RESEARCH PROGRAM: Subsurface Science Program
TITLE: Geochemical Constraints On The Longevity And
Environmental Habitat Of Subsurface Microbial Communities
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Objective: Research efforts were directed towards the acquisition of samples bearing microorganisms from the deep subsurface and characterizing those samples by petrographic and geochemical methods in order to constrain the origins of the microbial communities.

Approach: Subsurface Science Program research during 1994-1997 focused on three sites where microbial sampling of the deep subsurface was undertaken; 1) Taylorsville Basin, 2) San Juan Basin, and 3) Piceance Basin.

Microbial sampling of Taylorsville Basin was completed in April, 1992 (Onstott et al., 1998a). We have completed observations with respect to the thermal history of the basin (Tseng et al. 1996; Gao et al., 1998; Tseng et al., 1998a) and a fully coupled thermal/fluid flow history (Tseng and Onstott, 1997; Tseng et al., 1998b). Using solute transport models we are completing estimates of the migration rates in these models to determine the origins and activities of the microbial populations recovered from 2.8 kilometers beneath the surface (Onstott et al., 1998c,d).

Microbial sampling of the San Juan Basin was completed in October, 1994. We completed our research on the delineation of the thermal, salinity, and diagenetic history of the microbial site (Fredrickson et al., 1997; Gao et al., 1998). In collaboration with

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McKinley of Pacific Northwest Laboratory, we extracted a multilevel water sampler (MLS) from the borehole in May 1996. We have completed geochemical and isotopic analysis of the water samples from the MLS. A second MLS study is being completed now. These studies will be integrated to develop a coupled microbial/geochemical model for a sandstone/shale anaerobic, subsurface environment where sulfate is the dominant electron acceptor.

Microbial sampling of the Piceance Basin was completed between November to December, 1994. We completed initial geochemical and microbial sampling of groundwater and natural gas condensate for microbiota and geochemistry during July of 1995. We have completed the delineation of the thermal, salinity, and fluid flow history of the sample strata at the coring site and its relationship to the microbiota found there (Colwell et al., 1997; Yao et al., 1998). We are now completing a paper describing the geochemistry and microbiology of the Piceance Basin, based upon our groundwater samples.

Results to Date:

Taylorville Basin

Modeling of the petrophysical logs and borehole temperature data by a steady-state fully coupled 2-D heat transport model indicate that the groundwater age of the microbial sampling is approximately 80 million years. Analyses of the petrography, stable isotope chemistry, and fluid inclusions indicate that formation temperatures exceed the maximum survival temperature for bacteria 210-190 million years ago. Fluid inclusion analyses and transient fluid flow models indicate that the bacteria migrated into the sampling zone during the period of uplift and erosion of the basin, soon after 190 million years ago.

San Juan Basin

Analyses of the petrography and stable isotope chemistry indicate that the formation did not exceed temperatures for microbial survival, but that the original marine depositional environment was replaced by a fresh water meteoric environment during uplift in the Miocene. Analyses of the sulfur isotopes of pyrite in collaboration with Riciputi of OakRidge National Laboratory has revealed the early presence of microbial sulfate reduction. Analyses of sulfur isotopes in ground water indicates that sulfate reduction is ongoing today.

Piceance Basin

Analyses of the petrography, stable isotopes, fluid inclusions, and vitrinite reflectance indicate that the microbial sampling zones were heated to temperatures exceeding that for microbial survival. The presence of bacteria in one of these zones and their absence in the other reflects microbial transport during uplift and cooling of the basins over the last 5 million years. Numerical simulation of the fluid flow in the basin using data provided by Lorenz of Sandia National Laboratories and DOE Fossil Energy are providing constraints on the ground water ages that will be tested by cosmogenic isotope analyses in collaboration with Murphy of Pacific Northwest Laboratories. Analyses of ground water samples indicate that the microbial communities in Piceance Basin are stratified with sulfate reducers dominating the top 500 meters and metal reducers dominating the depths between 500 and 2000 meters.

Finally, the data gathered in these three projects has been summarized in review papers (Onstott, 1994; Fredrickson and Onstott, 1996; Onstott et al., 1997; White et al., 1998).

Deliverables:

Publications in Peer Reviewed Journals

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