Quartz crystal connections between magmatic, plutonic, and hydrothermal environments

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We use geochemical and textural records preserved in quartz crystals to investigate different generations and styles of high temperature quartz growth in felsic intrusions and related ore bearing veins from the porphyry-Cu-Mo deposit at Butte, Montana. Relationships between magmatic and hydrothermal realms are complex and often overlooked but are essential to understanding the evolution of porphyry deposits. Our goal is to understand better how different generations of quartz are related texturally, geochemically, thermally, and temporally. We use SEM cathodo-luminescence (CL) imaging, trace element concentrations, TitaniQ geothermometry, and Ti diffusion calculations to arrive at this goal.

CL textures of some quartz in the Butte host granite reflect a quartz eye form resembling that of porphyry dikes suggesting that the pluton was once a porphyritic magma. We present geochemical modelling to further test this hypothesis.

Porphyry dikes and mineralizing fluids were derived simultaneously from a parent pluton cupola. We have found vein cross-cutting relationships in CL showing significant quartz temperature fluctuations, supporting the hypothesis that dike and mineralization events are episodic in nature.

TitaniQ temperatures we have calculated for different quartz generations overlap considerably (host granite quartz ~770º to 790º C, porphyry quartz ~630º to 780º C, deep hydrothermal quartz ~480º to 740º C). However TitaniQ temperatures of quartz veins (600º to 740º C) that apparently grew by pressure-drop are up to 75º C hotter than temperatures indicated by alteration minerals. We hypothesize that this is due to non-equilibrium incorporation of excess Ti into quartz, suggesting that the TitaniQ geothermometer may need to be used with caution for some hydrothermal quartz. Alternatively, the alteration temperature estimates may reflect retrograde resetting.

Analyses of trace Ti, Al, K, and Fe show that Ti positively correlates with CL intensity. Assuming Ti is the primary CL activator, we have made preliminary Ti diffusion calculations based on CL images which should allow us to estimate temporal relationships between the magmatic, plutonic, and hydrothermal aspects of the system.

Geochemical evidence for a transient change in mantle melting from the deglaciation of Iceland

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At the end of the last glacial period ~10,000 BP a large pulse of volcanism took place in Iceland with eruption rates up to 100 times higher than in glacial or modern times [1]. Geophysical models (e.g. [2]) suggest that the rapid melting of a large ice sheet caused a transient increase in decompression mantle melting. Geochemical data (e.g. [1, 3], this study) support this interpretation. However, while previous studies have sampled only surface flows, this study provides a temporal perspective on a vertical sequence of lavas. Geochemical data was collected for lavas from Stóravíti volcano, which is the largest postglacial lava flow in the Theistareykir region of the Northeastern Volcanic Zone. Using technical climbing techniques, a vertical sequence of lavas was sampled from Litlavíti pit crater, which is located ~700m from the volcano summit. Major element, trace element, and isotopic (Sr, Nd, Hf, and Pb) data were obtained for five samples spaced around the crater rim and for thirteen samples at various depths (~2m to ~36m) along the crater wall. Like other postglacial lava flows in Iceland, the Litlavíti samples have lower Sm/Yb, lower La/Sm, and higher Mg#s than glacial and modern lava flows. Isotopically, the Litlavíti samples are more depleted than glacial and modern lava flows. However, compared with postglacial lava flows sampled on the flanks of Stóravíti, the Litlavíti lavas are more homogeneous and fall on the enriched, fractionated end of the postglacial data set and thus trend toward glacial and modern lava compositions. Therefore, the Litlavíti lavas are believed to represent the final stage of the Stóravíti postglacial eruption as melting rates in the region returned to steady state.

[1] Maclennan *et al*. (2002) *G-cubed* **3(11)** 1-25. [2] Jull & M^{c}Kenzie (1996) *J. Geophys. Res.* **101**, 21, 815-21, 828. [3] Stracke *et al*. (2003) *G-cubed* **4(2)** 1-49.