

A Geochemical Context for Stray Gas Investigations in the N. Appalachian Basin: Implications of Analyses of Natural Gases from Neogene-through-Devonian Age Strata

Christopher Laughrey¹, Fred Baldassare, Mark McCaffery, and John Harper

¹Weatherford

Abstract

As the pace of drilling activity to the Marcellus Formation in the northern Appalachian Basin has increased, so has the number of alleged incidents of stray natural gas migration to shallow aquifer systems.

Prior to the present study, the occurrence and origin of natural gas in the strata above the Marcellus Formation in the Northern Appalachian basin has not been well defined. More than 2,300 gas and water samples were analyzed in the present study for (1) molecular composition, (2) stable carbon and hydrogen isotope compositions of methane and (3) stable carbon isotope composition of ethane. The samples are from Neogene to Middle Devonian-age strata in a five-county study area in northeastern Pennsylvania. Gas and water samples were collected from (1) 234 gas wells during Mudgas Logging (MGL) programs for wells being drilled to the Marcellus Shale Formation, and (2) 67 private water supply wells during baseline groundwater water-quality testing programs. Regional and local geologic conditions were evaluated from core analyses and published studies.

Evaluation of this geochemical database reveals that microbial, mixed microbial/thermogenic, and thermogenic gases occur in some shallow aquifer systems, and that the gas occurrences pre-date Marcellus Formation drilling activity. The isotope data reveal that thermogenic gases in the Neogene and Upper Devonian strata are typically distinct from gases from deeper Middle Devonian strata (including the Marcellus Fm.).

Significantly, however, a more detailed review of the geochemistry at the site-specific level also reveals a complex thermal and migration history with gas mixtures indicated by partial isotope reversals ($\delta^{13}C_1 > \delta^{13}C_2$) in some areas throughout the stratigraphic section above the Marcellus Formation.

Defining a specific source for stray natural gas requires the investigation and synthesis of several data types at the site-specific level. Molecular and isotope geochemistry provide evidence of gas origin and evidence of secondary processes that may have affected the gases. Such data provide focus for investigations where the potential sources for stray gas include multiple naturally occurring and anthropogenic gases. Additional investigation to delineate migration pathways and the mechanism of migration are necessary to further constrain and identify specific stray gas source(s).