Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19364

Mapping metamorphic methane distribution and $\delta^{13}C$ across an orogenic, partially serpentinized massif: insights into abiotic CH_4 generation and pathways for fluid migration in subduction zones

ORLANDO SÉBASTIEN OLIVIERI[1], ALBERTO VITALE BROVARONE[1], JENS FIEBIG[2], ANTOINE BOUTIER[3], MARK VAN BAALEN[4], FRANCESCO RESSICO[1] AND VERONICA PEVERELLI[1]

[1]Alma Mater Studiorum Università di Bologna
[2]Goethe University Frankfurt
[3]Università di Torino
[4]Harvard University

Presenting Author: orlando.olivieri2@unibo.it

There is growing evidence attesting to the presence of abiotic CH_4 related to serpentinization of ultramafic rocks at high-pressure conditions in subduction zones [1,2,3]. Nonetheless, CH_4 isotopic compositions in high-pressure metamorphic settings remain largely unconstrained, leading to uncertainties on reaction pathways for CH_4 production/reaction and carbon recycling in subduction zones.

The mafic/ultramafic Belvidere Mountain Complex (BMC), Northern Vermont (USA), hosts CH_4 + minor N_2, NH_3, H_2 and S-H compounds fluid inclusions [1]. The BMC experienced a complex tectonic evolution including multiple events of high-pressure fluid-rock interaction and serpentinization from the Taconic (505-473 Ma) to the Acadian orogeny (415-360 Ma) [1]. A wide variety of CH_4 isotopic compositions observed in 9 samples from the BMC, ranging from thermogenic to abiotic signatures, was suggested to document the complexity of metamorphic CH_4 generation and transformation [4].

In this study, we investigated in more detail the spatial distribution of CH_4 and other fluid species across the BMC using a high spatial resolution approach. Fluid inclusions hosted in more than 50 samples were analysed through quantitative Raman spectroscopy and the bulk $\delta^{13}C$-CH_4 was measured through mechanical extraction combined with Cavity Ring-Down Spectroscopy (CRDS).

This approach allowed to depict gradients in the CH_4 isotopic compositions, from more enriched inside the ultramafic body, to more depleted close to its edges, in the proximity of a 6 m-thick graphite-rich shear zone cutting through it, and in the surrounding metasedimentary units. These large structural discontinuities could represent ideal pathways for the migration and mixing of CH_4 characterized by different isotopic signatures, as suggested by the preliminary work by Boutier (2022).

References

[1] - Boutier et al., 2021. (https://doi.org/10.1016/j.lithos.2021.106190)

[2] - Vitale Brovarone et al., 2017. (https://doi.org/10.1038/ncomms14134)

[3] - Vitale Brovarone et al., 2020. (https://doi.org/10.1038/s41467-020-17342-x)

[4] - Boutier, A., 2022. Genesis and migration of abiotic hydrocarbons in subduction zones. PhD Thesis, University of Torino.