Life in young ocean crust: Insights from subsurface microbial observatories

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Oceanic crust comprises the largest hydrogeologic reservoir on Earth, containing fluids in thermodynamic disequilibrium with the basaltic crust, yet we know little about microbial ecosystems that inhabit this vast realm and exploit chemically favorable conditions for metabolic activities. Samples recovered from ocean drilling operations are often compromised for microbiological assays, hampering efforts to resolve the extent and functioning of a subsurface biosphere. Here, we report results from the first *in situ* experimental observatory systems that have been used to study subseafloor life. Experiments that were deployed for four years in young (3.5 Ma) basaltic crust on the eastern flank of the Juan de Fuca Ridge record a dynamic, post-drilling response of crustal microbial ecosystems to changing physical and chemical conditions. Twisted stalk particles exhibiting a biogenic iron oxyhydroxide signature coated the surface of mineral substrates in the observatories - biosignatures indicating colonization by iron oxidizing bacteria during an initial phase of cool, oxic, iron-rich conditions following observatory installation. Following thermal and chemical recovery to warmer, reducing conditions, the *in situ* microbial structure in the observatory shifted, becoming more representative of natural conditions in regional crustal fluids. Notably, the microbial community in the post-rebound phase was dominated by *Firmicutes* bacteria, whose metabolic potential is unknown but may involve N or S cycling. The recorded transition of the subsurface ocean crust borehole microbial community confirms that observatory experiments are powerful tools for exploring the subsurface ocean basement biosphere, the largest but most poorly understood biotope on Earth.

Coal and human health

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Coal is an important resource, but contains inorganic and organic substances that may pose health and environmental concerns. Impacts may occur when the toxic substances in coal are mobilized into the air through combustion processes or into water supplies through leaching, thus leading to potential exposures. A recent study suggests that areas with high levels of coal production have worse overall adjusted health status, including higher rates of lung and kidney disease [1].

We are conducting studies that integrate epidemiology, toxicology, and geochemistry to examine the health and environmental impacts of coal. In studies of coal and water supplies, we have identified a possible link between the occurrence of coal and kideny nephropathy and renal/pelvic cancer [2]. One disease, Balkan endemic nephropathy (BEN) may have a multifactorial etiology, but with one key factor being the leaching of toxic organic substances from low rank coal into drinking water supplies. A high proportion of BEN patients also have renal/pelvic cancers, possibly from the same factors causing the kidney nephropathy in BEN itself. Interestingly, states in the USA with the highest incidence of renal/pelvic cancer also have large rural populations using untreated well water associated with low rank coal. Preliminary studies in two of these states (Wyoming and Louisiana) reveal the presence of significant levels of potentially toxic, coal-derived organic substances in the drinking water supplies. Epidemiology and toxicology studies are consistent with a role for coal-derived organics in drinking water in an increased risk for kidney disease.

Indoor coal combustion and inhalation of particulates containing toxic substances may also be linked to lung disease. Studies in the Navajo Nation, New Mexico are intended to investigate this link. Studies of coal fires will examine links (if any) between the emission of particulates and respiratory illness in people living downwind of these fires.

[1] Hendryx & Ahern (2008) *Am. J. Pub. Health* **98**, 669–671.
[2] Orem *et al*. (2007) *Ambio* **36**, 98–102.