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Numerical simulation to investigate the influence of a viscous layer on the mechanics and kinematics of accretionary wedges

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The mechanics and kinematics of an accretionary wedge depend on the physical properties of the incoming, undeformed sediment sequence particularly its basal detachment. This so-called décollement forms in the mechanically weakest layer of the incoming strata. Besides numerous studies which assume a brittle Mohr-Coulomb (MC) rheology for the basal detachment, the décollement could also be generated in the vicinity of viscous salt layers. This phenomenon is expected for the Hellenic subduction zone in the eastern Mediterranean. Here, the detachment of the accretionary wedge – the Mediterranean Ridge – correlates in the inner prism with Mesozoic carbonates whereas in the outer prism relocation into the younger and weaker evaporite horizons of Messinian age can be identified.

Major aim of this study is to identify and quantify influences of an embedded viscous layer on wedge mechanics and localization of the detachment. An extensive parameter sensitivity study varying the viscosity of this layer enables to investigate how this parameter controls (I) wedge geometry, (II) accretion mode, (III) fault geometry, (IV) mass transport pattern and (V) the location of the detachment.

For this study we developed a 2D numerical 'sandbox' model utilizing the Discrete Element Method (DEM) to simulate the evolution and deformation behaviour of accretionary wedges. Starting from a simple pure MC incoming sequence we embedded a viscous layer in the brittle undeformed incoming 'sediments' which follows the Burger′s rheology to model the creep behaviour of natural rocks such as evaporites. Subsequently, we tested different viscosity values to quantify the influence on wedge kinematics. As a result, we found a certain range of viscosities where an active down-stepping detachment evolved within the viscous layer, which completely decouples the over- and the underlying brittle strata. In addition, the influence of this new 'mid-level' detachment on fault and wedge geometry is strongly connected to the viscosity value. With increasing viscosity values an approximation to salt tectonics can be observed induced by a more symmetrical fault system developed on top of the mid-level detachment. Coevally, this increase favours antiformal stacking over hinterland dipping duplex growth underneath the 'mid-level' detachment.