Magmatic-hydrothermal transition in Mo-W granite-pegmatite-greisen systems: trace element chemistry of quartz, Krupka district, eastern Erzgebirge (Czech Republic)

Tereza Peterková1,2 and David Dolejší3

1Institute of Petrology and Structural Geology, Charles University, Prague, Czech Republic
2Czech Geological Survey, Prague, Czech Republic
3Institute of Earth and Environmental Sciences, University of Freiburg, Germany (david.dolejs@minpet.uni-freiburg.de)

Magmatic-hydrothermal transition in highly differentiated silicic igneous systems is responsible for several mineralization styles including pegmatite-, porphyry- or greisen-related ore deposits. The Krušné hory/Erzgebirge province in central Europe is characterized by late Variscan, Sn-W greisen mineralization that is spatially and temporally associated with W-Mo pegmatite-greisen mineralization in its eastern part. In the Knöttel district at Krupka, a complete sequence of highly differentiated Li- and F-rich granites, aplites, pegmatites, breccias, greisens, hydrothermal quartzites and late quartz veins is exposed and the nature of magmatic-hydrothermal transition has been investigated and interpreted by trace element composition of quartz. Abundance of the siliceous rocks points to sharp chemical gradients, controlling the precipitation and/or mineralization processes that may have been facilitated by involvement of hydrosilicate (silicothermal) fluids. The trace element concentrations of quartz and their correlations suggest that \( \text{Si}^{4+} = \text{Li}^+ + \text{Al}^{3+} \) and \( \text{Si}^{4+} = \text{H}^+ + \text{Al}^{3+} \) are the most important substitution mechanisms. Ratios in Ti vs. Li, Be and Al define several distinct genetic trends: (1) magmatic, high-Li/Ti or Al/Ti trend which involves granites, aplites and K-feldspar pegmatites; (2) late-magmatic or hydrosilicate, medium-Li/Ti trend recorded by quartz megacrysts and pegmatite-textured aggregates in granites and quartz-protolithionite pegmatite; (3) hydrothermal, low-Li/Ti or Al/Ti trend represented by a stockwork of coarse-grained hydrothermal quartzites and quartz veins, and quartz replacement in greisens. The medium-Li/Ti trend plausibly represents a hydrosilicate liquid, an \( \text{H}_2\text{O}- \) and \( \text{SiO}_2 \)-rich medium that was probably formed by disequilibrium crystallization in front of rapidly propagating solidification front of highly evolved granitic melt. Thermal evolution of the magmatic-hydrothermal system was monitored by Ti-in-quartz thermometry. The calculated rutile activity in the granitic melts was very low (0.3–0.05) but it increased (up to 1), that is, rutile saturation in the pegmatites and the hydrothermal quartz veins. Magmatic crystallization of the granites and aplites occurred from 700 to 580°C, the pegmatite formation between 600 and 500°C. The greisenization stage coincided thermally with the pegmatite crystallization, and it was followed by a late hydrothermal stage precipitating distal quartz veins at 500–390°C. The concentrations of Ti, Al, Ge, Li and Rb in quartz reveal that the granite and pegmatite magmas at Knöttel – and in the Erzgebirge in general – have reached extremely high Al, Li, Rb and Ge enrichment in comparison
with igneous rocks worldwide and their composition approaches that of pegmatites. In addition, the Knöttel system exhibits Be enrichment in quartz, apparently linked to F enrichment, and this feature marks the Mo-W-mineralized systems globally.