Updated Regional and Field-Scale Helium Accumulation Geochemistry, La Barge Platform, Wyoming

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ABSTRACT

Economic (>0.5 mol. %) accumulations of helium at the La Barge Platform (La Barge) in western Wyoming are the result of radiogenically-produced helium from sedimentary crust that was mobilized by deep basinal ground water flow or possibly hydrocarbon migration, and concentrated by diffusion into stable traps. Helium production from La Barge occurs in Paleozoic natural gas reservoirs; the resource is the largest in the U.S., representing approximately 55% of current helium production in the country. Though La Barge is the largest producer of helium and a target for additional exploration, helium geochemistry at La Barge and in the surrounding region is not well understood. From 2012-2016, gas and water samples were collected from six Mississippian Madison Limestone producing gas wells at La Barge, and from 17 regional gas-effusive surface springs within a 200-km radius of the field. Water and gas samples from all locations were analyzed for gas composition, major and trace element concentrations, and stable and noble gas isotopes. Regional sampling for helium and other noble gas isotopes indicates three distinct regional helium source groups that approximately match the three major geologic provinces in the area. The first province comprises tectonically stable sedimentary strata surrounding and including La Barge; results here suggest helium concentrations are relatively high (0.5-1.0 mol. %) and have primarily crustal origins. However, the helium of this group is not purely crustal and appears to represent an unknown source component with R/RA ratios of 0.05 to 0.07. The second source group occurs west of La Barge in the Basin and Range province of southeastern Idaho. Here, there is more mantle-sourced helium with R/RA values of 0.15-2.2 with lower helium concentrations (0.0004-0.008 mol. %) than the first region. The last group, from the Yellowstone province to the north, is well documented in the literature as mantle-sourced helium, and was therefore only tangentially sampled for this study. Regionally, higher concentrations of helium occur in the sedimentary province including La Barge, which exhibits more of a crustal- sourced helium signature than the other sampled geologic provinces. High helium concentrations sampled at the springs near La Barge may suggest that additional, potentially economic accumulations are present. Geochemical analyses of gas from La Barge field show trends in bulk composition with structural depth. Helium and carbon dioxide concentrations increase with structural depth while methane and hydrogen sulfide decrease with depth. These trends suggest a well-connected stable and stratified Madison Limestone reservoir, where the gas constituents have been able to concentrate by density through a permeable reservoir. Data from stable and noble gas isotope analyses do not show clear trends with depth. Instead, the data may provide preliminary evidence for two somewhat isotopically different pools of gas, one to the southwest on the steeper side of the structural crest of the platform, and another to the east on the more shallowly dipping side of the platform. Various proposed basement structures on the southwest margin of the La Barge Platform, related to its formation, may be conduits for migrating gases that cause the isotopic differences. However, confirmation that gases on opposite sides of the La Barge structure are in fact isotopically distinct is not possible given the current limited sample set.