Subsurface microbial ecosystems

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Conventional wisdom about the extent of biosphere on Earth replied upon the assertion that all life forms need photospherically-derived organic carbon. The distribution of life was thought to be limited to the upper 10 m of soil layer. Investigation of unconsolidated sediments by the Ocean Drilling Program and drilling to terrestrial aquifers during the last 20 years, however, has expanded habitable niches to a depth range of at least 800 m below either seafloor or land surface with decrease of organism abundance corresponding to increase of depth constantly observed. The extrapolation of this abundance-depth relationship to a depth of ~5000 m, where the temperature is beyond the maximum biological tolerance for heat, results in the estimate that subsurface biosphere would possess at least 70% of biomass on Earth. It appears that unicellular microorganisms are the numerically-dominant players in such an ample volume of space and versatile enough to persist under various environmental stresses. When considering global elementary cycling among atmosphere, geosphere and hydrosphere, subsurface biosphere could no longer be a missing factor. The distribution, identity, activity, and energy source for subsurface microbial community associated with consolidated rocks, however, remain largely unknown.

In this talk, two recent studies for groundwater and rock samples retrieved from South African gold mines and Taiwan Chelungpu Drilling Program will be used to illustrate the biosustainability of deep subsurface ecosystems in contrast geological settings (Achaean continental shield vs Cenozoic arc-continent collision). Multiple lines of evidence based upon geochemical, microbiological and molecular biological methods suggest that microbial communities at great depths are simply assembled (dominated by one or two species) and supported by metabolic energies derived from either abiotic geological processes or refractory organic compounds, depending upon whether organic carbon in sedimentary origin is available. Microbial communities in South Africa gold mines are low in abundance and activity and have been isolated from input of surface recharge for 10 Ma, whereas those in Taiwan are high in abundance and activity and have been subject to constant disturbance induced by arc-continent collision for 2 Ma. The contrast community structures, activities, and sources of metabolic energy reflect the fact that geology plays an important role to regulate the function of microbial community inhabiting at great depths.