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Synchrotron texture analysis of clay-rich sediments from the Nankai trench and accretionary prism

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Synchrotron diffraction is the most suitable tool for fast multi-mineral phase texture analysis of water-containing clay rich sediment samples due to short wavelengths (in the range of 0.12 Å), high energy radiation and a resulting mm- to cm-scale sample penetration. We carried out synchrotron texture analysis on a sample set from the Nankai trench and accretionary prism offshore Japan. Samples were encountered by IODP Expeditions 315, 316 and 333 of the NanTroSEIZE project from a depth range between 25 mbsf (meters below seafloor) and 522 mbsf. The accretionary prism sediments have a relatively uniform composition of approximately 40% clay minerals, 25% quartz, 25% feldspar, and up to 10% calcite. A first sample set analyzed was taken as recovered from drilling; a second sample set was additionally experimentally deformed in a triaxial deformation apparatus up to axial strains of 60%.

Measurements were carried out at DESY (German Electron Synchrotron source) in Hamburg. In order to measure complete pole figures sample cylinders of 2 cm in diameter and 2 cm in length were measured in a phi angle-range from -90 to +90° in 5° steps. Rietveld refinement results using the MAUD program package show that the composition of the IODP Expedition 333 samples from the incoming plate differs slightly from the relatively uniform IODP Expedition 315 and 316 samples of the accretionary prism. They contain ∼35% clay minerals, ∼30% quartz and ∼35% feldspar. For IODP Expedition 315 and 316 samples the Rietveld refinement results correspond to the standard XRD data. The synchrotron texture results of the recovered samples without experimental deformation show an increasingly strong preferred orientation of the clay minerals with increasing sediment depth for the incoming plate. Interestingly, also feldspar shows a significant texture, which is likely due to a shape fabric of the grains. The sediment texture can be explained by compaction and porosity reduction with increasing depth. Also the original samples from the accretionary prism show a bedding-related texture, but the relation to sediment depth is not so clear. This is probably related to the intense reworking of the accretionary prism sediments by slumping and/or by tectonic deformation, especially in the zone between the frontal thrust and the megasplay fault. The experimentally deformed samples show an increasingly strong texture of the clay minerals with increasing axial strain. While the low strain samples show relict bedding, which rotates towards an orientation perpendicular to the axial shortening direction, no such relict bedding orientation can be observed in the very high strain experiments up to 60% axial shortening.