Press Releases

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JAMSTEC

Real-scale numerical sandbox experiments suggest arcuate stress structure in accretionary prisms

Direct numerical simulations of sandbox experiments suggest the existence of arcuate stress structures that control the formation of deformation structures in sand and possibly in accretionary prisms, according to a study led by Dr. Furuichi at the Department of Mathematical Science and Advanced Technology, the Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) and his colleagues.

The stress states in accretionary prisms are important for understanding the building and releasing of seismic energy as they control the generation of great earthquakes and tsunami. To understand the formation of accretionary prisms, researchers have carried out sandbox experiments as a scaled physical analog model and compared the stress state obtained from the experiments with borehole data. However, it is still technically difficult to accurately grasp the stress state inside the granular layer.

In this study, scientists have performed large-scale simulation for the discrete element method (DEM) for real-scale numerical sandbox experiments using up to 1.9 billion particles with similar sizes of a grain of sands for identifying the three dimensional stress state. The DEM simulations have presented macro-scale undulations of faults similar to those observed in the trenches of an accretionary prism despite nearly uniform initial conditions. The formation of stress arches causes these undulations. The mechanism behind the arch formation is the discontinuous change in the stress orientation during the rearrangement of the stress chain. In addition, further analyses have demonstrated 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 the stress arch.

These findings will help analyze the data obtained from long-term monitoring areas including the Nankai Trough.

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Title: Arcuate stress state in accretionary prisms from real-scale numerical sandbox experiments
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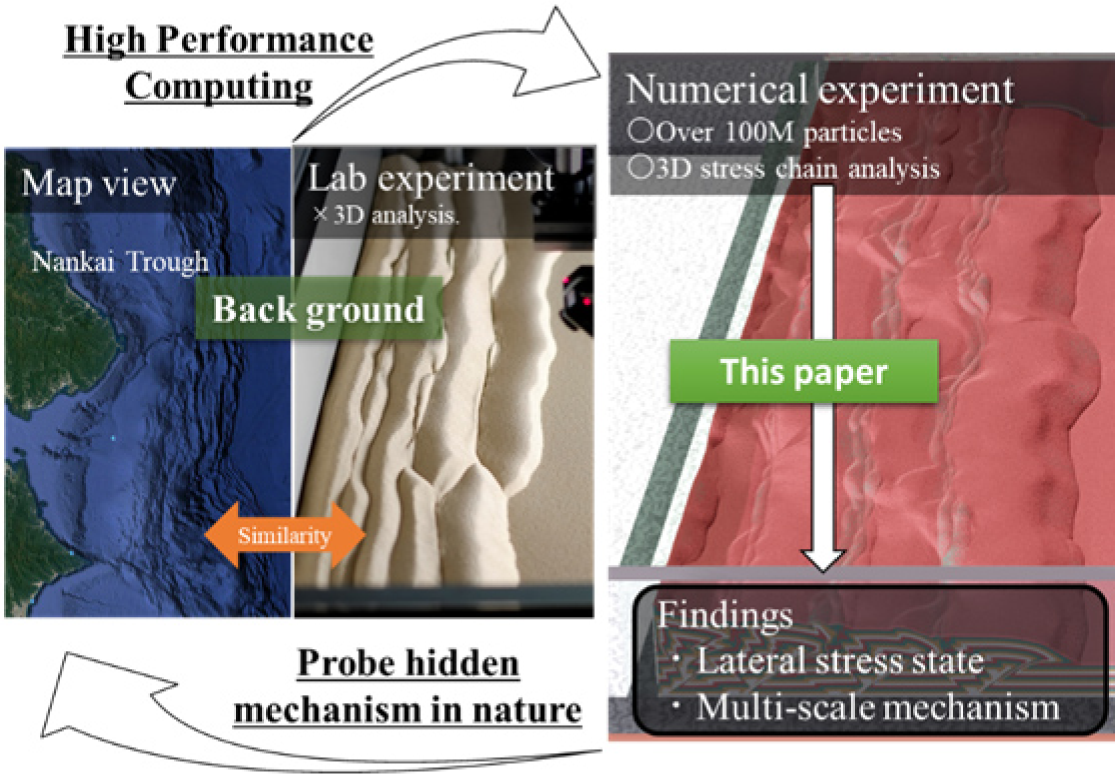

