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Natural hydrogen and blend gas: A dynamic model of accumulation

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Natural hydrogen accumulates in the form of “blend gases”, with the association mainly of methane, nitrogen, and helium. The extreme variation in the proportions of these four gas compounds is explained by a model of dynamic accumulation, in which some compounds, such as helium are chemically inert in the reservoir, nitrogen is almost inert, methane is altered into CO_2, and hydrogen is strongly altered mainly into protons, and to a lesser extent into methane. All gas compounds can also escape from the reservoir, either by advection without any chemical fractionation, or by solubilization in water and diffusion, resulting in a variable composition of the residual gas remaining in the accumulation.

The model can explain the coexistence of high concentration of helium, which has clearly accumulated over geological time, and hydrogen, which is supposedly renewable on human time scales. After a short time, the absolute amount of hydrogen in the accumulation remains constant, only being increasingly diluted over time by the more stable accumulation of helium and nitrogen. Methane also reaches a steady state, later than hydrogen, with a constant amount, implying an increasing dilution in nitrogen and helium over geological time.

With the best choice of parameters for the model, the estimated ages of high-concentration hydrogen accumulation in the World are small, as the hydrogen is increasingly diluted in nitrogen and methane over geological time. Diffusive leakage through water appears to be negligeable compared to advective leakage and compared to the reactivity of hydrogen in the reservoir. The example of the Bourakébougou hydrogen field would have an age of 500 years according to the model. Diffusive leakage by water solubilization has a small effect on the gas composition. Advective leakage, even without fractionation, has a significant effect on the composition of the accumulated gas due to mixing with active deep flow. For future production of natural hydrogen accumulations, it is predicted that the proportion of hydrogen should increase during the production period, while the concentrations of helium and nitrogen should decrease.