Influence of geochemistry and biology on community protein expression within a chemoautotropic biofilm

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Using community proteogenomic methods we study the links between ecology and geochemistry for model biological communities growing chemoautotrophically within an acid mine drainage environment. Acid mine drainage (AMD)-generating systems are characterized by hot (often > 40 C), pH < 2 solutions, enriched in toxic heavy metals [mM] that are released by dissolution of sulfide minerals exposed by mining. The organisms that proliferate in AMD are well suited to cope with these extreme stresses and accelerate sulfide mineral dissolution and acid production as a byproduct of metabolism.

We have examined the whole community protein complements of twenty-eight natural biofilms to understand the community response to fluctuations in biotic or geochemical conditions. Correlations of protein detection patterns with environmental factors show that low abundance members of the microbial community strongly respond to changes in physical factors (e.g. [SO_4^{2-}], [Ca^{2+}], temperature, and pH). In contrast, the proteome of dominant organism of these biofilms is less responsive to abiotic changes, with proteome changes correlating strongest with changes in community structure. For this organism, responses to geochemical factors appear to invlove only small subsets of proteins, which are specific to each factor. Using this proteomics approach, we are able to propose geochemically constrained niches where specific community members can proliferate and presumably affect overall ecosystem function. Fine-scale relationships between organismal activity and specific environmental determinants are also defined, which provide insight into the adaptive measures of these organisms within this highly stressful environment.

Submarine basalts from the Alpha / Mendeleev Ridge and Chukchi Borderland: Geochemistry of the first intraplate lavas recovered from the Arctic Ocean

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During the August-September 2008 Arctic Ocean cruise of icebreaker USCGC HEALY, two dredges taken at 3.2-3.5 km depth recovered some of the first known submarine basaltic samples from the Amerasian Basin sea floor. Two suites of rocks were recovered. The first one is low-Si, low-alkaline and high-Mg rock (SiO_2 = 43.7%; Na_2O+K_2O = 3.4%, MgO = 9.1%; Mg# = 51; Cr = 140 ppm; Ni = 212 ppm) while the second is more evolved (SiO_2 = 43.9-46.0%; Na_2O+K_2O = 4.4-4.9%, MgO = 4.5 – 5.0%; Mg# = 34 – 38; Cr = 40-50 ppm; Ni = 109-168 ppm).

In some respects, these seamount volcanic rocks are similar to late Mesozoic basaltic rocks of Ellesmere Island of Arctic Canada and continental flood basalts (CFB) of Franz Josef Land. Trace element composition of the seamounts (enrichment in most incompatible LILE relative to primitive mantle; Ce_N/Yb_N = 1.7-2.8, Gd_N/Lu_N = 1.0-1.6; pronounced trough at Sr with Sr_N/Nd_N = 0.28-0.45) are very similar to those of other CFB. The elemental ratios of highly incompatible elements like Th/Ce (0.05) and the absence of negative Nb and Ta anomalies show that crustal assimilation was not a significant process during the evolution of these basalts. None of the samples exhibits chemical characteristics typical of mid-ocean ridge basalts (MORB). All seamount basalts are depleted in terms of Sr, Nd and Hf isotopic ratios relative to Bulk Silicate Earth or BSE ($^{143}Nd/^{144}Nd$ = 0.512669-0.512919; $^{87}Sr/^{86}Sr$ = 0.703894-0.704764; $^{176}Hf/^{177}Hf$ = 0.283128-0.283191). All of these isotopic ratios fall between MORB and BSE. Occurrence of this volcanism away from any obvious spreading centers, geochemical characteristics that are different from those of lavas from the Gakkel Ridge, and lack of evidence for rifting, suggest that the seamount lavas originated from deep-seated plume sources, the first to be recognized in the Arctic Ocean.