Biogeography of serpentinite-hosted ecosystems

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Ultramafic rocks in the Earth's mantle represent a tremendous reservoir of carbon and reducing power. Upon tectonic uplift and exposure to fluid flow, serpentinization of these materials generates copious energy, sustains abiogenic synthesis of organic molecules, and releases hydrogen gas (H_2). To date, however, the "serpentinite microbiome" is poorly constrained: almost nothing is known about the microbial diversity endemic to rocks actively undergoing serpentinization.

We have obtained metagenomic and 16S rRNA tag sequence datasets from fluids and rocks collected in serpentinizing ophiolites in California, Canada, and Italy. The samples include wells which directly access subsurface aquifers, rocks obtained from drill cores into serpentinites, and natural, high-pH serpentinite springs that are presumably representative of deeper environments within the ophiolite complex. Our results point to potentially H_2-utilizing Betaproteobacteria thriving in shallow, oxic-anoxic transition zones and anaerobic Clostridia thriving in anoxic, deep subsurface habitats. Similar bacterial taxa and genes encoding hydrogenase enzymes were also observed in seafloor Lost City hydrothermal chimneys, indicating that we are beginning to identify a core serpentinite microbial community that spans marine and continental settings.

These data represent a unique opportunity to examine biogeographic patterns among a specialized set of organisms and genes and to explore their evolution during the uplift and obduction of mantle rocks onto continents over geological time scales. We are currently testing for correlations between these metagenomic data and the geochemical conditions and the geological histories of the host rocks with an ultimate goal of inferring an integrated metagenomic-biogeochemical natural history of the serpentinite habitats.

Characterization of natural gem diamonds and UV light sources using fluorescence spectroscopy

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Gemologists have used fluorescence reactions to long wave ultraviolet light for identification of gemstones for decades. Simple visible observations of fluorescence color, intensity, pattern, and duration have proven invaluable for separating natural diamonds and other gemstones from synthetic or treated equivalents. Fluorescence viewing and imaging, however, can only provide a limited amount of information about the lattice defects that produce the luminescence. Spectroscopy provides details about the nature of the fluorescence, the combinations of defects that produce the observed colors, and the effects of different excitation sources. Spectra collected from natural gem diamonds show blue fluorescence from N3 defects (415 nm), green from H3 (503.2 nm) and H4 (496 nm), orange/red from N-V centers (575, 637 nm), and yellow from a combination of several defects associated with a visible absorption band at 480 nm. Using variable excitation, three dimensional maps (excitation, emission, fluorescence) of the luminescence spectra from each defect reveal complexities that cannot be discerned visually. In addition to this fundamental fluorescence information, spectroscopy also allows characterization of the excitation light source output and evaluation of how it affects the fluorescence produced from a diamond. A wide range of UV light sources are currently used in the gem and mineral industry with large differences in output intensity and wavelength. Small variations in bulb/LED and filter materials can significantly impact the visual fluorescence, leading to inconsistent results. The use of fluorescence spectroscopy provides additional detail that is not available from visual observation to help to identify subtle differences produced by variable light sources as well as many of today's modern gemstone treatments.

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