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Fault formation and stress change in the frontal zone of an accretionary wedge: Insight from numerical simulation

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We studied a relation between a fault formation and a stress change in the frontal zone of an accretionary wedge using numerical simulation. We modeled a formation process of an accretionary wedge by using the Distinct-Element method. We observed the fault activities and measured dynamic stress state in the numerical model.

Frontal thrusts were formed in the sediments in front of the wedge, and the displacements of the active frontal thrusts were large. On the other hand, intermittent reactivations with small displacement of the existing faults were observed in the wedge, though the new faults were not formed in the inside of the wedge.

Relatively isotropic and vertical compressional stress state was observed in the sediment far from the toe of the wedge. However, as coming closer to the toe of the wedge, the stress state change into anisotropic, and high and horizontal compressional stress is observed in front of the wedge. After the sediments were incorporated into the wedge, the direction of the maximum compressional stress inclined to trench ward and the stress state was changed into isotropic. The compressional stress was recovered to the horizontal as the wedge growth, but the increase of principal stress ratios was still small.

The relation between fault activity and stress change is summarized based on these results. Frontal thrusts were formed by the dominant horizontal compressional stress, which is caused by the plate subduction, in front of the wedge. The activities of the frontal thrusts release the stress, and the stress state is changed into isotropic. The frontal thrust is not able to be active under this isotropic stress state, and new frontal thrust is formed within the sediments under the anisotropic stress state in front of the wedge. On the other hand, horizontal compressional stress is increased again by the stop of the fault activity in the inside of the wedge. The existing faults are reactivated in the increasing horizontal state and release the stress by their activities before a formation of a new fault. To form new faults (out-of-sequence thrusts) within the wedge, particular mechanisms are necessary that existing faults are to be inactive and that an anisotropic stress state is to be generated.