Controls of mud diapirism on gas hydrate systems in the Lower Fangliao Basin, offshore southwest Taiwan

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The accretionary wedge of the incipient arc-continent zone of Taiwan has been identified rich in gas hydrates as inferred from reflection seismic data. We employed 2D and 3D seismic data to understand the interplay of structural development, especially mud diapirism, and gas hydrate formation in the Lower Fangliao Basin, a slope basin situated in the upper accretionary wedge. Seismic reflection data show mud tectonics exerts controls on the formation of bottom-simulating reflectors (BSRs) and the distribution of gas hydrates. Mud diapirs can be recognized on seismic profile in terms of acoustically transparent piercement structures. The formation of mud diapirs in the study area is ascribed to overpressured sedimentary layers, compressional tectonic forces, and gas-bearing fluids. The sedimentary strata on both sides of a mud diapir exhibit dragging and onlapping features due to uplifting of the diapir. Both normal strata and growth strata are discernable, suggesting the dynamics of mud diapiric development through time.
The interplay of mud diapirism, sediment dispersal, and regional convergent tectonics to the gas hydrate system is echoed from seismic facies in the study area. Five seismic facies have been observed, including uneven-truncated, stratified-parallel, chaotic-transparent, strong-parallel-reflection, reflection-free facies and are deciphered as seafloor/erosional surface, hemipelagic sediments, mass transport deposits (MTDs), sandy turbidite sediments, and mud diapirs, respectively. The gas hydrate and free-gas zonation within gas hydrate stability zone (GHSZ) is characterized by (1) high amplitude reflections with the analogous phase of seafloor indicating possible porous turbidite sands reservoir; (2) BSRs showing polarity reversal to that of seafloor, suggesting higher impedance gas-hydrate charged sands overlying lower impedance sands with free gas; (3) those strong reflections in the fault zones as gas-bearing fluid conduits; (4) strong reflections on the sides of mud diapirs (e.g. flank drags) and above buried mud diapir demonstrating the presence of gas hydrates, and (5) high amplitude reflections dragging on diapiric flanks with reversal phase of seafloor indicating free-gas charged sands abutting mud diapirs.
Vertical venting governed by mud tectonics is the key to inducing thermogenic gas seepages. When such structure is absent, biogenic gas could be the alternative source for free gas or gas hydrate accumulations. Upward mud intrusion contributes to initiation of brittle deformation for deeply buried gas migration pathways. The low-permeability nature of mud diapirs promotes prominent traps for free gas or gas hydrate preservation along the diapiric flank. Due to its high thermal conductivity, active mud diapirs may act as dewatering catalyst for hitherto preserved gas hydrates, allowing dissociated gas to be accumulated, even within GHSZ.

Keywords: gas hydrates, mud diapirs, seismic reflection, accretionary wedge, Taiwan

