A Methodology for Incorporating Dynamic Salt Evolution in 3-D Basin Simulation Models: Application to Regional Modeling of the Gulf of Mexico

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Construction of 3D basin models in areas of detached salt tectonics poses difficult challenges, but is necessary in order to simulate the 3D thermal effects of salt and to correctly model sub-salt burial histories. Over much of the offshore northern Gulf of Mexico basin, a regional salt canopy detaches shallow structures, formed by growth and subsequent collapse of allochthonous salt sheets, from sub-salt structures formed largely in response to movement of the deep ("autochthonous") salt. Dynamic simulation modeling of this system requires (1) understanding the evolution of salt distribution and thickness through time, (2) a methodology for incorporating thickness changes within the simulation model, and (3) geometric solutions to account for the fact that allochthonous salt occurs at various stratigraphic levels across the basin.

A number of regionally mapped horizons, including top and base of allochthonous salt and a composite weld representing areas of collapsed salt canopy, were used to build a regional Gulf of Mexico simulation model. Salt isopach maps for sequential stages of the basin evolution were derived by vertical back-stripping using "regionals" constructed to approximate the pre-deformation geometry of selected horizons. For a given horizon, the salt thickness change since horizon deposition is represented by the difference between a mapped horizon and its regional. Simple rules were applied to partition the derived salt thicknesses between the allochthonous and autochthonous salt levels. In order to model the climb of the salt canopy across stratigraphy, the basin model was divided into sub-salt and supra-salt portions containing horizons of equivalent age and separated by an intervening allochthonous salt layer. Thickness of both the allochthonous and autochthonous salt layers were altered through time using the salt isopachs.

The resulting simulation model reasonably represents the large-scale structural evolution of the northern Gulf of Mexico basin, including (1) progressive southward displacement and evacuation of salt along the Louann level, (2) basinward stratigraphic climb and progressive welding of salt within the canopy, (3) seaward progradation of depositional systems throughout the Mesozoic and Cenozoic, and (4) Miocene uplift and erosion of the onshore portion of the basin. The methodology outlined here can be adapted to assist in building basin models in other structurally complex basins.