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Salt flow during basement extension and differential loading simulated in analogue and numerical models

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In many geological situations involving salt tectonics, rock salt can be considered as a pressurized fluid between brittle basement rocks and brittle cover sediments. Within this system, salt flows in response to hydraulic pressure gradients due to differences in elevation or differential loading, which can be induced e.g. by sedimentary thickness changes.

Salt tectonics have been intensively studied in analogue experiments and increasingly in numerical models. Nevertheless, a combination of both methods to investigate specific processes is relatively rare. We used analogue experiments and numerical modelling in order to examine the early evolution of salt structures in intra-continental basins. In particular, our study focuses on salt deformation due to extensional basement faulting (thick-skinned extension).

In our study, both model procedures have similar model set-ups involving a rigid basement overlain by a ductile layer (representing salt) and brittle layer (representing cover sediments). Deformation is driven by displacement of a normal fault in the rigid basement and continuous addition of syn-kinematic sediment. The analogue experiments use silicone putty, which possesses a nearly Newtonian viscous rheology, to simulate salt and granular sand with frictional plastic material behaviour to simulate cover sediments. To observe strain patterns during experiment evolution, a modern monitoring tool PIV (particle imaging velocimetry) was applied. The 2D plane-strain numerical modelling study was conducted with finite element software ABAQUS/Standard. In a first series of experiments, dimensions and material parameters in the numerical models are chosen similar to those in the analogue experiments in order to validate experimental results. In a second series, numerical simulations are adapted to natural conditions. Thus, issues related to model scaling can be identified.

Preliminary experimental results reveal that bulk salt flow reflects an interplay between downward flow driven by differential basement subsidence and upward flow driven by differential loading. Although significant horizontal displacement occurs in the viscous layer even at small off-set of the basement fault, the overburden remains relatively unaffected and solely moves vertically. The overall strain patterns in the materials are similar in analogue experiments and numerical models, which indicates that material behaviour is simulated properly.