Microbial Controls on Biogeochemical Cycling in Deep Subsurface Shale Carbon Reservoirs

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Abstract: Terrestrial deep shales and their interfaces are carbon-rich environments that represent a significant component of the U.S. energy portfolio. Energy resources in these environments have recently been accessed via hydraulic fracturing (i.e. 'fracking') technologies that introduce a complex mixture of biocides, surfactants, and proppants into the shale matrix. Previous studies have identified 16S rRNA gene sequences from the surrounding interfaces (not shale matrix) and monitored fluids during and after the fracking process, but much remains to be known about the cultivated and uncultivated microbial functionality in these economically important ecosystems. This proposal aims to improve our understanding of microbial diversity and metabolism in deep shale, with implications for novel enzyme discovery and energy development. We request JGI sequencing resources for microbial metagenomic reconstructions from undisturbed deep shale rock cores from different depths and locations, and from fluids temporally before, during, and after fracturing. These analyses will elucidate key (bacterial, archaeal, and viral) members, identify metabolic reactions that govern biogeochemical cycling in pristine and altered deep shale environments, identify physical, geochemical, and biotic components that regulate microbial functionality. EMSL resources that leverage Nuclear Magnetic Resonance (NMR), tandem mass spectrometry, and electron microscopy to identify active metabolisms in microbial enrichments and pure cultures developed from deep shale material will complement genomic hypotheses. Our expected results tie directly to JGI and EMSL missions of understanding linked metabolic roles between carbon and other biogeochemical cycling in terrestrial systems. Data generated from this proposal will provide the first understanding of the abiotic and biotic factors that contribute to methane, hydrogen, sulfur, nitrogen cycling in these poorly sampled biomes. This will advance both fundamental subsurface science and contribute knowledge for industrial and government partners interested in short and long-term impacts of microbial and geochemical processes on energy extraction.