Geophysical Research Abstracts
Vol. 15, EGU2013-3301, 2013
EGU General Assembly 2013

Numerical investigation of dewatering and fluid pressure in the western Nankai subduction zone: Implications for fluid flow and mechanical behavior of the subduction thrust

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Excess pore water pressure is one of crucial factors that controls the nature and physical property of the plate boundary and, thus, the updip limit of the seismogenic zone. Variation of sediment composition and lithostratigraphy are key players for the spatial distribution and magnitude of fluid pressures. To investigate their impact we chose the underthrust sequence of the western Nankai subduction zone offshore Japan for our study. Sand layers characterize the incoming sediment sequence at the western Nankai margin with a total thickness of up to >200 m within a matrix of hemipelagic mud. We use a coupled loading and diffusion model that allows continuous sediment deformation. To investigate the impact of sand layers on fluid flow and fluid pressures hydrogeological properties are updated in the models based on new laboratory reference data of clays and sands from the Nankai margin area.

The simulations demonstrate that $\sim$79-89% of the incoming pore water in the underthrust sediment may be expelled by lateral fluid flow along the sands, which are at least partially cycled back to the ocean. Different deformation behavior of sands and clays enhances the effective sand permeability to be 5-24 times higher than the matrix sediment. The average pore pressure ratio along the base of the accretionary prism is lower than along the central Nankai margin where sand layers are absent. This result emphasizes that sediment lithostratigraphy is a key player for the along-strike variation in mechanical strength of the subduction thrust. The numerical study also suggests that lateral fluid flow mediates the distribution of effective stress in the underthrusting sediments, and may cause downstepping of the décollement $\sim$20-30 km landward of the trench (as observed in seismic reflection profiles) and initiates underplating in the Nankai subduction zone.