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Controls of the Geometry and Evolution of Salt Diapirs in Experimental Models and Natural Examples

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ABSTRACT

The geometry and evolution of salt diapirs are dependent primarily on the rates of sedimentation (Ra) and salt flow (Rsg). Experimental models were conducted to study the controls of sediment load, sedimentation rate, and thickness of the source layer on the geometry and evolution of diapirs. The experiments used both constant and variable sedimentation rates, and different thicknesses of silicone gel, representing salt. Constant sedimentation rate experiments show that larger loads, lower rates of sedimentation and thicker source layers result in higher Rsg to Ra ratios leading to cylindrical diapirs, which eventually develop flared shapes with overhangs, whereas smaller loads, higher sedimentation rates and thinner source layers result in lower Rsg to Ra ratios leading to tapered shapes and eventual eclipse and occlusion of the diapirs. Variable sedimentation rates result in changing shapes of diapirs over time. A small increase in sedimentation rates for flared or cylindrical diapirs result in an initial eclipse followed by tapering and a transition to active diapirism, enabling the diapir to pierce the overlying sediments and continue to grow by passive diapirism. A large increase in sedimentation rates result in a permanent eclipse, because the tapered diapir is unable to penetrate the larger thickness of the overburden.

The models suggest that tapering and flaring are mechanisms for maintaining an equilibrium between net rates of sedimentation (Ra) and salt rise (Rsn), with changing Rsg/Ra values. Flaring is caused by high Rsg/Ra, but is also an effective mechanism of decreasing the rate of net salt rise by increasing the surface area of the top of the diapir. Tapering is caused by low Rsg/Ra, but is also a mechanism for increasing the rate of salt rise by decreasing the diameter. The results of the experimental models can be used to understand the geometry and evolution of natural diapirs. The models are directly applicable to analyzing the geometry and evolution of poorly or partially imaged salt diapirs in salt basins.

In the East Texas Basin, diapirs located on the basin flanks, such as the Bethel and Oakwood domes are characterized by small diameters and salt volumes, likely related to a relatively thin source layer. They exhibit cylindrical to flared geometries followed by rapid tapering and flattening of the top of the diapir due to increased sedimentation rates. On the other hand, diapirs located along the central basin axis such as the Butlerand Stein domes are characterized by larger diameters and salt volumes, because of a thicker source layer. They exhibit early cylindrical to flared patterns, but also show earlier tapering of the top, suggesting the effects of a depleted source layer, during the later stages of their evolution.