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Timing of Microbial Gas Generation in Upper Cretaceous Reservoirs, Montana and Canada—Interpretation from ^{129}I/I ratios

More than nine trillion cubic feet of microbially generated methane has been produced from the Upper Cretaceous Belle Fourche Formation, Medicine Hat Sandstone and its lateral equivalents in the Niobrara Formation, Milk River Formation, and Eagle Sandstone in Alberta and Saskatchewan, Canada, and eastern Montana. Twenty-two wells were sampled for gas and co-produced water in the producing formations in Canada and Montana. Of the formations sampled, eight samples were from the lower part of the Belle Fourche Formation, six were from the upper part of the Belle Fourche Formation, one each was from the Medicine Hat Sandstone and the Martin sandy member of the Niobrara Formation, and three each from the Milk River Formation and Eagle Sandstone. Chemical and stable isotopic compositions for both gas and water fractions and the ^{129}I/I ratios in the waters were determined. Based on $\delta D_{methane}$, δD_{water}, and $\delta^{18}O_{water}$ and water chemistry, the water associated with the gas in the formations is a mixture of marine and meteoric water. A cross plot of δD_{water} versus $\delta D_{methane}$ indicates that the microbial methane was produced in an aqueous setting primarily via CO_2 reduction. However, the water and gas isotope data (especially $\delta D_{methane}$ values) can also support a small component of the microbial gas forming from acetate fermentation. Of the sampled wells, 14 samples showed isotopic equilibrium between the methane and water.

Stable isotopes of water, patterns of methane-water equilibria, or regional trends in gas and water composition do not provide information on the time and duration of gas generation. However, they might be useful in indicating local and regional flow paths, which could affect gas accumulation. ^{129}I/I of the produced water helps place constraints on the timing and duration of gas generation by determining the residence time of the water in the reservoirs and the probable source of the iodine. For samples where the methane and water are in equilibrium, this also provides some time constraints on gas generation. Minimum uncorrected ^{129}I/I ages for all samples range from 23.5 to 101.4 Ma. Preliminary corrected (for fissiogenic production) ^{129}I/I ages for all samples range from 24.4 to 101.4 Ma, whereas samples in which the methane and water are in isotopic equilibrium have corrected ^{129}I/I ages ranging from 31.6 to 92.6 Ma. These ages are generally younger than any of the host reservoir rocks and support the hypothesis of past mixing of connate and meteoric water. There is no regional pattern or depth relation to age distribution within the formations that would indicate the presence of a single continuous regional flow system through each formation. Rather, ^{129}I/I data, when used in conjunction with other gas and water geochemical parameters, indicate multiple flow paths affected by depositional patterns of reservoirs, local structures, and times of exsolution of free gas. Based on ^{129}I/I ages, methane was generated from the mid-Cretaceous through early Oligocene.