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Hydro-mechanical modelling of slow slip phenomena in subduction channels

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Subduction zone seismicity is widely variable in origin and also includes more recently discovered families of “slow earthquakes”, such as low- and very-low-frequency earthquakes, slow slip events and tremor. Several lines of evidence suggest that both regular and slow slip phenomena in subduction zones are intrinsically related to and controlled by fluid-related processes. It is therefore important to investigate and better understand the role that fluids play for the different events and processes in subduction zones. A finite difference fully coupled visco-elasto-plastic hydro-mechanical numerical code with marker-in-cell technique was developed to investigate how the presence of fluids in the pore space of a (de)compacting rock matrix affects shear band formation in subduction channels. Good correlations between shear band and fluid related parameters, such as porosity, permeability and fluid pressure factor have been observed. Tensile shear bands are present when no gravity is taken into account in the model, showing higher porosity and permeability than outside the shear zones. Gravity, however, plays an important role in stabilizing the model; confined shearbands (lower porosity and permeability than outside the shearbands) are observed in the presence of gravity. The model also spontaneously produces periodic slow slip events along plastic shear zones, which could be comparable to slow earthquakes observed in subduction zones. Slow-slip-like events develop in response to the process of propagation of individual fault zones through the subduction channel medium. This process is associated with lowering of total pressure along these zones at nearly constant fluid pressure, which notably reduces brittle/plastic strength of deforming fault rocks. Providing in this way a dynamic feedback for the accumulated elastic stress release in the channel.