

How much can we interpret mineral surface area with distributions of minerals and pores?

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Fluid-rock interactions play an important role in science and engineering processes such as chemical stimulation of enhanced geothermal systems and carbon capture, utilization, and storage. However, these interactions highly depend on the accessible reactive surface area of the minerals, values which are difficult to characterize. In particular, quantifying surface area of each reacting mineral within whole rock samples is challenging due to the heterogeneous distribution of minerals and pore spaces. In this study, detailed laboratory analyses were performed on sandstone samples from deep geothermal sites in Lithuania in an effort to enhance reservoir productivity.

We measure specific surface area of whole-rock samples using a gas adsorption method (so-called B.E.T.) with N₂, at a temperature of 77.3K. We also quantify the porosity and pore-size distribution using a Helium gas pycnometer and Hg porosimetry, respectively. Rock compositions are determined by a combination of X-ray fluorescence (XRF) and quantitative scanning electron microscopy (SEM) - Energy-dispersive X-ray spectroscopy (EDS), which are later geometrically mapped onto 2D images derived from SEM-Backscattered electrons (BSE, resolution: 1.2 μm) and 3D images derived from Micro Computed Tomography (Resolution of 10.3 μm for cylindrical samples with a diameter of 25.4 mm and a resolution of 1.2 μm for sub-samples with a size of 1.2×1.2×1.2 mm³) and from Synchrotron X-ray Tomographic Microscopy (Resolution of 0.35 μm for sub-samples with a size of 1.2×1.2×1.2 mm³). These digital maps of minerals are then linked back to B.E.T. specific surface area, whole rock porosity, and pore size distributions. Moreover, porosity and pore size distribution are analyzed using both 2D and 3D images. This richness of data is greatly advancing our understanding of pore-scale geochemical processes. It is anticipated that these analyses will provide an in-depth understanding of fluid sample chemistry for subsequent hydrothermal-reactive-flow-through experiments on whole rock samples at elevated pressure and temperature.