Stable Isotope Forensics as a Means of Differentiating between Thermogenic and Biogenic Gases in the Wilcox Aquifer, Haynesville Shale Trend, Caddo Parish, Louisiana

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ABSTRACT

Hydraulic fracturing (fracking) of formations such as the Haynesville Shale, Barnett Shale, and Eagle Ford Shale has become a well-established means of increasing the production of natural gas from formations that, for many decades, were considered to be too "tight" to be produced economically. A great many environmentalists, however, are concerned that fracking makes possible the migration of natural gas and brine from deeply-buried strata to fresh-water formations. Stable-isotope geochemistry, specifically analyses of the carbon-13 ($\delta^{13}C$) and deuterium (δD) signatures of dissolved gases and produced gases, is a highly-effective means of resolving questions related to the source(s) of methane and other gases in groundwater. Geosyntec Consultants investigated this matter in December 2013, at the request of Anadarko Petroleum Corporation, in coordination with the Louisiana Department of Natural Resources, after a landowner in Caddo Parish, Louisiana, reported that natural gas was discharging from water produced by his domestic well completed in the Wilcox Aquifer. The water well is located approximately one quarter of a mile from three Haynesville formation wells that Anadarko had drilled in 2013.

Geosyntec proposed a program of work that involved the collection of groundwater samples for analysis of dissolved gas and abundances of the stable isotopes carbon-13 and deuterium. The program also included the collection of produced gas samples from nearby Haynesville wells. The samples of produced gas were analyzed for mole fractions of the C1 through C6+ hydrocarbon fractions, along with carbon-13 and deuterium isotope ratios. The stable isotope data illustrated conclusively that natural gas discharging from the landowner's well is not of thermogenic origin (that is, not Haynesville gas), but is a biogenic product related to a methanogenic pathway in the Wilcox by means of CO_2 reduction. The role of CO_2 reduction was also highlighted by the deficiency of dissolved sulfate and by reduction-oxidation potential measurements of -200 millivolts and lower in groundwater. The occurrence of methane in the water well is related to the occurrence of lignite, which, as illustrated by researchers with the Louisiana Geological Survey, is common to the Wilcox Aquifer of northwestern Louisiana.