Figure 1. Schematic figure of this study

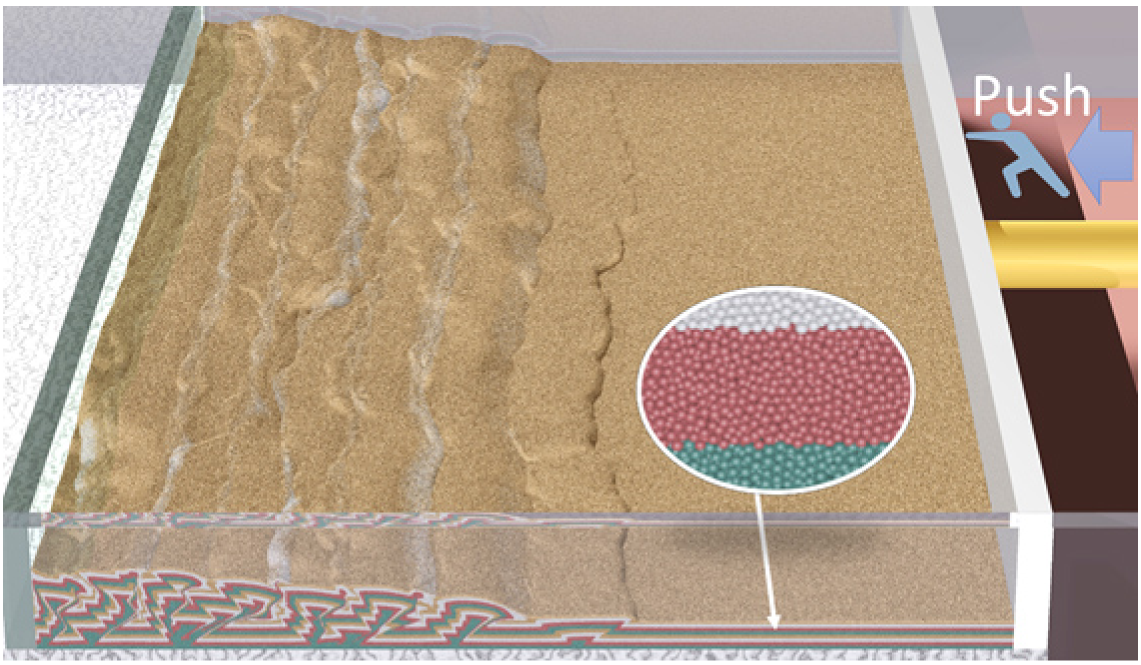

Figure 2. Result of sandbox simulation with 1.9 billion particles.
When pushed against the backstop, the sand layer deforms into pop-up structures with new frontal thrusts forming sequentially to generate the similar geometries seen in accretionary prism.

<Reference video>
Simulation using 2.4 billion particles : https://www.youtube.com/watch?v=yQLbUsZAJbc

