Quantifying the Effects of Salt Structures on Source Rocks Thermal Evolution of the Marine Sedimentary Basins

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Evaporitic salt is prevailed in marine sedimentary basins, and the discovered hydrocarbon reservoirs are generally associated with salt structures in the world; accordingly salt structures have attracted much attention from academic and industry during the past decade. Tarim Basin that locates in northwest China, is the largest marine sedimentary basin in China with great hydrocarbon resources potential. Previous studies of salt structures in this basin mainly focus on its strong sealing capacity and structural traps created by salt structures. However, besides its extreme impermeability and low viscosity, rock salt has another unique thermal properties, featured by a large thermal conductivity as high as 5~6 W/(m.K), usually 2~3 times greater than that of other common sedimentary rocks, but a relatively low radiogenic heat production. This strong contrast in thermal properties could change the evolving thermal regime and associated thermal history of the source rocks around salt bodies, but has not been understood well. Herein based on the theoretical models and interpreted salt bearing seismic profiles from the Kuqa Foreland Basin, northern Tarim Basin, we use the 2D finite element numerical experiments to investigate the impacts of salt structures on basin geothermal regime and associated hydrocarbon thermal evolution. Our results show that, owing to its high efficiency in heat conduction, the salt rocks would result in obviously positive temperature anomalies (3~13%) above the salt body and negative temperature anomalies (11~35%) in the subsalt, enhancing and restraining the thermal maturation of source rocks above and below the salt body, respectively. The amplitude and extent of geothermal effects of salt structures depend on the thermal conductivity, geometry, thickness and burial depth of the salt bodies. The thermally affected area around the salt body can be 2 time of salt radius laterally and 2~3 times of salt thickness vertically. Salt structures in the Kuqa Foreland Basin can prominently cool the subsalt formation temperature and accordingly reduce the thermal maturity (Ro) of Jurassic source rocks as much as 18%, enabling the source rocks to be still of gas generation other than over-mature stage as expected previously, which is favor for deep hydrocarbon preservation below salt. In particular, salt structures in the west and east Kuqa Foreland Basin show strong differences in their thickness, geometric pattern, burial depth and composition, the thermal effects of salt structures on thermal maturation of subsalt source rocks should differ accordingly, which is supported by the observed tempo-spatial variation of Ro for Jurassic source rocks in this basin. Finally, we propose that the geothermal effects of salt structures will be of great importance in the deep hydrocarbon resources potential assessment and exploration in marine sedimentary basins in China.