Assessment of Reservoir Compartmentalization by Inorganic Geochemical Modeling

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Abstract

Objectives/Scope: Geochemical fingerprinting of formation water represents a complementary and analogue tool to the interpretation of hydrocarbon fluids and petrophysical well logs for the assessment of lateral and vertical migration pathways for reservoir fluids and communicated flow regimes. This paper proposes the utilization of machine learning techniques (ML) on inorganic geochemical data with lithological and structural information to design a hydrodynamic model for the tracking of gas migration, continuity and compartmentalization.

Methods, Procedures, Process: As a basic concept, pore fluids from connected pay zones are geochemically homogeneous, while the presence of sealing units in compartmentalized reservoirs causes the conservation of a primary fluid fingerprint. Water samples from gas producing wells were geochemically analyzed and filtered by ML methods to identify samples with formation water properties. Subsequently, representative samples were clustered into hydrodynamic groups and integrated into stratigraphic cross-sections and fault maps to 1) trace migration pathways through different geological layers, 2) reconstruct lateral and vertical connectivity within Devonian and Permian sandstones, and 3) assess the functionality of existing faults as potential conduits or seals.

Results, Observations, Conclusions: The postulated hydrodynamic model of a SW-NE directed regional flow trend with increasing fluid salinity in the studied sandstones is triggered by the recharge of meteoric water, and its gravity-related descent toward deeper sections in the east. This flow trend is aligned to the WSW-ENE directed gently dipping of both stratigraphic units. Subsequently, the fluid phase becomes increasingly mineralized toward the NE by a) depth-triggered water-rock interaction processes, and b) continuous replenishment of deep connate brines by low-saline meteoric water. Furthermore, structural features, mainly NNW-SSE elongated faults and lithological heterogeneity caused the local entrapment of water bodies and the formation of isolated zones within separate hydrodynamic groups of lower (100,000 - 166,000 mg/L), intermediate (161,000 - 217,000 mg/L), and hypersaline salinity (263,000 - 329,000 mg/L) in both formations. Unidentified structural or stratigraphic boundaries were detected along borders of hydrodynamic groups. Wells within each of these vertically-stratified and laterally-isolated hydrodynamic groups show potential for being hydraulically interconnected. With the provided geochemical assessment, the risk of drilling dry holes can be reduced by targeting new drilling sites within defined sections of a hydrodynamically-connected block.
**Novel/Additive Information:** The integration of fluid chemistry along with pressure and production data highly de-risks exploration and reduces uncertainty of establishing compartment limits. Geochemical fingerprinting of formation water as dominant reservoir fluid can provide analogous clues on the source rock, migration, trapping, and alteration of hydrocarbons.