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Mapping the distribution of melt during anatexis at the source area of crustal granites by synchrotron μ-XRF

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Abstract

The garnet-biotite-sillimanite enclaves from El Hoyazo are quenched anatectic metapelites found within peraluminous dacites (Betic Cordillera, SE Spain), representing a residual lower crust in the area after 40–60% of melt extraction. Anatexis occurred concomitantly with deformation in a regional metamorphic setting during the Upper Miocene at the base of the continental crust. Previous studies have provided detailed information on the pressure-temperature evolution, the sequence of melting reactions, and associated melt proportions and compositions. They show that enclaves mostly record peak metamorphic assemblages, mineral compositions, and, likely, microstructures, with minor changes upon entrapment within the dacite magma and rapid ascent and extrusion. The enclaves still preserve a proportion of the primary melt, that solidified to glass in abundant melt inclusions (MI) and matrix melt, permitting the study of the microstructural relationships between melt and residue. This study focuses on the geometry of the glass network at the microscale that, combined with the previously reported anatectic history, helps shed light on the mechanisms and history of melt drainage from these rocks.

A representative sample of the enclaves was investigated by synchrotron μ-XRF and scanning electron microscopy to map the distribution of glass and minerals on three thin sections cut perpendicularly to the foliation. The combination of major and trace element μ-XRF distribution maps and detailed backscattered electron images evidence the presence of a pervasive and mostly interconnected glass network through the studied centimeter-scale sections. Interconnection is due to the crosscutting of films and glass-rich domains oriented parallel and at high angle with foliation. Although enclaves lost ~40–60% of melt, they still contain ~10–15% of glass, with a considerable proportion of it stored within the Mix, which is an aggregate of micrometer-sized fibrolitic sillimanite and glass. The distribution of glass (former melt) is not in textural equilibrium with the solid residue and resembles the interconnected network of deformation bands observed in migmatites of anatectic terranes at the mesoscale.

Microstructural studies of melt pseudomorphs in migmatites and granulites of anatectic terranes are scarce, but the following remarkable interpretations can be made combining our observations of these enclaves: melt formed an interconnected network during anatexis that permitted melt segregation and extraction, though melt-residue textural disequilibrium is the rule rather than the exception. The proportion of melt present in residual migmatites can be much higher than the permeability threshold for crustal protoliths; in this particular study, two reasons for this might be that (1) melt was still being produced and flowing through the residual migmatite right before disaggregation and inclusion within the host dacite, where additional melt drainage was impeded by the hydrostatic stress field, and (2) a particular microstructure produced at the onset of anatexis, such as the Mix, acted as a trap for melt impeding or delaying melt segregation.

Keywords: Melt distribution, enclave, El Hoyazo, synchrotron, granite, micro-XRF; High-grade Metamorphism, Crustal Melting, and Granite Magmas