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Exploring new frontiers in fluids processes in subduction zones

Numerical modelling of porosity and fluid escape structures in subduction zones (invited)

Johannes C. Vrijmoed (1), Oliver Plümper (2), Timm John (1), Yuri Y. Podladchikov (3), and Marco Scambelluri (4)

(1) Institut für Geologische Wissenschaften, Freie Universität Berlin, Berlin, Germany (j.c.vrijmoed@fu-berlin.de), (2) Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands, (3) Institute of Earth Sciences, University of Lausanne, Lausanne, Switzerland, (4) Dipartimento di Scienze della Terra, Ambiente e Vita, Università di Genova, Genova, Italy

Water is brought down into the Earth through subduction zones mostly in the form of hydrous minerals. This water is released again by dehydration reactions that are triggered by elevated temperature in the subduction zone at depth. The released water needs to find a way to flow out of the rock as the volume increase due to the water release is too large to be accommodated. Porosity estimates on such rocks reveal that porosity is extremely low, in principle inhibiting efficient flow of fluid. Yet there must be an efficient way of transporting the fluid out of the rock and bringing it up to the surface. Rough estimates of the global water budget indicate that if this was not the case, the oceans would be drained within several millions of years. Geophysical imaging above subduction zones also reveal that large scale fluid transport does occur. Here I present developments in numerical modelling methods to gain insight into this problem.

The focus lies on several aspects of the initial stages of fluid release: the problem of porosity generation, and the possible ways of reaching pore connectivity in the initial stages enhancing the fluid transport. The main aspects are treated with a numerical model that solves for fluid pressure, mineral and rock density evolution, and porosity evolution coupled to local thermodynamic equilibrium. Methods of computation involve the generation of large pre-computed thermodynamic data to use in a local equilibrium transport model. The advantage of this approximation method over traditional reaction-based approaches is that most sophisticated solution models for solids and fluids can be treated more easily.

One of the interesting aspects is that with including solid solution models, fluid release occurs gradually in divariant fields in pressure-temperature space. This results in a spatially varying porosity and fluid pressure distribution already at the millimetre scale that is largely dominated by the intrinsic chemical heterogeneities in hydrous minerals such as antigorite and brucite, which occur never as perfectly pure phases in nature. The occurrence of near pure olivine veins in dehydrated serpentinite is further enhanced by involving mass transport into the model. During this process, fluid flow transport also become more effective, thus showing that mass transport further contributes to the efficiency of fluid release from subduction zones.