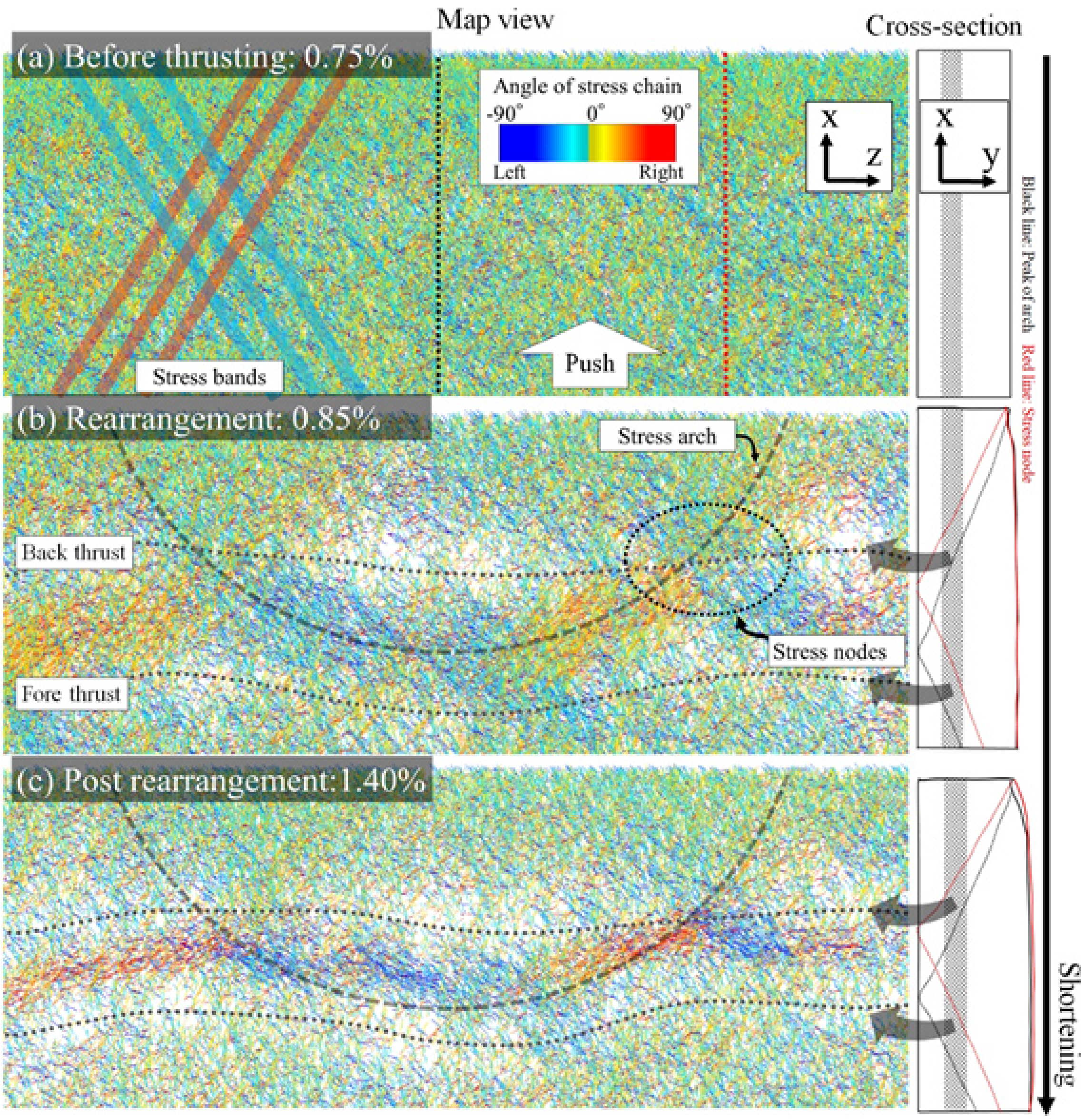

Figure 3. Evolution of the stress chains during the first thrust formation. The degree of the shortening is (a) before thrusting, and (b) and (c) after thrusting. In the left figure, map views of the most compressive principal stress vector in the stress chain in the thin layer are shown. The colors denote the angle of the vector from the x-axis in the horizontal plane. The position of the thin layer and cross-sectional views of the thrust are also shown at the righthand side of the map view. The thin layers and thrusts in the map are denoted by the shaded area and the thick arrows in the cross-sectional view, respectively. The black dash lines guide the geometry of stress arch.

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