Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.11939

Coupling of reactive fluid flow and deformation during carbonation of peridotite at the base of the Samail ophiolite, Oman

MANUEL D. MENZEL[1], JANOS L URAI[2], ESTIBALITZ UKAR[3], THIERRY DECRAUSAZ[4], MARGUERITE GODARD[5] AND PETER KELEMEN[6]

[1]Tectonics & Geodynamics, RWTH Aachen University
[2]Tectonics and Geodynamics, RWTH Aachen University
[3]The University of Texas at Austin
[4]Géosciences Montpellier, CNRS, U. Montpellier
[5]Géosciences Montpellier, CNRS, Univ. Montpellier
[6]LDEO, Columbia University

Presenting Author: manuel.menzel@emr.rwth-aachen.de

The reaction of serpentinite with CO_2-bearing fluids to listvenite (carbonate-quartz rock) involves high fluid flux, but the processes accommodating volume expansion and mass transfer during this reaction are not well understood. Here we present results of microstructural analysis [1,2] of listvenites and serpentinites from Oman Drilling Project Hole BT1B, which record the complex structural evolution and related deformation during interaction of peridotite with CO_2-bearing fluids along the base of the Samail ophiolite. Using multi-scale correlative (electron-)microscopy and chemical mapping, we identify the key stages as: (i) serpentinization concurrent with or followed by brittle to ductile deformation of serpentine, (ii) formation of serpentine veins, (iii) incipient formation of ellipsoidal magnesite and early magnesite veins, concurrent with ductile deformation of the reacting medium, (iv) progressive magnesite growth with concentric zoning, (v) formation of syn-carbonation quartz veins, (vi) precipitation of dendritic magnesite and massive quartz under mostly static conditions, followed by (vii) post-listvenite brittle overprints forming syntaxial veins, cataclasites, faults and late veins. Our results show that several carbonation reaction stages were coeval with vein formation and reaction-assisted ductile deformation, likely at lithostatic pore pressures. Sets of parallel magnesite veins show that tectonic stress was important during early carbonation, with permeable micro-reaction fronts along vein – wall rock interfaces facilitating transformation of the non-veined matrix. Crystal growth microstructures indicate that these deformation processes, in addition to the textural and crystallographic variability of serpentine, have a strong influence on reaction progress and a positive feedback on porosity and fluid flux. We infer that listvenite formation involves a significant change in rheology, causing deformation and fluid flow to focus along the advancing reaction front. Overall our results demonstrate that, in nature, tectonic stress and related deformation are key ingredients for full carbonation of peridotite to listvenite. The observed feedback mechanisms between deformation and reaction progress may be common in the mantle wedge overlying subduction zones and other fault zones, allowing massive carbonation of mantle rocks.

[1] Preprint on Eartharxiv: https://doi.org/10.31223/X53K87
[2] Preprint in Solid Earth Discussion: https://doi.org/10.5194/se-2021-152

Funding: DFG grants UR64/20-1, UR64/17-1. This research used samples and data provided by the Oman Drilling Project.