Impact of Salt Tectonics on the Maturation of Pre-Salt Source Rocks: Case Studies From Onshore and Offshore Yemen

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ABSTRACT

Evolving salt diapirs can modify significantly the thermal regime around them, as shown by numerous numerical modelling studies in the last two decades. The thermal anomalies then can modify the maturation of source rocks in the vicinity of the salt features. In particular, when a salt diapir reaches the surface, a monopole-shaped temperature steady-state anomaly develops. Beneath the salt structure, all sediments, regardless of their lithology, are colder compared to a sedimentary section with no salt at all. The salt-related negative thermal anomalies were shown to extend to considerable depth (i.e. a few kilometers) beneath the base of a salt diapir. The temperature anomaly may reach values of -85°C locally. Salt diapirs connected to their source dissipate heat more efficiently and thus keep deeper regions of the basin relatively colder and potentially within the oil window for a longer time. The cooling effect is maximized when the top of the salt diapir remains at or very close to the surface for a significant period of time. To test the impact of the cooling effect, two areas were selected in Yemen. In the onshore study area in the Sab'atayn basin, the Milh Kharwah salt diapir was studied, as the Upper Jurassic salt here could have reached the surface as early as the latest Cretaceous. If correct, then the cooling of the pre-salt petroleum kitchen would have been effective for the last 70 Ma. Alternatively, if the diapir was exposed only during the Pliocene, then the cooling effect would have had only a 5 Ma time span. Basin modelling presented in this studyshows that these scenarios could make a big difference to the hydrocarbon phase in the present-day pre-salt trap, i.e. whether it is a light oil, condensate or gas. In the Yemeni offshore example, the impact of the large Miocene salt massifs was modelled. Historically, pre-salt exploration was considered very risky due to the very high heat flow related to the opening Red Sea oceanic domain. However, the interpreted shape and temporal evolution of the salt structures offshore do have a major influence on the expected hydrocarbon phase beneath the salt. Basin modelling results highlight another important and many times underappreciated aspect of salt tectonics in a petroleum basin, other than just providing traps and seals.