Geophysical Research Abstracts
Vol. 15, EGU2013-3310, 2013
EGU General Assembly 2013

Coupled deformation and dehydration processes in smectite-rich sediments constrained by laboratory experiments

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Subduction zones play a central role in the geological activity of the earth which is expressed as devastating events such as earthquakes, tsunamis and explosive volcanism. Many processes that lead to such catastrophic behavior are driven by fluids, which in turn affect the rock mechanical behavior. The kinetic reaction of hydrous smectite to illite is widely accepted as a fluid source in subduction zone forearcs that also affects the mechanical state of subduction zone sediments. The released fluids are characterized by low-chlorinity and high volatile content. Also, previous workers demonstrated in uniaxial deformation tests that smectite partially dehydrates with increasing effective stress. To shed light on this process we performed uniaxial deformation experiments on smectite-rich samples from the Nankai and Costa Rica subduction zones. Experiments were conducted at temperatures of up to 100°C under constant rate of strain and effective stresses of up to ∼100MPa. Fluids expelled during the experiments were analyzed for major and minor element content. The fluids are characterized by fluid-freshening and increasing volatile content that starts at ∼1.3MPa effective stress. During the course of the experiments the smectite interlayer water content decreases from 27 wt-% to 20 wt-%. The released interlayer water comprises up to 17% of the total fluid volume released from the consolidating sediment. The onset of fluid freshening is characterized by a change in deformation behavior of the samples. The porosity decrease with increasing effective stress is smaller at effective stresses greater 1.3MPa. We propose that dehydration of the low permeable smectite leads to excess pore pressures in the sample, which causes a load transfer from the solid phase to the pore fluid.