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Using Microbiology as a Tool to Explore Mid-Ocean Ridge Sub-seafloor Systems

Melanie Summit & **John Baross**

Oceanography, box 357940, Seattle WA, 98195, USA

Physiology and phylogeny of micro-organisms can be used to gain information about inaccessible environments. The ocean crust beneath mid-ocean ridges cannot be directly sampled and the geochemistry of this environment must currently be inferred from the chemistry of exiting fluids and from studies of ophiolites. We have used the physiology of thermophiles cultured from the sub-seafloor and their phylogenetic relationships with thermophiles from other habitats to infer characteristics of the sub-seafloor environment that complement those insights gained from measurements of fluid chemistry.

The sub-seafloor in stable hydrothermal systems was investigated by culturing micro-organisms from samples of low-temperature (5-30 ºC), basalt-hosted hydrothermal fluids on the Endeavour Segment, Juan de Fuca Ridge (Holden et al., 1998). The cultured microbes included hyperthermophilic micro-organisms with growth ranges of 50-100 ºC; these microbes are below the limit of detection in ambient deep ocean water. Their elevated concentrations in fluids 20-50°C below their minimum temperature for growth implies that they are derived from a warmer environment in the sub-seafloor. Though many low-temperature hydrothermal fluids are believed to derive from sub-seafloor mixing between seawater and the hot hydrothermal end-member, the manner of this mixing is mysterious. The microbial studies show that along the sampled fluid flowpaths there must be warm environments that are stable over periods of days to weeks or longer, and that these habitats are accessible to colonization. The pH and redox potential of this sub-seafloor habitat can also be constrained by the physiologies of the cultured micro-organisms and are consistent with a fluid of mixed origin.

This sub-seafloor habitat was compared to that created within hydrothermally active sulfide structures (Summit, 2000). Phylogenetic comparison of thermophiles cultured from these low-temperature fluids with similar micro-organisms cultured from sulfide precipitates shows that the two groups of organisms are distinct. As there is supporting evidence for free exchange between these habitats, there must be biological, chemical, or physical differences between the two habitats, creating two distinct types of niches and thus two distinct groups of organisms. Physiological differences between the two groups of organisms support the conclusion that moderate-temperature (50-100 ºC) sulfide and sub-seafloor habitats are geophysically and/or geochemically distinct.

Hyperthermophiles were also used as tracers after the 1996 North Gorda Ridge eruption (Summit & Baross, 1988). Hyperthermophilic micro-organisms were cultured from a hydrothermal event plume associated with the eruption; no hyperthermophiles could be cultured from ambient seawater. The cultured hyperthermophiles indicate that a portion of the fluids that formed the plume must have derived from a warm, stable, anoxic fluid reservoir and, therefore, the plume was not simply formed by seawater that interacted with hot lavas or a sub-seafloor pool of 350°C hydrothermal fluids. The physiology of the hyperthermophilic micro-organisms cultured from this event plume are concordant with predicted characteristics of the sub-seafloor environment.

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