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Pattern formation of down-built salt structures: insights from 3D numerical models

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Many salt diapirs are thought to have formed as a result of down-building, which implies that the top of the diapir remained close to the surface during sediment deposition. This process is largely three-dimensional and in order to better understand what controls the patterns that form as a result of this down-building process, we here perform three-dimensional numerical models and compare the results with analytical models. In our models, we vary several parameters such as initial salt thickness, sedimentation rate, salt viscosity, salt-sediment viscosity contrast as well as the density of sediments. Down-building of three-dimensional diapirs only occurs for a certain range of parameters and is favored by lower sediment/salt viscosity contrasts and sedimentation rates in agreement with analytical predictions and findings from previous 2D models. However, the models show that the sedimentation rate has an additional effect on the formation and evolution of three-dimensional diapir patterns. At low sedimentation rates, salt ridges that form during early model stages remain preserved at later stages as well. For higher sedimentation rates, the initial salt ridges break up and form finger-like diapirs at the junction of salt ridges, which results in different salt exposure patterns at the surface. Once the initial pattern of diapirs is formed, higher sedimentation rate can also result in covered diapirs if the diapir extrusion velocity is insufficiently large. We quantify the effect of sedimentation rate on the number of diapirs exposed at the surface as well as on their spacing. In some cases, this final pattern is distinctly different from the initial polygonal pattern. We also study the extrusion of salt through time in the simulations, and show that it can be related to the geometries of the sedimentary layers surrounding the diapirs.

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