Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5045

Quantifying transient, reaction-induced permeability during fluid-rock interaction: A multi-resolution imaging and multi-scale pore network modelling approach.

HAMED AMIRI[1], AMIR RAOOF[1] AND OLIVER PLÜMPER[2]

[1]Department of Earth Sciences, Utrecht University
[2]Utrecht University
Presenting Author: h.amiri@uu.nl

When fluids infiltrate rocks, chemical reactions are inevitable; but what controls fluid transport? Fluid-rock interactions within the crystalline lithosphere, beyond the thin sedimentary cover, are typically addressed by assuming a time-integrated fluid flux in which the spatiotemporal behavior of the porous network is not accounted for. As such, current models suggest that permeability decreases with depth [1], as a result of pressure-induced pore closure. However, numerous recent natural and experimental observations show that fluid-driven mineral reactions within the middle/lower crust and upper mantle are governed by dissolution-precipitation processes that can in tandem generate and vanish a dynamically evolving network of fluid pathways. Here, we employ a multi-scale, fully correlative electron and X-ray microscopic imaging strategy coupled to advanced pore network modelling to estimate the reaction-induced permeability of large-scale (>60 km²) hydrothermally altered igneous rocks (~10 km depth) from the Oslo rift, Norway [2]. Using stochastic and machine-learning techniques, we integrate 3-dimensional X-ray tomographic imaging at a resolution of 500 nm, with large-area automated backscattered electron imaging to bridge the resolution gap of 50 to 500 nm. We find that nearly all porosity is presently disconnected although the feldspar reaction microstructures imply that pore space must have been connected at the time of reaction. To reconstruct the prior connectivity, we use pore size distributions and average coordination number of the natural sample at different scales and generate a representative and statistically equivalent pore network, but with interconnected porosity, which is subsequently used to calculate permeability. Our results show that the average permeability equates to $\sim 1\times10^{-15}$ m^2, which is two to three orders of magnitude higher than previously reported values at the corresponding depth [1]. This, however, accords with recent investigations based on Li-isotope profile modelling [3], suggesting an enhanced permeability during fluid-driven metamorphism. Overall, our study provides the foundation to reevaluate the impact of mineral (replacement) reactions on the dynamic evolution of permeability during fluid-driven rock transformation processes.

References

[1] Ingebritsen & Manning (2010). *Geofluids*, *10*(1-2), 193–205.

[2] Beinlich et al. (2020). *Nature Geoscience*, *13*(4), 307–311.

[3] Plümper et al. (2017). *Nature Geoscience*, *10*(9), 685–690.