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Advanced petrological modelling for predicting fluid fluxes in subduction zones

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The release of aqueous fluids in the crust and subsequent interaction with surrounding rocks is a fundamental process on Earth especially in subduction zones. Dissolution of hydrous minerals during prograde metamorphic reactions releases aqueous fluids, which can be traced using geochemistry. While the occurrence of a free fluid phase in subduction zones is accepted, the generation of free fluid *via* dehydration reactions can be simulated using forward petrological models [1]. However, the predicted continuous releases of fluids during burial [2, 3] is in apparent disagreement with geophysical data indicating localized tremor and slow slip events. A more robust petrological model requires a physical-mechanical model for realistic simulation of fluid flow associated with metamorphic reactions. The transition from closed to open system is expressed in permeability changes. Quantifying the lithology-dependent intensity of dehydration and the links with densification is key to better understand fluid-rock interaction processes and thus to the occurrence of e.g., pervasive fluid flow.

This contribution presents an advanced petrological model that performs Gibbs Energy minimizations coupled with a physical-mechanical model for fluid extraction and geochemical model for oxygen isotope fractionation. While considering multiple rocks, the model allows the investigation of release events related to mineral reactions. Estimation of fluid fluxes and time-averaged permeability values can be obtained. Additionally, the fluid extraction model shows alternation between continuous and episodic events. Modelling metabasic and metasedimentary compositions show that predicted onsets of episodic fluid release events at depth could match the distribution of recorded tremor and slow slip events. On the other hand, the transmission of fluid between lithology units influences the time and trigger of fluid release as well as the magnitude of permeability. Important parameters are explored such as the mineral reactions and their impact on system properties and the reaction overstepping which can delay metamorphic reactions.

References:

[1] Baxter and Caddick (2013) Geology 41:643-646

[2] Condit et al. (2020) EPSL 552:116601

[3] Hacker et al. (2003) Solid Earth 108:B1

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