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Feedbacks of Rock Hydration on Hydrothermal Convection

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Hydration of the oceanic lithosphere is an important process which alters both the chemical and physical properties of the affected lithologies. Although hydrothermal convection has been extensively researched, little work has been done on the effects of hydration reactions occurring during convection. One of the most important reactions occurring in the oceanic lithosphere is serpentinization of ultramafic rocks. We present a numerical solution for hydrothermal circulation which explores the feedbacks generated during serpentinization of mantle rocks. The model is two dimensional and uses the FEM approach. Three coupled, time-dependent equations are solved: the first equation is mass conserving and is based on Darcy flow. The second equation describes heat transport and accounts for advective and diffusive heat transfer as well as latent heat effects. The final equation describes the serpentinization rate of olivine in ultramafic rocks (Emmanuel and Berkowitz, 2006) and is derived from experimental results (Martin and Fyfe, 1970). Serpentinization is a fluid-consuming process and manifests itself as a sink term in the Darcy flow equation. The exothermic heat of reaction is added as a source term in the heat transport equation. Moreover, serpentinization is associated with a large positive volume change. This large volume change may decrease the porosity of the rock but can also increase permeability by deformation. The rate of serpentinization used in the model is, therefore, also coupled to the porosity and permeability. We investigate the role of hydration in a box model using thermodynamically constrained fluid properties where the lower part is composed of reactive mantle rocks. The effects of serpentinization on the temperatures of the venting fluids and variations in flow pathways are explored. Furthermore, the model is also used in a mid-ocean ridge setting and the amount and depth of serpentinization, in addition to the above mentioned effects, is also studied in relation to the spreading rate.

References

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