Chemical and textural variation of quartz-tourmaline aggregations – Using mineral chemistry to track the magmatic-hydrothermal transition

Kristian Drivenes[a], Rune Berg Larsen[b], William Brownscombe[c], Reimar Seltmann[c], John Spratt[c], Bjørn Eske Sørensen[b]

Affiliation in format: [a]Geological Survey of Norway, Trondheim, Norway, kristian.drivenes@ngu.no; [b]Department of Geoscience and Petroleum, Norwegian University of Science and Technology, Trondheim, Norway; [c]Natural History Museum, London, United Kingdom

The large stability fields and the ubiquity of quartz and tourmaline in S-type granitic systems, make these minerals potential petrological monitors of the magmatic-hydrothermal transition. The contrast in chemical complexity between the two minerals cause them recorders of different parameters. The ability of tourmaline to incorporate a range of major, minor and trace elements will record variations of melt/fluid composition. Contrary, the main trace element composition of quartz is dominated by Al and Ti, which combined with the growth textures can provide information of temperature, pressure and physical state of the crystallizing medium. In this study we have analyzed quartz-tourmaline pairs in order to decipher the magmatic-hydrothermal transition in the Land's End Granite, SW England.

Throughout the Land's End granite, a range of quartz-tourmaline textures and structures can be observed: disseminated in the granite matrix, pegmatitic pockets, quartz-tourmaline aggregations in the form of orbicules, sheets, and larger bodies +/- K-feldspar phenocrysts (massive quartz-tourmaline (-K-feldspar) rocks – MQT/MQTK), veins, and replacement of the granites on a variable scale. The distinct color variation of tourmaline is a first indication of the crystallization mode. Brown-orange tourmaline with major element composition plotting in the middle of the schorl field occur as interstitial matrix mineral in the granites, and cores in quartz-tourmaline sheets. Grains with euhedral terminations growing into miarolitic cavities are typically pale brown/blue oscillatory zoned with composition closer to endmember schorl, and with slightly higher Sr and Sn content compared to granite matrix tourmaline. This type is similar to more erratically zoned pale blue/brown/greenish tourmaline replacing feldspar in the granite. The final main group of tourmaline is typically strongly zoned, from green, colorless and deep blue, associated with veins or extensive replacement of the granite.

Quartz in the different granites and quartz-tourmaline structures has a large range of Ti and Al content. Early-forming quartz in the fine-grained granite has a distinctly higher Al/Ti ratio (~10) compared to phenocrysts and central zones of the matrix quartz of the coarse-grained granite (~5), likely reflecting the more evolved chemical character of the fine-grained granite. Quartz zones coexisting with interstitial tourmaline in the fine-grained granite has 30-60 µg/g Ti, and 300-500 µg/g Al. In a miarolitic cavity formed in a tourmaline-rich part of the fine-grained granite, quartz overgrowing the euhedral brown tourmaline has no apparent cathodoluminescence zoning, and 20-30 µg/g Ti and 500-600 µg/g Al. This zone may be the coexisting quartz generation of the weakly oscillatory tourmaline generation, representing the transitional stage where the crystallization goes form melt dominated to fluid dominated. Overgrowing this zone is a strongly zoned quartz generation with <5 µg/g Ti and 50-150 µg/g Al, likely corresponding to the metasomatic tourmaline generation, representing the hydrothermal quartz-tourmaline crystallization.