Melt inclusions in metamorphic rocks: how localized melting promoted the formation of the Gore Mountains mega garnets (Adirondacks, US)

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Melt inclusions have been for almost 150 years an exclusive feature of magmatic rocks. However, intensive research activity in the last decade has shown that melt inclusions, or nanogranitoids, are also a widespread feature of high grade metamorphic rocks. Such inclusions rapidly became fundamental tools to unravel partial melting and melt-related processes taking place during orogenesis.

One of the latest discoveries in this field has been the identification of nanogranitoids and glass inside the mega almandine-pyrope garnets of Barton Mine (Gore Mountain, NY State, US). These crystals are arguably the world’s largest garnets and occur within garnet hornblende. Their size is ca. 35 cm in average, while garnet diameters up to 1 m were reported in historical record. Fluid is often invoked in the formation of large crystals, but so far no study has identified clear witnesses for the presence of fluid during garnet formation, e.g. primary fluid inclusions.

Polycrystalline inclusions of primary nature were instead reported by Darling et al. (1997) to occur inside the garnet: such inclusions are the main target of our study. Their shape ranges from tubular (2-100 µm in length) to negative crystal shape (2-50 µm). They mainly contain cristobalite/quartz, kumdykolite and amphibole. Minor phases such as biotite/phlogopite, enstatite, rutile, ilmenite and a second, Ca-richer plagioclase (or its rare polymorphs dmisteinbergite and svyatoslavite) may be also present. The inclusions were re-homogenized to a silicate-rich glass via piston cylinder experiments at 1.0-1.5 GPa and 925-940°C. Experimental results prove that such inclusions are former droplets of melt, in agreement with the finding of preserved residual glass in one single inclusion before the experimental runs. The melt composition measured in situ via electron microprobe is tonalitic-trondhjemitic with 5-6 wt% H2O.

The identification of melt inclusions points toward a melt rather than a fluid as the medium which favored extreme garnet growth under low nucleation rate conditions. The elements necessary to
grow garnets – mainly Fe, Al, Si, Mg- are indeed far more effectively transported by a silicate melt rather than simple aqueous fluid, at least at the limited depth envisioned for this process. In conclusion, the finding of melt inclusions in metamorphic rocks brought us forward along the path toward the solution of the enigma represented by the formation of these giant garnets.

References