Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31831

Distribution of major and trace elements in metapelitic garnets across a metamorphic gradient.

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Garnet is a key mineral for tracing and understanding metamorphic processes due to its ability to preserve a record of its history through elemental zoning. While the chemical zoning of garnet under different *P–T–X* conditions is well documented, most studies rely on randomly sectioned crystals, which can introduce bias by not analysing the chemical centre. In addition, the lack of systematic studies along a prograde metamorphic gradient limits the understanding of the evolution of zoning patterns in response to changing *P–T* conditions. This study integrates whole-rock geochemistry, μ-CT, and EPMA/LA-(Q)ICP-MS mapping to analyse centrally sectioned garnet crystals along a metamorphic gradient in the Sergipano Belt (NE-Brazil). The crystal size distribution shows a systematic decrease in the number of garnet crystals and an increase in their radius with increasing metamorphic grade, particularly at the onset of partial melting. Major element zoning from the garnet to the staurolite-kyanite zones is preserved as concentric bell-shaped patterns. The Y+HREE distribution is similar, suggesting that Rayleigh fractionation is the dominant mechanism controlling the element partitioning between the growing garnet and the matrix. Oscillatory zoning of Ca-Fe and MREE is common, interpreted as variations in growth rates, pulsed fluid circulation, or breakdown of accessory phases. The major element zoning becomes smoother in the K-feldspar–kyanite zone and nearly homogeneous in the K-feldspar–sillimanite zone. In samples that reached to *suprasolidus* conditions, garnet shows quartzofeldspathic inclusions—interpreted as former melts—that are not spatially correlated with major cation zoning but are consistent with high V and Cr contents. These elements were probably released during dehydration of muscovite and biotite. The replacement of garnet is attributed to a mechanism of interface-coupled dissolution-precipitation in the presence of melt. Meanwhile, due to its slow diffusivities and strong partitioning into garnet, the Y+HREE zoning is preserved, showing only slight modifications that mimic the shape of the V-Cr-rich zone. The structurally-controlled sampling across the metamorphic gradient allowed us to trace the extent of the replacement phenomena. By focusing on central sections of the largest crystals, this study provides new insights into the mechanisms of garnet growth and modification in metapelites under greenschist to upper-amphibolite facies conditions.