite and granite porphyry exhibit zonal structures, their core is rich in Al (200-350 ppm) and poor in Ti (5-30 ppm), while their outer zones and rims are depleted in Al (80-130 ppm), but enriched with Ti (40-100 ppm). The CL intensity of all of the zonal quartz crystals was found to be directly proportional to the zone's Ti content. The quartz grains from granites are chemically homogeneous: older biotite granite has quartz chemistry similar to the core of crystals from the rhyolite (100–150 ppm of Al, 15–40 ppm of Ti), while Al contents of the quartz from the younger zinnwaldite granite are more scattered, which is also characteristic of extremely low Ti concentrations (150–300 ppm of Al, max. 10 ppm of Ti).

The exact measurements of the Ti content in the zonal quartz crystals together with application of the Ti-in-quartz thermobarometer (Huang and Audétat 2011) allows for the interpretation of the zonal structure of quartz crystals by two-stage crystallization: the crystal cores grew in the deep-seated magma chamber (750 °C, 10 kbar), followed by their adiabatic ascent linked with the partial resorption of some crystals. The growth of crystals then continued in the shallow magma reservoir (700 °C, 2 kbar). During the ascent, some of the quartz crystals corroded and obtained an oviform or rounded shape. These rounded cores are visible in the CL images, as they are overgrown with the CL- and chemically- contrasted rims. Some of the quartz crystals from the post-caldera granites grew in the deep-seated magma chamber and were partially resorbed during the magma ascent. The snowball quartz grains have grown in place of the final magma crystallization (anticipated pressure 200-100 MPa), but the low activity of the Ti in the residual leucocratic melt (<0.03 wt% TiO_2) resulted in the low Ti content in the rims and outer zones of these crystals.

Huang R., Audétat A. (2011) A critical look at the titanium-in-quartz (TitaniQ) thermobarometer. Goldschmidt Conference Abstracts, Mineralogical Magazine 75, 1065.