ECOLE LEMANIQUE DES SCIENCES DE LA TERRE
DES UNIVERSITES DE GENEVE ET DE LAUSANNE

Master ès Sciences in Earth sciences

Metamorphic Redox Partitioning in Subduction Zones: Insight from Alpine Corsica

Contact persons

Matthieu Galvez (UNIL/ETH) - matthieu.galvez@unil.ch
Othmar Muntener (UNIL)

Context

Subduction zones are major pathways for the exchange of materials between surface and deep Earth (Evans, 2012; Galvez and Pubellier, 2019; Peacock, 1990). Serpentinite, formed by hydrothermal alteration of peridotites on the seafloor (Evans, 2008), conserve part of their reducing power as they are progressively subducted (Malvoisin et al., 2012). This reducing power may be redistributed in and around surrounding lithologies (marbles, basalts, evaporites etc), and promote metasomatic exchanges of reductant and oxidants. This is the reason why serpentinites are thought to exert a crucial control on the partitioning of C, Fe and S between rocks and fluids in subduction zones (Evans and Frost, 2021; Galvez et al., 2013a). Much remains to be understood about the nature, chronology and mechanisms of redox-driven metamorphic reactions.

Previous works have investigated a reactive contact between serpentinites (reducing) and marbles (oxidizing) in Alpine Corsica (Galvez et al., 2013a; Galvez et al., 2013b). At the interface, the marble has been reduced to an assemblage comprising graphite, wollastonite and grossular. The reaction occurred at a peak metamorphic T of around 400 °C and a pressure of 10 kbar (Chopin et al., 2008). This reaction has been used to constrain the magnitude of the redox gradient between the two contrasted lithologies (Malvoisin et al., 2012). It is not yet clear, however, what volumes of serpentinite and marble have been engaged in the redox exchange. This is a mass balance issue which cannot be resolved by conventional approaches such as equilibrium thermodynamics (Evans, 2006; Galvez and Jaccard, 2020). But it can be addressed by a quantitative approach of redox reactions using a metric such as the redox capacity ΔO_2, which is the total amount of O_2 necessary to oxidize all redox- sensitive element within a given mass to their highest accessible valence state.

In this project, we will sample the reactive interface in the field. Back to the laboratory, we will study the compartimentalization of redox power across this reactive interface using a novel analytical approach giving access to the redox capacity of rocks (Galvez and Jaccard, 2020).

Aims and Methods

The objective of this project is to resolve the mass balance problem associated with the metasomatic and redox- driven formation of graphite at a lithological interface in Alpine Corsica.

The project will involve field sampling in Alpine Corsica, and extensive laboratory work. This includes the preparation of rocks for thin sectioning, general petrographical description of thin sections, selected characterization with Raman spectroscopy, and laboratory redox titration. Requirements for the project are a taste for the study of complex natural objects, and for quantitative laboratory work.

References

Chopin, C., Beyssac, O., Bernard, S., Malavieille, J., 2008. Aragonite-grossular intergrowths in eclogite-facies marble, Alpine Corsica. European Journal of Mineralogy, 20(5): 857-865.
Evans, B.W., 2008. Control of the Products of Serpentinization by the Fe2+Mg-1 Exchange Potential of Olivine and Orthopyroxene. Journal of Petrology, 49(10): 1873-1887.
Evans, K.A., 2006. Redox decoupling and redox budgets: Conceptual tools for the study of earth systems. Geology, 34(6): 489-492.
Evans, K.A., 2012. The redox budget of subduction zones. Earth-Science Reviews, 113(1-2): 11-32.
Evans, K.A., Frost, B.R., 2021. Deserpentinization in Subduction Zones as a Source of Oxidation in Arcs: A Reality Check. Journal of Petrology.
Galvez, M.E. et al., 2013a. Graphite formation by carbonate reduction during subduction. Nature Geoscience, 6(6): 473-477. Galvez, M.E., Jaccard, S.L., 2020. Redox capacity of rocks and sediments by high temperature chalcometric titration. Chemical Geology: 120016.
Galvez, M.E. et al., 2013b. Metasomatism and graphite formation at a lithological interface in Malaspina (Alpine Corsica, France). Contributions to Mineralogy and Petrology, 166(6): 1687-1708.
Galvez, M.E., Pubellier, M., 2019. How Do Subduction Zones Regulate the Carbon Cycle? In: Orcutt, B.N., Daniel, I., Dasgupta, R. (Eds.), Deep Carbon: Past to Present. Cambridge University Press, Cambridge, pp. 276-312. Malvoisin, B., Chopin, C., Brunet, F., Galvez, M.E., 2012. Low-temperature wollastonite formed by carbonate reduction: a marker of serpentinite redox conditions. Journal of Petrology, 53(1): 159-176.
Peacock, S.A., 1990. Fluid Processes in Subduction Zones. Science, 248(4953): 329-337.

 	**Website**
Prerequiste	