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Serpentinization: Getting water into a low permeability peridotite

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Fluid consuming rock transformation processes occur in a variety of settings in the Earth's crust. One such process is serpentinization, which involves hydration of ultramafic rock to form serpentine. With peridotite being one of the dominating rocks in the oceanic crust, this process changes physical and chemical properties of the crust at a large scale, increases the amount of water that enters subduction zones, and might even affect plate tectonics[**?**]. A significant number of papers have studied serpentinization in different settings, from reaction fronts progressing over hundreds of meters[**?**] to the interface scale fracture initiation[**?**]. However, the process represents a complicated multi-physics problem which couples external stress, mechanical deformation, volume change, fracture formation, fluid transport, the chemical reaction, heat production and heat flow. Even though it has been argued that fracture formation caused by the volume expansion allows fluid infiltration into the peridotite[**?**], it remains unclear how sufficient water can enter the initially low permeability peridotite to pervasively serpentinize the rock at kilometre scale.

In this work, we study serpentinization numerically utilizing a thermo-hydromechanical model extended with a fluid consuming chemical reaction that increases the rock volume, reduces its density and strength, changes the permeability of the rock, and potentially induces fracture formation. The two-way coupled hydromechanical model is based on a discrete element model (DEM) previously used to study a volume expanding process[**?**, **?**] combined with a fluid transport model based on poroelasticity[**?**], which is here extended to include fluid unsaturated conditions. Finally, a new model for reactive heat production and heat flow is introduced, to make this probably the first ever fully coupled chemo-thermo-hydromechanical model describing serpentinization. With this model, we are able to improve the understanding of how water is able to penetrate deep into the crust to pervasively serpentinize the initially low permeability peridotite.

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