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Seismic Imaging of Sandbox Models

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Analog sandbox simulations have been applied to study structural geological processes to provide qualitative and quantitative insights into the evolution of mountain belts and basins. These sandbox simulations provide either two-dimensional and dynamic or pseudo-three-dimensional and static information. To extend the dynamic simulations to three dimensions, we combine the analog sandbox simulation techniques with seismic physical modeling of these sandbox models. The long-term objective of this approach is to image seismic and seismological events of static and actively deforming 3D analog models. To achieve this objective, a small-scale seismic apparatus, composed of a water tank, a PC control unit including piezo-electric transducers, and a positioning system, was built for laboratory use. For the models, we use granular material such as sand and glass beads, so that the simulations can evolve dynamically. The granular models are required to be completely water saturated so that the sources and receivers are directly and well coupled to the propagating medium. Ultrasonic source frequencies ($\sim$500 kHz) corresponding to wavelengths $\sim$5 times the grain diameter are necessary to be able to resolve small scale structures.

In three experiments of different two-layer models, we show that (1) interfaces of layers of granular materials can be resolved depending on the interface preparation more than on the material itself. Secondly, we show that the dilation between the sand grains caused by a string that has been pulled through the grains, simulating a shear zone, causes a reflection that can be detected in the seismic data. In the third model, we perform a seismic reflection survey across a model that contains both the prepared interface and a shear zone, and apply 2D-seismic reflection processing to improve the resolution. Especially for more complex models, the clarity and penetration depth need to be improved to study the evolution of geological structures in dynamic models with this method. However, these experiments show, that seismic imaging of shallow sandbox models, that are structurally evolving, is feasible.