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The real-scale numerical sandbox experiments for understanding stress state in accretionary prisms

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The sandbox experiment is known as a scaled physical analog model of accretionary prisms. Thus, understanding the stress state inside the sand layer is the interesting challenge of the geology. However, measuring stress states in laboratory sandbox experiments is still practically infeasible. Here we performed real-scale numerical sandbox experiments using the Discrete Element Method (DEM) to understand the 3D stress state in the accretionary prism. The critical bottleneck of DEM was the limited number of particles acceptable for practical computation time and it was difficult to simulate a system with a huge number of particles required by such as our target sandbox test with realistic particle size. We had overcome this issue by developing the dynamic load balancing technique for the DEM codes and run the real-scale numerical sandbox simulation using up to 2.4 billion particles [Furuichi et.al. 2017]. We also performed the large-scale stress chain analysis. One of the interesting findings was that the simulation of the horizontal shortening of the granular layer showed undulated margins similar to those observed in accretionary prism, despite the nearly uniform initial conditions. The 3D stress chain analysis that is practically infeasible for the laboratory experiment studies, revealed that arcuate faults emerge from micro-scale perturbations owing to the formation of the stress arch [Furuichi et.al. 2018]. Furthermore, analyses demonstrate that the in-situ stress orientation from borehole data can be a signal of either the regional direction of plate convergence or the local stress orientation associated with such a stress arch. The results may greatly enhance the outcome of long-term monitoring in areas, such as the Nankai Trough. In this contribution, we also investigated the stress state associated with a seamount (indenter) entering the accretionary prisms. The role of indenter was significant as a frictional heterogeneity to control the tomography (taper angle), material transport and stress chain distribution. Especially, amount of sediment covering the indenter was transported inward without deformation. This mechanism potentially constructs the thick low-velocity zone into the plate boundary, the subduction channel. In this presentation, we discuss the detail mechanism of these observed compressional events inside the sand layers.

[Furuichi et.al. 2017] M. Furuichi, D. Nishiura, Comput. Phys. Comm. (2017) DOI:10.1016/j.cpc.2017.05.015
[Furuichi et.al. 2018] M. Furuichi, D. Nishiura, O. Kuwano, A. Bauville, T. Hori, H. Sakaguchi, Scientific Reports (2018), DOI:10.1038/s41598-018-26534-x