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Modelling transient fluid trap and release by metamorphic reactions: implications for fluid flow in subduction zones

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Metamorphic reactions do not only modify rock chemical and mineralogical compositions but they also have strong impacts on density and porosity. Therefore, they have first-order impact on rock hydraulic properties with consequences for fluid flow in metamorphic environments. A new fully-coupled model was developed to take into account the effect of metamorphic reaction on deformation and fluid flow. The model considers reaction kinetics and poro-viscoelastic rheology and allows predicting hydraulic properties evolution by taking into account changes in densities and porosity due to reaction. Introducing porosity anomalies in the model leads to deviation of fluid pressure from lithostatic pressure and thus triggers reaction. Through the modification of rock density, metamorphic reaction will then induce porosity evolution in opposite directions at the top and at the bottom of the anomalies and, thus, anomaly propagation (reacting porosity waves). The study of porosity propagation at high resolution in 3-D indicates that fluid extraction by this mechanism is efficient and can occur from deep to shallow environments. Among the various parameters controlling the impact of reaction on fluid flow, the Clapeyron slope relating the evolution of porosity to fluid pressure is shown to play a key role. This is well evidenced when studying subduction zones for which the model provides a new mechanism for episodic tremor and slip events migration.