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Deformation of a thick sedimentary layer caused by dip-slip motions of the faults reaching to an interior of the layer

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We employed the software Particle Flow Code in 2D (PFC 2D) based on discrete element modeling and attempted to simulate deformations of a thick sedimentary layer caused by dip-slip fault motions. In this study, we discussed (1) effects of which the dip-slip motions of the faults reaching from the basement to an interior of sedimentary layer deform an interior and surface of the layer, and (2) effects of frictional coefficient between the fault plane and the particles.

The 2D discrete element modeling represents an arbitrary medium by an aggregate of rigid disks and its elasticity is described by connecting each disk by elastic springs. Young's modulus and Poisson's ratio are decided by spring constants in a computer. In 2D analysis, magnitudes of spring constants and contact bonds are set by the biaxial compression test. In this study, because we evaluate behaviors of soft sedimentary layers, we assumed Young's modulus of 207 MPa, Poisson's ratio of 0.24 and the compressive strength of 13 MPa. In order to represent these elastic constants and strength, we set each spring constant (normal direction and shear direction) of 500 MN/m, frictional coefficient of 0.6, the contact bond of 1 MN.

In the simulations, the sedimentary layer modeled with depth of 900 m and width of 5000 m was assumed and the basement under the layer is the rigid body. We moved the basement to vertical direction till depth of 600m from the surface. We considered the cases that the fault will reach to the depth of 810m, 720m, 530m, 450m, 180m and 0m from the surface, in the simulations. And, we assumed 0.6 and 0.06 as the frictional coefficient between the fault plane and the particles in each case.

As a result, it was found that the depth of tip of the fault affected the geometry of sedimentary layer and the deformation zone at the surface. If the fault tip reaches to thickness (450 m) of 50 % of the sedimentary layer from the basement rock, the fault motion made the interior deformation field that is different from the field caused by the motion of the fault without its extension to the layer. If the fault tip reaches to thickness more than 80 % of the sedimentary layer from the basement rock, the fault motion made the interior and surface deformation field that are different from the field caused by the motion of the fault without its extension to the layer. And, the difference of the frictional coefficient between the fault plane and the particles also affected the geometry of sedimentary layer and the deformation zone at the surface. If the fractional coefficient is large, it was found the structures of which the sedimentary layers around the fault were dragged toward the directions of the fault motions. If the fractional coefficient is small, it was not found the structures mentioned above. These characteristic structure described here appeared only under the condition of which the fault tip reaches to thickness more than 50 % of the sedimentary layer from the basement rock. If the fault tip reaches to thickness less than 50 % of the sedimentary layer from the basement rock, these structures did not appear in the sedimentary layer simulated.

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Keywords: Numerical simulation, Discrete element method, PFC 2D, Fault reaching to an interior of sedimentary layer, Fault motion