Hydrocarbon Trapping Mechanisms in Hybrid Conventional and Unconventional Gas System

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Abstract

OBJECTIVE
A fluid interpretation workflow was developed and integrated with charge and structural evolution analysis to interpret contrasting fluid distributions in two adjacent gas fields. The structurally shallower field is characterized by drier gas upsection, while the deeper field is characterized by drier gas downdip. The lack of correlation between fluid regions, depth and sedimentological facies instigated this study in order to optimize development plans and completion strategies.

PROCEDURE
Relationships between fluid composition and petrophysical variations were inspected to explore controls on the contrasting fluid distributions in both fields. Phase envelopes, routinely used by reservoir engineers in production-related context, were employed here to reconstruct migration relationships and to understand hydrocarbon filling and trapping mechanisms. Composition-depth profiling and interrelationships of reservoir pressures, saturation pressures and gas-oil ratios (GOR) were interpreted within the context of charge history and geospatial architecture of both fields. Fluid maturity was estimated using PVT fluid composition data, such as isoprenoid to n-alkane ratios and the slope factor of volatile light hydrocarbons. The structural evolution history was reconstructed by flattening and tilting of stratigraphic horizons coeval with charge time, supported by seismic stratal geometries.

RESULTS and CONCLUSIONS
A reservoir model combining both accumulations was conceptualized, defining conventional reservoir at the crest of the anticlinal trap that degrades with depth into tighter and more heterogenous siliciclastic lithologies. The hybrid nature of the reservoir from conventional to unconventional (tight sand) is reflected in contrasting fluid distributions that imply different trapping mechanisms. Buoyancy trapping dominates in the shallower conventional reservoir, allowing drier gas to move upsection, while tighter lithologies in the deeper accumulation are dominated by permeability/capillary trapping, forcing the bulk of the drier gas to remain at depth.
Composition-depth profiles, such as methane mole fraction, GOR, and fluid maturity support this interpretation regarding the dominant trapping mechanisms and additionally point to fluid connectivity at a regional scale. The regional fluid continuity is reflected in the systematics of dewpoint pressures decreasing toward the shallower PVT regions, concomitant with systematic shrinking of respective phase envelopes.

Structural analysis suggests that only the deeper structure closer to the kitchen was in place at the start of the peak charge. A later regional tilting resulted in the development of the shallower structure and triggered fluid redistribution across both fields. The recent testing of wet gas in the saddle between the two accumulations confirms our finding of a single fluid system spanning the entire region, spreading over reservoirs of varying qualities, varying pressure regimes, and varying trapping mechanisms. Proximity of the tight sand to the gas- mature kitchen and the ongoing gas charging is believed to have played a key role in forming an overpressured basin-centered gas system.