Geophysical Research Abstracts
Vol. 16, EGU2014-10666, 2014
EGU General Assembly 2014

Causes and consequences of the great strength variability among soft Nankai accretionary prism sediments from offshore SW-Japan

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The Nankai Trough Seismogenic Zone Experiment of the International Ocean Discovery Program (IODP) is the very first attempt to drill into the seismogenic part of a subduction zone. Offshore SW-Japan the oceanic Philippine sea plate is subducted beneath the continental Eurasian plate causing earthquakes of magnitude 8.0 to 8.5 and related tsunamis with a recurrence rate of 80-100 years. For the tsunamigenic potential of the forearc slope and accreted sediments their mechanical strength, composition and fabrics have been investigated. 19 drill core samples of IODP Expeditions 315, 316 and 333 were experimentally deformed in a triaxial cell under consolidated and undrained conditions at confining pressures of 400-1000 kPa, room temperature, axial shortening rates of 0.01-9.0 mm/min, and up to an axial strain of ∼64% (Stipp et al., 2013). With respect to the mechanical behavior, two distinct sample groups could be distinguished. Weak samples from the upper and middle forearc slope of the accretionary prism show a deviatoric peak stress after only a few percent strain (< 10%) and a continuous stress decrease after a maximum combined with a continuous increase in pore pressure. Strong samples from the accretionary prism toe display a constant residual stress at maximum level or even a continuous stress increase together with a decrease in pore pressure towards high strain (Stipp et al., 2013). Synchrotron texture and composition analysis of the experimentally deformed and undeformed samples using the Rietveld refinement program MAUD indicates an increasing strength of the illite and kaolinite textures with increasing depth down to 523 m below sea floor corresponding to a preferred mineral alignment due to compaction. Experimentally deformed samples have generally stronger textures than related undeformed core samples and they show also increasing strength of the illite and kaolinite textures with increasing axial strain. Mechanically weak samples have a bulk clay plus calcite content of 31-65 vol.-% and most of their illite, kaolinite, smectite and calcite [001]-pole figures have maxima >1.5 mrd. Strong samples which were deformed to approximately the same amount of strain (up to 40%) have no calcite and a bulk clay content of 24-36 vol.-%. Illite, kaolinite and smectite [001]-pole figure maxima are mostly <1.5 mrd, except for one sample which was deformed to a considerably higher strain (64%). The higher clay and calcite content and the stronger textures of the mechanically weak samples can be related to a collapsing pore space of the originally flocculated clay aggregates. This process is insignificant in the strong samples from the prism toe, for which deformation would tend to involve large rock volumes and lead to strain dissipation. The weak samples from the forearc slope which become even weaker with increasing strain may provoke mechanical runaway situations allowing for earthquake rupture, surface breakage and tsunami generation.

Stipp, M., Rolfs, M., Kitamura, Y., Behrmann, J.H., Schumann, K., Schulte-Kortnack, D. and Feeser, V. 2013. G-Cubed 14/11, doi: 10.1002/ggge.20290.