Natural compaction and experimental deformation derived from magnetic fabrics of clayey sediments from the Nankai and Costa Rica trenches

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Two major endeavors of the International Ocean Discovery Program (IODP), the **Nan**kai **Tro**ugh **Sei**smogenic **Z**one **E**xperiment (NanTroSEIZE) and the **C**osta **Ri**ca **S**eismogenesis **P**roject (CRISP), investigate the processes and controlling factors of deformation and seismogenesis at accretionary and erosive continental margins including the incidence of megathrust earthquakes and tsunamis. A key for the formation of faults in the soft sediments of forearc wedges of subduction zones is the capability for strain localization within these sediments. Natural compaction modifies the deformability of the sediments. This compaction as well as the effects of natural and experimental deformation can be investigated conducting shape- and crystallographic preferred orientation measurements including the analysis of the anisotropy of the magnetic susceptibility (AMS). Such measurements allow to quantify compaction and deformation and to unravel if the investigated sediments tend to deform more locally by strain concentration or, alternatively, by distributed deformation over the entire sample volume. Here, we studied the deformability of soft sediments from the Nankai accretionary margin (NanTroSEIZE Expeditions 315, 316, 333, 338) and the Costa Rica erosive margin (CRISP Expeditions 334 and 344).

Thirty-one IODP samples were selected to investigate the AMS in a low magnetic field of 300 Am-1. The AMS reveals the crystallographic preferred orientation (CPO) of paramagnetic minerals so that magnetic fabrics correlate to bulk CPO analysis. The method is in particular useful to study fabric development of fine-grained sediments, such as the clayey sediments sampled in NanTroSEIZE and CRISP expeditions. We have measured the AMS of 14 original CRISP samples from a depth down to 365 mbsf, 8 original NanTroSEIZE samples from a depth range of 28 to 522 m and 9 NanTroSEIZE samples experimentally deformed to variable strain conditions (Stipp et al., 2013). 15 of the 17 NanTroSEIZE samples used here were previously analyzed by synchrotron texture (=CPO) analysis (Schumann et al., subm). A comparison of the naturally compacted and experimentally deformed samples is used here to evaluate the effect of compaction and triaxial deformation on magnetic fabrics of weakly consolidated sediments.

K_{mean}-values show a large variation ranging from 70 to 3700 x 10^{-6} SI units due to a heterogenous distribution of magnetite, which was identified based on observed Verwey transition and Curie temperature by temperature-dependent measurement of the susceptibility K(T). CRISP samples show lower K_{mean}-values than samples from the Nankai Trough. Experimentally deformed samples show the highest susceptibilies. In the absence of magnetite, magnetic fabrics of the clay-rich samples are controlled by the orientation of paramagnetic sheet silicates. The orientations of the principal susceptibility axes of the ferrimagnetic samples are coaxial with the paramagnetic samples. Naturally compacted Nankai samples predominantly show oblate fabrics. Experimentally deformed samples consistently show oblate magnetic fabrics with T-values > 0.2 and P'-values of up to 1.15. A comparison of the orientations of principal susceptibility axes of natural and experimentally deformed samples nicely document the reorientation of platy sheet silicates into an orientation perpendicular to the axis of shortening and can be interpreted as the formation of a new subhorizontal planar fabric (foliation). In contrast to the Nankai material, samples from the CRISP area show both, oblate and prolate magnetic fabrics. The prolate fabrics occur predominantly at the lower trench slope (U1412) possibly indicating the superposition of two sub-fabrics.

References

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