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Evolution of garnet distribution, shape and composition in high-grade pelitic migmatites of Salvador da Bahia, Brazil: insights from LA-ICP-MS trace element mapping

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Garnet is a widely used mineral in metamorphic petrology and more particularly for thermobarometric modelling to reconstruct the P-T-t evolution of Earth's crust. This is due to its ubiquity in high grade rocks (T > 450°C), its occurrence in many assemblages of interest for thermobarometry, and mostly to its ability to preserve chemical zoning. Two types of zoning are distinguished: growth and diffusion zoning. Growth zoning reflects crystallisation coeval with changes in P-T conditions or bulk composition. This type of zoning is therefore particularly useful to unravel the P-T evolution of open systems and determine the growth mechanisms involved. However, growth zoning in major elements is commonly altered by processes such as volume diffusion, which is particularly efficient at high temperatures and for elements like Fe or Mg that have high diffusion coefficients. In such cases, information that relates to the environmental conditions of garnet growth is either totally or partially obliterated. To minimise the impact of this process on growth zoning and retain useful information, trace elements are more appropriate because of their lower diffusion coefficients compared to major elements. In this study, the distribution of trace elements in garnet has been imaged using an emerging LA-ICP-MS mapping technique. This is achieved by rastering of the focused laser beam in linear transects, which are then stitched together by post-acquisition processing to form a quantified or semi-quantified image of the trace element distribution, with excellent detection limits (ppb) over a wide isotopic range (7Li to 238U) and minimal sample preparation required.

This technique has been applied to high-grade pelitic gneisses and migmatites from the Paleoproterozoic Itabuna-Salvador-Curaça belt (adjacent to the Farol da Bara, Salvador da Bahia, Brazil). Structurally, it is located in a steeply-dipping high strain zone that may have played a major role in the segregation and transfer of melt. In migmatitic domains, garnet presents unusual grain shapes, varying distribution patterns and complex chemical zoning depending on its textural position with respect to leucosomes. Garnet grain size decreases and the number of garnet grains increases in the melanosome away from the leucosome. Furthermore, the type, amount and shape of inclusions in garnet varies greatly and continuously across the gneissic foliation. Garnet porphyroblasts in direct contact with the leucosomes are characterised by a bell-shape zonation in grossular, with a maximum content of 0.12 in the core that decreases to 0.03 at the rim. Garnets away from the leucosomes are characterised by the presence of quartz and plagioclase inclusions that modify the bell-shape zoning. What is the significance of these polymineralic inclusions? What is the significance of the 'modified' garnet zoning and its relationship to melting? These questions are critical in order to select appropriate compositions for thermobarometric modelling and arrive at a valid interpretation of the P-T evolution. LA-ICP-MS trace element mapping of garnet provides a novel methodology to investigate and re-interpret the growth and evolution of key minerals using high-resolution and comprehensive geochemical data that was previously inaccessible.