Sediment Diagenesis in the Gulf of Mexico Basin and its Role in Pore Fluid Pressure Evolution: Implications for Hydrocarbon Transport via Solitary Waves

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ABSTRACT

Rapid, kilometer-scale vertical migration of fluids through low permeability sediments has been documented in numerous sedimentary basins around the world, including the South Eugene Island 330 field in the Gulf of Mexico basin. Solitary waves, which can travel at speeds orders of magnitude greater than Darcian flow, are hypothesized to be a mechanism for rapid transport of fluids from deep overpressured source sediments to shallow reservoirs. Solitary waves occur as regions of high porosity and fluid pressure and may form in oil-saturated sediments when the ratio of fluid pressure generation rate (Pg) to hydraulic diffusivity (D) exceeds about 1.1 ×108 Pa m−2. The main purpose of the present study was to investigate the rate and magnitude of fluid pressure generation from sediment compaction and hydrocarbon formation that can develop in sedimentary basins to assess the likelihood of solitary wave formation. Using the BasinMod2D™ software, a two-dimensional numerical model was constructed that calculated pore fluid pressure generation as a result of sediment deposition, burial, quartz cementation, and compaction, heat transport, kerogen maturation to form hydrocarbons, and associated flow of oil, gas, and water.

Results showed that sediment diagenesis in a hydrocarbon forming sedimentary basin could generate pore fluid pressures at rates of 1's up to a maximum of 510 Pa year−1. Solitary waves that are capable of transporting oil could form at depths greater than 4 kilometers from kerogen-rich source rocks. However, the high hydraulic diffusivity of methane-saturated sediments would likely require high pressure generation rates of at least 2000 Pa year−1 in order to form solitary waves capable of transporting methane, which is unlikely to be achieved by hydrocarbon formation and sediment compaction but might be achieved by earthquakes.