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Numerical models of diapiric structures: comparison of the 2D finite deformation field between Rayleigh-Taylor like and down-built like diapirs

Lukas Fuchs, Harro Schmeling, and Hemin Koyi
Uppsala University, Earth Sciences, Uppsala, Sweden (lukas.fuchs@geo.uu.se)

Magmatic and salt diapirs are common structures in different tectonic regimes. Salt diapirs can act as possible hydrocarbon traps and, moreover, they could be used as repositories for nuclear waste disposal. Understanding the evolution and the dynamics of diapirs as well as their driving mechanisms has fundamental and applied significance. In general, salt diapirs seem to be driven by differential loading of sediments creating an uneven load that drives the salt from high to low pressure areas, e.g. a down-built diapir. Magmatic diapirs, instead, seem to be driven by buoyancy where lighter material rises vertically through a heavier overburden, i.e. a classical Rayleigh-Taylor instability [RTI]. These different driving mechanisms and dynamics strongly govern the internal deformation of the diapirs.

In this study, we use a two-dimensional finite difference code (FDCON) in combination with a marker and cell method to calculate the finite deformation within diapiric structures. Thereby, we distinguish between the two different driving mechanisms, i.e. the differential loading and the buoyancy. We calculate the different finite deformation patterns during the evolution of RTI's and down-built diapirs for different viscosity ratios $m = \frac{\eta_{buoyant}}{\eta_{overburden}}$. The deformation pattern in the buoyant layer shows similarities for both diapiric structures, like high shear deformation at the bottom, a high finite deformation within the middle of the stem, and an increasing maximum finite deformation for a decreasing m. However, the strain partitioning between the overburden and the source layer is different within down-built diapirs compared to the RTI's, even for down-built diapirs with $m = 1$. Thus a higher amount of the total strain induced by down-building is concentrated within the buoyant layer. Moreover, in the case of viscosity ratios of $m = 0.1$ or 1 the sinking overburden units create an internal rotation within the diapiric bulb. This rotation depends indirectly on the sedimentation rate as it determines the width of the sediment basin; the higher the sedimentation rate, the wider the basins and the weaker the internal rotation. In addition, the viscous drag between the sinking overburden and the rising diapir creates a stronger and wider band of finite deformation along the edges of the down-built diapir in comparison to the RTI.