SALT DYNAMICS: SIMULATION OF MUSHROOM CAPS ON SALT AND AN APPLICATION IN BARENTS SEA, NORWAY

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ABSTRACT

The economic significance of salt structures and related effects in sedimentary basins have given rise to an extensive literature. Three major properties of salt play a dominant role in sedimentary basins development. (1) On a geologic time scale salt flows as a nearly incompressible fluid under applied stress, thereby both distorting sedimentary patterns and influencing further basin evolution; (2) Salt has a density intermediate between sediment densities at deposition and fully compacted sediments. Thus at some point in a basin's evolution, salt will become buoyant and will attempt to rise up through the overlying formations; (3) Salt has a thermal conductivity approximately three times greater than that of "typical" sedimentary formations, so salt bodies act as conduits for heat transport from deeper depth, producing local thermal effects and impacting in the vicinity of the salt on chemical precipitation and dissolution, hydrocarbon maturity, and fluid flow.

Various shapes of moving salt were simulated in response to gravity contrast and tectonic movement, and the deformations and fractures of the surrounding sediments examined. The varying parameters in the model include the burial depth of the salt base, the overhang depth of the salt cap, the salt body's size, the salt speed of motion, and the sediment depositional rate. Variation of the surrounding rock properties with depth, such as Lame constants, shearing strength, and internal friction, were also considered. Mohr's criterion for failure was applied, allowing an indication of where fractures occur and their orientations.

Including the thermal effects of salt in the models yields features favorable to hydrocarbon accumulation: (1) Fractures generated near the vertical salt body and below the mushroom cap salt provide a continuous pathway for hydrocarbon migration due to the enhancement of permeability; (2) The overhanging-cap salt-sheet provides a good trapping mechanism by formation of seals; (3) The thermal effect of salt enhances the maturity of the source rocks; and (4) The observed faulting behavior around the salt body is accounted for by primary and secondary fracture development as exhibited through the simulations.

Application of modelling to the study of a salt diapir with mushroom cap on salt in Barents Sea, Norway, shows that the salt would most likely start to rise during the Early-Mid Triassic and Jurassic, when the sediment cover was about 1700-2400 m. Depositional faulting associated with the rise of the salt diapir was generated while the salt dome was moving upward at about 150 ± 50 m/my, which results in different sedimentary rates on the two flanks of salt diapir. The modeling also indicates that at least 1000 m, but likely not more than 1500 m, of the salt cap was eroded, based on the dip angles of sedimentary strata against the salt stock.

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