

Salt Movement and Associated Salt Structures in the Red Sea

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Abstract

Understanding the salt structural framework, composition and migration is critical in defining the petroleum systems in the Red Sea. Salt plays a major role in creating structures, faults and traps that create reservoir porosity/permeability compartments, initiates reservoir reef growth and helps to migrate hydrocarbons throughout the sedimentary system. Heat flow, which determines the oil and gas generation windows, is also controlled by the presence of salt due to its ability to transmit heat from more mature to less mature source rock. In the studied area (rift basin with rift initiation: Oligo-Miocene), salt was deposited when the Middle Miocene pre-salt layers (late rift or sag sequence) changed from open to restricted conditions and transitioned upwards to a mostly evaporitic sequence (ca. 14 to 11.5 Ma), with maximum salt thickness reaching up to 2-3 km. A structural/stratigraphic analysis was carried out using the regional 2D seismic dataset accompanied by high-resolution bathymetry data. Salt mobilization and emplacement was observed across the Red Sea. Salt extrusion and salt flow in the form of submarine salt glaciers were mapped at or near the sea floor. Salt movement may have initiated soon after its deposition and accelerated during and after the deposition of post-salt layers (~ 5 Ma). The basinward salt movement along the rift margins and ongoing rifting processes have triggered an array of reactive and passive salt structures that include salt rollers, diapirs, stocks and extensive salt walls with associated minibasins. Allochthonous salt tongues and discontinuous/coalesced salt canopies are also observed. Coalesced salt canopies completely surrounding or tilting the minibasin were also observed in some areas, suggesting an active translation of salt overburden. A regionally extensive detachment surface just above the Middle Miocene pre-salt layers controls the down slope movement of the salt. The slope of the Middle Miocene pre-salt detachment surface varies between 2 to 8 degrees for the most part of the Red Sea margins. Locally where the slope is low (2-3 degrees), polygonal faulting was observed on the bathymetry where polygonal faults are formed by shallow salt ridges surrounding the minibasins. The top of the salt map revealed four distinct trends of kilometer-scale long salt walls and canopies along the length of the Red Sea. In each trend, the strike of the salt walls are parallel or sub-parallel to the coast line, suggesting the direction of the sedimentary loading and salt sliding is at a high angle to the main strike of the developing rift margins. An initial salt volume estimate for the Red Sea basin, excluding the Gulf of Suez and the southern part of the Red Sea (Yemen and Ethiopia), is approximately 290,000 km³. This suggests that 1 to 2 kms of accommodation space was created in the basin during the time of salt deposition.