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CO_2 storage in the northern Victoria Land (Antarctica) SCLM: clues from fluid inclusions, mineral chemistry and X-ray microtomography

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Quantifying the amount of carbon stored in the Sub-Continental Lithospheric Mantle (SCLM) and its mobility during melt extraction, metasomatism and refertilization episodes is crucial for understanding large-scale geodynamic processes, and thus modelling the evolution of our planet. Thanks to the recent analytical advancements, the integrated application of petrology, fluid inclusions (FI) geochemistry and high-resolution imaging techniques to mantle xenoliths can open new windows on the estimation of CO_2 budget and recycling in the lithosphere.

Here, we studied modally and/or chemically heterogeneous ultramafic xenoliths brought to the surface by the Cenozoic magmatism in northern Victoria Land (Antarctica) to investigate the extent and modality of CO_2 storage into depleted and fertile (or refertilized) SCLM portions beneath active rifts. To do that, 3D textural and volumetric characterization of intra- and inter-granular microstructures performed by synchrotron X-Ray microtomography were combined with measurements of CO_2 released from bulk-rock- and single phase- (olivine, orthopyroxene, clinopyroxene and amphibole) hosted FI, as well as with mineral chemistry data. High-resolution imaging enabled us to identify the presence (and related connection network) of melt/fluid components, which range from 2 to 50 μm in size and have tetrahedral to prismatic shape, as well as of secondary fractures. In most of the samples, the highest CO_2 amounts (up to 4×10^{-6} mol/g) were released from amphibole- and pyroxene-hosted FI, whereas olivine was relatively gas-poor (CO_2 down to 3×10^{-9} mol/g). A comparison between the amounts of CO_2 released from FI hosted in bulk-rock and those retained in mineral-hosted FI was performed to quantify eventual CO_2 unbalances, and in turn relate them to the volumetric abundance of melt/fluid components determined by X-Ray tomography. Complemented by mineral chemistry data, our results enabled us to explore: i) the CO_2 storage capability of SCLM portions in which pristine melt extraction event/s were followed by multiple and complex enrichment episodes; ii) the role played by intragranular and intergranular fluids during these events; and iii) the rheological properties of the mantle.