Microbial adaptive evolution to the oxic/anoxic interfaces in serpentinizing systems.

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All life requires energy and nutrient, which must be extracted from the surrounding environment. Since microbes are capable of obtaining energy from the oxidation of inorganic or organic reduced compounds, an energetically-favorable setting for microbes exists where the reduced compounds generated in deep reductive subsurface in the Earth contact with the oxidized compounds presenting at the surface. Such environments are found around the areas of anoxic/oxic interfaces in the systems of hydrothermal vents, hot springs, cold seep, mud volcanos, and often harbor unique microbial communities.

Serpentinization is an aqueous alteration process in which low-silica ultramafic rocks (for example, olivines and pyroxenes) are hydrolyzed with water into serpentinite, brucite, magnetite and other minerals. During these reactions, abundant hydrogen gas is produced creating the conditions capable of the abiotic reduction of carbon to produce methane and hydrocarbons. Serpentinization also releases hydroxide ion which issues highly alkaline fluids (usually above pH 11). In the highly alkaline fluid, carbonate is the dominant form of inorganic carbon which can precipitate out of solution as carbonate minerals with the divalent cations, such as Ca^{2+} and Mg^{2+} in the serpentinite fluids. While reductants (fuel) are abundant in these systems, corresponding oxidants and available carbons are severely limited, which restrain the range of potential microbial metabolisms. Here I present the unique physiological and genomic features of microbes inhabiting at the oxic/anoxic interfaces in serpentinizing systems, where oxidants and carbon dioxide must be supplied from the air beside the reduced compounds from the deep. I further show the evidence of potential adaptive evolution to the local geochemistry of the various serpentinizing systems.

We isolated novel three-related microorganisms, named genus *Serpentinomonas*, from highly alkaline (pH 11.6) serpentinizing springs at The Cedars, California[1]. All three strains are obligate alkaliphiles with an optimum for growth at pH 11 and are capable of autotrophic growth with hydrogen, calcium carbonate and oxygen. The features fit well to the alkaline and calcium-rich environments represented by the terrestrial serpentinizing ecosystems, thus the organisms are considered to be adapted to the geochemical setting.

Although the closely-related *Serpentinomonas* strains have been detected globally in all of the studied highly-alkaline serpentinized waters, the chemistry of water discharging from different serpentinizing sites are considerably different especially in the concentrations of methane, hydrogen and sulfate/sulfide. Since microbial community composition and metabolic activities rely on the geochemistry of the habitat, geochemical differences of respective serpentinization sites must affect to the selection of associated microbial taxa and the metabolic activities. Comparative physiological and genomic studies of the *Serpentinomonas* strains isolated from the two different serpentinization sites, The Cedars and the Cabeç o de Vide in Central Portugal, illustrated the evidence of potential adaptive evolution to the geochemistry of the site. Namely, genomic constitution of the *Serpentinomonas* strains were changed toward having advantages in the respective geochemistry of the springs where the strains were isolated. I further discuss the roles of *Serpentinomonas* strains in the carbon and sulfur cycling in the respective serpentinizing systems.

1) Suzuki et al. (2014) Nature Commun. 5, 3900

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