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Evaluation of dynamics of crustal fracturing and fluid flow revealed by static and petro-equilibrium analyses.

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Fluid flow in the crust promote hydration reactions, and changes rheology of rocks. Fluid pressure rise cause rock fracturing and permeability enhancement allowing fluid infiltration. Such fluid activity is related to shear fracturing and can possibly induce earthquakes generation (e.g., Katsumata and Kamaya, 2003; Obara et al., 2004). However, quantitative constraints on fluid fluxes associated with shear fracturing are limited, particularly regarding its temporal and spatial heterogeneity. Therefore, it is important to estimate amount of fluid fluxes to understand roles of fluids in earthquakes triggering. We constrain fluid fluxes by thermodynamic modeling of fluid chemistry in the metamorphic fluid-rock reaction zones and discuss their relation to potential seismic events based on shear fracturing evidence.

We investigated reaction zones in hydrated metamorphic rocks samples from the Mefjell and Brattnipene Sør Rondane Mountains (SRM), East Antarctica. Several amphibolite- and granulite-facies (0.3–0.65 GPa, 400–740°C) millimeter-scale hydration zones provide information on duration and hydraulic parameters of fluid infiltration. Here we analyse samples underwent rapid hydration (~10 h) and permeability evolution from low-permeable ($\sim10^{-22}$–10^{-20} m^2) to highly-permeable rocks ($\sim10^{-9}$–10^{-8} m^2) related to crustal fracturing at depths around 10-20 km (Mindaleva et al., 2020). We used these estimations to calculate fluid fluxes in the reaction zones and through the fracture.

We present new methodology based on alteration processes in the reaction zone estimating the fluid volume required to induce fluid-driven seismic activity via coupled reactive-transport modelling and thermodynamic analyses. To evaluate the moment magnitude of potential seismic events we apply two approaches, based on estimated fluid volumes (10^2 to 10^4 m^3) and on the shear fractures characteristics, such as slip geometry. We find that moment magnitudes, short fluid infiltration timescales (~10 h) are comparable to some tremor and/or slow-slip events within continental crust. Our observation corresponds to the depth of ~10–20 km, and are shallower than source region of tremor and slow-slip events (~plate interface depth). Thus, we conclude that large amount of fluid transported over short timescales through the single fracture may be widespread mechanism to generate crustal fracturing and induce seismic activity above source regions of tremor and slow slip events in the lower–middle crust.

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