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What can we learn from melt inclusions in migmatites and granulites?

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The application of melt inclusion (MI) studies to migmatites and granulites is a recent, small-scale approach to a better understanding of melting in the continental crust. It builds on the discovery of glassy inclusions and of their crystallized counterparts ("nanogranites") in garnet and other host minerals from anatectic crustal enclaves in lavas and from regional migmatites.

Unlike inclusions in igneous rocks, formed by magma cooling and crystallization, MI in migmatites are trapped during incongruent melting, generally along the up-temperature path of anatexis. Because of such peculiar origin, they can provide key microstructural and chemical information.

Microstructurally, when MI appear trapped within potential peritectic minerals (garnet, cordierite, spinel, ilmenite) and display textural features pointing to a primary origin, they demonstrate the growth of their host in the presence of melt. Therefore MI represent one of the most reliable microstructural criteria for the former presence of melt in a rock, particularly in cases where deformation has erased previously present igneous microstructures. Not only MI indicate that a rock was partially melted, but also they add constraints to the mineral(s) which coexisted with the melt. In the case of hosts such as zircon or monazite, the occurrence of MI allows anatectic events to be dated with unprecedented confidence.

Chemically, as the composition of anatectic MI is representative of that of the bulk melt in the system during anatexis, these tiny objects (rarely exceeding 15 μm) represent embryos of anatectic granites. With an appropriate characterization and analytical strategy they can provide the missing information on the primary composition of natural crustal melts before they undergo modification processes such as cumulus, fractional crystallization, mixing or entrainment of exotic material. Information on primary compositions includes the concentrations of volatile components, and hence the nature of the fluid regime during anatexis.

In the last decade we have studied MI from a dozen of occurrences worldwide: while glassy inclusions can be analyzed directly, nanogranites need to be rehomogenized and then quenched. Remelting is done in a piston cylinder, to prevent the decrepitation of inclusions and loss of volatiles. Inclusions can then be analyzed for major and trace elements, and also for H_2O: most melts are leucogranitic and peraluminous, but show important variations in normative Qtz-Ab-Or proportions (with some tonalitic compositions), as well as in H_2O contents.

This presentation will summarize some key results from MI occurrences at El Hoyazo and Ronda (Spain), the KKB of India, the Ivrea Zone (Italy) and Kali Gandaki (Nepal).