Geophysical Research Abstracts
Vol. 21, EGU2019-10446, 2019
EGU General Assembly 2019

Multiscale structure evolution during peridotite carbonation and hydration in an oceanic subduction zone: a case study of listvenite in the Oman Ophiolite

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Listvenites in the Oman Ophiolite formed from oceanic mantle peridotite thrust over carbonate-bearing sediments in the hanging wall of a subduction zone. In this example of large scale peridotite hydration and carbonation processes, core BT1 of the ICDP Oman Drilling Project (OmDP) provides a unique sample. Although listvenites record carbon fluxes in oceanic subduction zones and are a possible natural analogue for carbon capture and storage via mineralization, the processes by which this carbonation occurs are not well understood, calling for work to understand the evolution of this natural example. We aim to better understand the interplay of force of crystallization, tectonic stress and pore pressure during large scale hydration and carbonation processes in BT1 and test hypotheses on driving forces, structural evolution and fluid transport pathways in this system.

The core has revealed a wonderfully diverse petrology and structure, from serpentinite with peridotite relics, massive listvenite, foliated listvenite, several generations of veins, ductile shear zones, cataclasite, breccia and planar faults. First inspection of the thin sections has shown a correspondingly rich microstructure.

The density of veins in the core is very high, > 100 per m. Both the serpentinite and listvenite in the core contain and are overprinted by several generations of veins, followed by cataclasites, sharp planar faults and late, partially open veins. One type of vein is antitaxial, with a median line rich in iron oxides (haematite, goethite) and carbonate. This vein type (oxy-carb veins) occurs in both serpentinite and listvenite where it is responsible for the red-brown colour. Overprinting relations suggest that these are the oldest veins. Quartz + chalcedony +/- carbonate veins are syntaxial and younger. These structures are overprinted by cataclasites and breccia, often enriched by iron oxides (maybe a later generation of iron mobilisation, and sharp, planar faults with silica or carbonate veins on the slip surface. Syntaxial, partially open veins of magnesite or dolomite are the latest structures. Overprinting relations may not be the same everywhere in the core, and structures belonging to one generation may or may not be synchronous. Listvenite not affected by this overprinting ("primary listvenite") can be massive, containing relics of serpentine and the typical iron oxide mesh textures. In other parts of the core primary listvenite has a well-developed foliation defined by lithological banding and at the microscale ellipsoidal carbonate particles with an iron oxide core. Shear zones are also common in the serpentinite, and also in the transition between serpentinite and listvenite, where there are no discernible faults or cataclasites. We hypothesise that the primary listvenite formed from serpentinized harzburgite, in a system of localized ductile shearing and high pore pressure with the force of crystallization acting at the walls of antitaxial veins.