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Numerical simulation of ice-load induced salt movements

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A correlation between salt structures, glacigenic features and faulting of Pleistocene deposits above salt structures has been recognised in many places of the formerly glaciated areas in northern central Europe and attributed to ice-sheet loading. Conceptual models predict that the load applied by an ice sheet will favour ice-marginal salt rise and obstruct salt rise beneath the ice sheet (e.g., Liszkowski, 1993). To test these models, we simulated the response of salt structures to ice-sheet loading using a 2D finite-element model (ABAQUS). The subsurface geometries used in our models are based on regional geological cross-sections and 2D seismic profiles of salt structures in the Central European Basin System. The model layers represent (i) sedimentary rocks of elastoplastic rheology, (ii) a viscoelastic salt structure and (iii) elastoplastic basement rocks. At the model surface a temporarily and spatially variable pressure simulates ice-sheet loading. All our simulations show a response of salt structures to ice-sheet loading, which strongly depends on the location of the ice margin relative to the salt structure. Salt structures rise in front of the ice margin (up to 4 m), if load is applied to the salt source layer. Beneath an ice sheet salt structures are pushed down (up to 36 m). Much of the subglacial downwards displacement is compensated by a reversal of the movement during ice retreat. The resulting surface displacements are therefore rather low and depend on the spatial and temporal configuration of the ice load (Lang et al., 2014). Permanent deformation is restricted to the model layers above the salt structure, which either have a low yield stress to represent the unconsolidated infill of secondary rim-synclines or are dissected by steeply dipping crestal graben faults. Ice-induced salt movements will reactivate faults above the crests of salt structures, although the resulting displacements will be low due to the repeated reversals of the sense of movement. The surface displacement due to ice-load induced salt movement will impact the pattern of glacigenic deformation, erosion and deposition. Ice-marginal uplift will provide favourable conditions for push-moraine formation, while subglacial subsidence of salt structures will enhance erosion and contribute to tunnel-valley incision.

References

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