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BURIED GAS HYDRATES IN THE DEEPWATER OF THE SOUTH CASPIAN SEA, AZERBAIJAN: IMPLICATIONS FOR GEO-HAZARDS

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Two multi-channel seismic reflection profiles in the deepwater of the South Caspian Sea, offshore Azerbaijan, document one of the first examples of buried gas hydrates. Based on their geophysical signature, these clathrates are characterized by (1) a depth-restricted, lenticular body well beneath the seafloor, (2) the apparent accumulation of free gas within the underlying sediment, and (3) evidence of associated recent slope failure in the overlying strata. Such attributes make these gas hydrates important, and perhaps previously underestimated geo-hazards of the South Caspian region. Primary among these are uncontrolled release of free gas trapped beneath the hydrate seal, or disruption of the gas hydrate stability field leading to either explosive dissociation of the gas hydrate, or reduction in sediment strength, slope instability, and mass sediment transport. Association of gas hydrates with active mud volcanoes in the South Caspian Sea increases the potential for offshore flaming eruption, as attested to in historical records. Documentation of the presence and distribution of gas hydrates especially when concealed at depth in the subsurface is a clear pre-requisite for exploration activities in the deepwater region of the South Caspian.

Acquired as part of Chevron's exploration program in the South Caspian Sea, two ~70-km seismic reflection profiles near the Absheron Ridge were analyzed with the aim of identifying potential geo-hazards due to the presence of gas hydrates. Processing of these profiles was focused on noise reduction and preservation of true amplitudes, necessary for accurate evaluation of elastic properties, including possible "blanking" (reduced acoustic impedance) effects, and detection of potential free gas accumulations beneath the hydrated layer. Principal steps included wavelet deconvolution, spherical divergence, bandpass filtering, surface consistent amplitude scaling, finite-difference migration, and depth conversion.

Seismic evidence for the presence of buried gas hydrates within the study area consists of a shallow zone of pronounced high velocity ($V_p \approx 2.1$ km/s, $V_s \approx 0.8$ km/s) as compared with the surrounding sediments ($V_p \approx 1.55$-1.60 km/s, $V_s \approx 0.36$ km/s). This zone appears on the seismic data as a depth-restricted layer (~200 m thick) well beneath the seafloor (~300 m), extending down the flanks of the buried Absheron anticlinal structure. The top of this velocity anomaly is marked by a strong, ($R_c \approx 0.123$), positive-polarity (same polarity as the seafloor ($R_c \approx 0.198$)) reflector that is interpreted as the top of the gas hydrate layer (Top Absheron Hydrate; THA). Similarly, a high-amplitute ($R_c \approx 0.11$), negative polarity reflector (reserved relative to the seafloor) coincides with the base of the high-velocity layer, and is interpreted as the base of the hydrate zone (Base Absheron Hydrate; BAH). Both the TAH and BAH approximately parallel the seafloor, and display a crosscutting geometry with the shallow stratigraphy, suggesting that these two reflectors are thermobaric and not stratigraphic interfaces. As in other gas hydrate examples identified worldwide, the shallow high-velocity anomaly zone is associated with blanking effects of the sedimentary section. Results from AVO modeling suggest that (1) gas hydrate concentration in the sediments is ~20%, and (2) the BAH displays decreasing AVO, suggesting accumulation of free gas underneath the hydrated layer. Shallow faulting, evident on detailed bathymetry of the seafloor and associated with slope failure at the shelf margin, appears to be structurally controlled by the base of the gas hydrate layer. In turn, the zone of gas hydrate appears to be continuous across these shallow faults, implying rapid and dynamic re-equilibration of the gas hydrate stability field following very recent faulting.

The interpreted thickness and depth of gas hydrates in the South Caspian Basin matches well with the hydrate stability field predicted from thermobaric modeling. The presence of both thermogenic and biogenic gas, identified from coring at the seafloor, suggests that gas hydrates in the South Caspian Sea may be stable in water depths as shallow as ~150 m, much shallower than areas reported worldwide for gas hydrate formation. Moreover, the maximum predicted thickness of gas hydrates in the South Caspian sediments is 1,300 m, considerably thicker than other known hydrate occurrences. The results of this study suggest that gas hydrates (1) are widespread features in the deepwater of the South Caspian Sea, (2) can occur as buried deposits well beneath the seafloor, and accordingly, (3) may represent significant and previously underestimated geo-hazards.