Effects of layer strength on shear band style in sandbox accretionary wedges

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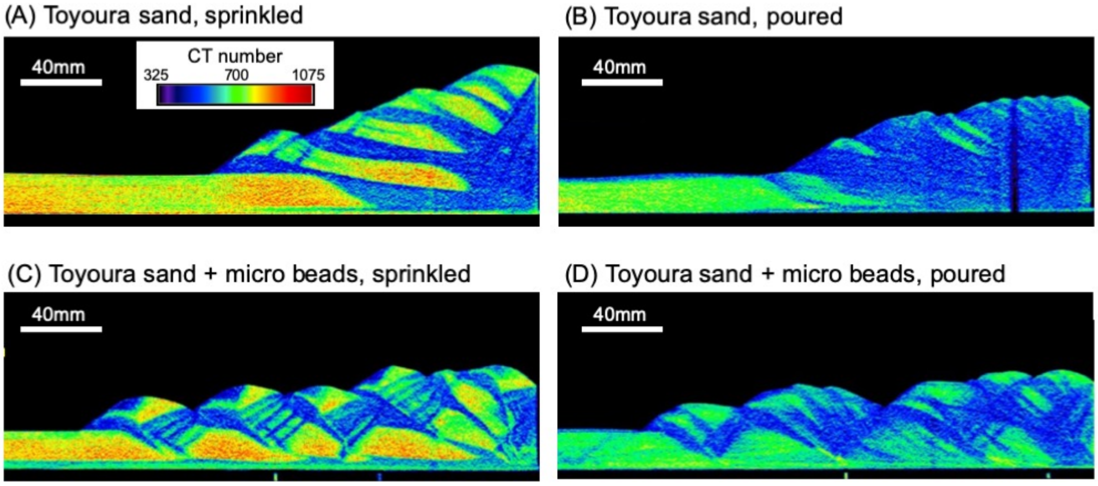
Accretionary wedges formed at plate subduction zones are characterized by the formation of multiple shear bands. These shear bands control the deformation styles of the wedge and its internal fluid flow, thus the mechanism of shear band formation has vital importance. Some previous investigations by sandbox modeling reported typical wedge shapes and shear band patterns. In this study, we examined the effects of layer strength of the wedge by using different sand filling methods and/or different sand material that may produce variations in the deformation style.
Our accretionary wedges are made by dry sand (ca. 18 mm thickness) in an acrylic box (118 mm x 693 mm x 158 mm) with a basal sheet, that can be pulled out of the box to deform the sand layers. The horizontal displacement of the sheet was 250 mm, that displaced the sand against the fixed wall to deform. We have tested four different initial states of the sand layers; (A) a single layer of sprinkled sand, (B) a single layer of poured sand, (C) two layers consist of basal microbeads (sprinkled) and a sprinkled sand, and (D) two layers consist of basal microbeads (sprinkled) and a poured sand. The deformation in each experiment was recorded by sequential photographs. Some experiments were scanned with X-ray Computed Tomography (XCT) and/or were measured the pulling forces using a load cell.
The results show that, the angle of the accretionary wedges had the largest in the experiment A and decreases in the order of the experiment B, C and D. The shear band spacing of the experiment B is narrower than that of the experiment A. It is probably due to the weak strain softening of the poured sand layer. In the experiment C and D, the back thrusts are developed clearly, and the basal microbeads layer displaced as a décollement. Décollement propagation in the sprinkled sand layer occurs intermittently shortly before the formation of a new shear band (frontal thrust), while décollement in the basal microbeads layer begins well prior to the formation of a new frontal thrust. These results show that the strength characteristics of the input layer affect the shear band spacing and the décollement propagation style in the accretionary wedges.
Structural differences similar to those observed in the experiments are also observed in natural accretionary wedges that develop in the current subduction zones, such as Cascadia, Nankai Trough, and Barbados. Comparing the logging data and the seismic reflection data of the natural wedges, there are differences in the density structure and the presence or absence of proto-décollement in the input layers. This suggests that the strength characteristics of the input layers may also affect the deformation style in the natural wedges.

Keywords: accretionary wedge, subduction zone, décollement, analogue modeling, X-ray computed tomography


(A) Toyoura sand, sprinkled
40mm
CT number
325
700
1075
(B) Toyoura sand, poured
40mm
(C) Toyoura sand + micro beads, sprinkled
40mm
(D) Toyoura sand + micro beads, poured
40mm

