Grain growth-induced channelization of non-wetting fluids in synthetic quartzite

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The migration mechanisms of intergranular fluids in deep-seated rocks are of fundamental importance in geological and geophysical processes. Grain-boundary wetness, often characterized by a dihedral angle, is a parameter used to determine the grain-scale geometry, and accordingly, the migration mode of the fluids. When the dihedral angle is larger than 60˚in a fluid-rock system, an interconnected fluid network is not established along the grain edges and corners at low fluid fractions, and thus pervasive permeable flow is not assumed to occur. In such a case, the processes that allow fluids to migrate within rocks are poorly understood. To address this issue, we performed sintering experiments on aqueous-fluid-bearing quartzite and observed the evolution of the fluid distribution with time. The experiments were conducted with various fluid fractions and compositions (3.21–15.1 vol% of aqueous fluid, = 0, 0.35–0.85) at 900 ℃ and 1.0 GPa for up to 192 hours.
In the end products (from experimental runs under CO_2 saturation) that had greater than 60˚dihedral angles between the fluid and the quartz grains, fluid pockets (grain-scale fluid reservoirs surrounded by faceted quartzite grains) were found to have formed via fluid expulsion during grain growth. These fluid pockets were likely formed by smaller grains, surrounded by fluid-filled triple and multiple junctions, that were consumed by grain growth, followed by the coagulation of the fluid-filled junctions [1], [2]. In some of the product runs, the fluid pockets were aligned to be in proximity with one another. These fluid pockets are likely to be interconnected three-dimensionally. The spatial distribution of smaller quartz grains measured with the line-transect method revealed that smaller grains tend to acquire network-like arrangements; probably due to a geometrical (packing) requirement in self-organizing fluid-rock systems that have grain size variations. Such a grain arrangement may result in the increased interconnectivity of fluid pockets via consumption of the small grains during extensive grain growth, a process that would significantly increase the permeability of non-wetting, fluid-bearing systems.

References

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