# A One-Year Metagenomic Trajectory after Hydraulic Fracturing in Marcellus Shale – From Microbial Function to Well Infra-structure and Production

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## Abstract

Energy extraction using horizontal drilling and hydraulic fracturing technologies in deep hydrocarbon-bearing shales significantly alters biogeochemical conditions and microbial ecological function– with implications for productivity, corrosion, and fouling in the Marcellus and Utica. We tracked changes in microbial community dynamics and functional potential over an 11-month period in fluids injected and produced from three wells drilled and fractured in the Marcellus shale. These systems were genomically tractable, with near complete draft genomes recovered for most of the dominant taxa identified in 16S rRNA analyses. A marked shift in microbial taxa occurred with time; community composition shifted from low-salt tolerance, mesophilic aerobic bacteria to halophilic fermentative bacteria and methanogenic archaea. Earlier time points (up to 14 days after fracturing) had an abundance of *Halolactibacillus*, members of Vibrionales, and *Arcobacter* spp., the latter which encoded the potential for chemoautotrophic sulfide oxidation. Relative to the earlier samples, the 11-month community was dominanted by several strains of *Halanaerobium* spp. and a member of the Halomonadaceae. This sharp shift in the microbial community was correlated with the attenuation of injected organic carbon and a higher porportion of genes for the acquisition and degradation of aromatic compounds and the assimilation of reduced sulfur species, supporting the importance of these processes in later produced fluids when anoxic conditions prevail. *Methanohalophilus* and *Methanolobus* spp. also are enriched in later time points, both of which encode the complete pathway for producing methane from the utilization of mono-, di- and trimethylamines. These data provide insight into the microbial functional potential within Marcellus shale as it relates to well infrastructure (e.g. production of corrosive metabolites such as acids and sulfides) and productivity (e.g. shale carbon fermentation, biogenic methanogenesis, and H2S generation).