Formation of High Helium Gases: A Guide for Explorationists

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Economic helium (He) accumulations, like hydrocarbon accumulations, result from predictable processes of generation and migration. He-rich gas forms as a two step process: (1) generation/accumulation of He in pore water and (2) interaction of pore water with gas.

Radioactive decay of U and Th forms He, which then diffuses to pore water. He concentration in pore water increases with increasing U and Th concentration, increasing age, and decreasing porosity.

He is concentrated into economic gas accumulations where pore water rich in dissolved He interacts with a gas phase. Most He quickly partitions into the gas. High He concentration in the gas is favored by high He concentration in the pore water, low gas volume interacting with water, and low pore pressure where the gas interacts with the water. Once He is entrained in the gas, it migrates with the gas to traps just like other gas accumulations.

Old (Paleozoic) sediments can act as efficient He source rocks and have sufficient He generation potential to account for known economic He accumulations. He generated in the deep crust is not likely to form economic accumulations. Deeply generated He cannot migrate to traps in overlying strata unless some fluid carries it out of the basement. Most basement is devolatilized, so there are few settings where fluid is available for He transport.

The following guidelines are proposed to aid exploration for high He gases. (1) Old siliciclastic sediment, not deep basement, is the most probable source rock for economic He accumulations. Old fractured shales, arkoses, granite wash, and shallow fractured basement are good potential source rocks. (2) The pore water must be old prior to gas interaction, preferably 100 My or more. (3) Gas and water should interact at shallow depths to maximize He extraction from the water. (4) The total volume of gas that interacts with the pore water should be relatively small to avoid He dilution by later gas charge. Explore in petroleum systems with marginal hydrocarbon gas generation or near the updip limits to supercharged petroleum systems. Less gas is available in these settings, so He concentrations will not be diluted.

The validity of these controls are demonstrated by geochemical interaction models and correlations of regional- and field-scale He concentrations in the southwest US.