

Using Geomechanical Forward Modeling to Define Trap Formation and Trap Timing in a Layered Evaporite Sequence, Red Sea, Saudi Arabia

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ABSTRACT

Throughout the Red Sea, the Mansiya Fm. layered evaporite sequence (LES) was deposited in a restricted marine setting as a sequence of intercalated halite, anhydrite and clastic sediments. Subsequent rapid deposition of the Ghawwas and Lisan Formations as well as tectonic uplift, crustal subsidence and rotation mobilized the halite within the Mansiya Fm. This tectonic-sediment driven halokinesis resulted in a linked system of salt tectonics involving; down slope translation, raft tectonics, diapirism and allochthonous structures and the formation of large post and intra salt structures including four way anticlinal closures. A 2D geomechanical model was constructed across one of these structures incorporating a viscoplastic rheology for salt and a cap-plasticity-based rheology to model compaction and dilational failure in sediments. Gravity, sediment and thermal loading are imposed on the halite and sediment layers and the impact of competition among these on the structural style is systematically investigated. Results of the model suggest that the initiation of halokinesis is strongly dependent on the proportion of halite within the LES sequence, salt viscosity and timing of sediment loading. The relatively uniform deposition of the LES and low temperature during deposition resulted in only minor salt withdrawal, minor deformation of the sediments within the LES and no trap formation. Subsequently, the rapid deposition of the Ghawwas and Lisan Formations simultaneously created a large gravitational load on the updip end of the LES system and elevated the temperature above the critical temperature where halite becomes highly mobile. As a result of these two factors, rapid salt withdrawal and downslope translations of the LES took place, creating an anticlinal structure, similar to a turtle structure, during the past 2 million years. Clastic sediments within the LES deformed contemporaneously with halokinesis to produce large intra-salt traps. The results of the structural model illustrates how geomechanical models can be used to investigate the evolution of salt related structures where many separate geological and physical criteria need to be considered. Expansion of the geomechanical models to other areas in the Red Sea is indicating that the physical system and resulting structure - trap formation can have dramatically different trap timing and stress-strain histories which must be taken into account when risking oil and gas traps for intra-salt plays.