

Deciphering the behavior of trace elements during partial melting using multi-phase quantitative compositional mapping by LA-ICPMS

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The study of the behavior of major, minor and trace elements during partial melting is a challenging task. Two fundamental limits have restricted the use of natural samples for this purpose. The first limitation is related to the open-system behavior of partially molten rocks. In migmatites the minerals present in a leucosome can be used to study the former melt composition at the time of crystallization. Any further comparison with the residual part to retrieve the melting history requires the assumption that the melt was immobile, which is unlikely due to the density and viscosity contrast between melt and solids. The second limitation is our capability to map the distribution of elements in domainal rocks. Minerals in migmatite are often chemically zoned and large variations in major element compositions can cause significant matrix effects making the map calibration for trace element challenging.

In this study we present a data reduction routine for multi-phase quantitative compositional mapping in chemically zoned minerals using LA-ICP-MS. Each mineral in the mapping area is individually calibrated using an independent element as internal standard with the option of a variable composition. This routine was implemented in the open-source software XMapTools 4.1 [1]. Quantitative compositional mapping was applied to a migmatite sample from the El-Oro complex in Ecuador. This sample comes from a 30-m wide metasediment xenolith in the Marcabellí pluton and shows an exceptional record of partial melting in a closed system. The results allow the systematic behavior of these elements during partial melting to be retrieved and show that strong chemical potential gradients in major, minor and trace elements were established between the leucosome and the residuum during cooling. This dataset can also be used to identify domains of local equilibrium and to quantify disequilibrium gradients at the thin section scale. Implications for phase equilibrium modelling based on the bulk-rock composition will also be discussed.

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[1] Lanari, P. Laughton, J. Tedeschi, M & Markmann, T (2023). XMapTools 4.1 Zenodo. DOI:10.5281/zenodo.7656958