BIOENERGETIC AND KINETIC CONSTRAINTS ON MICROBIAL COMMUNITIES SUPPORTED BY WATER ROCK INTERACTIONS. D. E. LaRowe[1] and J. P. Amend[1,2], [1]University of Southern California, Department of Earth Sciences, 3651 Trousdale Pkwy., Los Angeles, CA 90089-0740, USA, larowe@usc.edu, [2]University of Southern California, Department of Biological Sciences, 3616 Trousdale Pkwy., Los Angeles, CA 90089-0371, USA, janamend@usc.edu

Introduction: The temperature and compositional conditions that promote the abiotic formation of appreciable amounts of compounds that can be used by microorganisms to gain energy typically do not also provide environments that are particularly conducive to life. For instance, chemical reactions associated with serpentinization can lead to the production of H_2, a bioavailable electron donor, but also extremely high pHs and an environment so reducing that electron acceptors are scare. As a result, fluids whose compositions are mostly derived from serpentinization reactions tend to have very low amounts of biomass in them. This is due to not only the low fluxes of energy supplied by the environment, but also the relatively high flux of energy needed to survive in such a challenging setting. Reconciling the environmental supply and microbial demand for energy is key to determining the extent of microbial communities that can be supported by water rock interactions. The purpose of this study is to quantitatively relate the amount of energy available to microorganisms supported by water rock interactions and the number of organisms that these reactions can sustain.

Methods: Determining whether a microbial population is growing, maintaining a steady state or declining in size can be directly related to the amount of power that is available to it using the model developed by [1]. In this approach, the potential for growth exists when the amount of power available from the environment exceeds the cumulative maintenance power. That is, if the rate of energy supply is larger than the amount of power required to maintain basic, non-growth functions, then this extra power can be used to build biomass. The amount of biomass that is made with this extra power is related to how much energy is takes to synthesize biomolecules. This is, in turn, a function of environmental conditions – the availability and type of carbon, nitrogen and sulfur sources, the oxidation-reduction potential, temperature and pressure, among others.

Cost of anabolism. One of the goals of this work is to quantify the cost of synthesizing biomass under different environmental conditions. In particular, it will be shown that the amount of energy required for anabolism is strongly dependent on (1) the average nominal oxidation state of carbon, NOSC, in the compounds that are used for anabolism and (2) the oxidation state of the environment where growth is occurring. For instance, the energy required to synthesize glycine (NOSC = +1) from CO_2 (NOSC = +4) under relatively oxic conditions, log a_{H2} = -9, is +87 kJ (mol glycine)$^{-1}$, whereas under more reducing conditions, log a_{H2} = -4, it's only +1.8 kJ (mol glycine)$^{-1}$. If acetate (NOSC = 0) is used as the carbon source for glycine anabolism, it's *exergonic* to synthesize glycine throughout a very broad range of redox states (from O_2 saturated water to log a_{O2} = -45).

An additional factor affecting the amount of energy required to make microorganisms is the size of cells and the proportions of biomacromolecules in them. In reviewing the literature, we have assessed that non-eukaryotic cell masses vary by at least two orders of magnitude, from 3 to 310 fg C cell^{-1}, and that the proportions of biomacromolecules such as proteins, lipids, and carbohydrates in cells can also vary substantially. By dry cell mass, the range of biomacromolecules vary as follows: protein (30% - 65%), free amino acids (0 – 12%), carbohydrate (5% to 45%), lipids (15% to 65%), RNA (3% to 15%) and DNA (0.5% to 3%). Taken together, the number of cells that can be synthesized by a joule of energy can vary by several orders of magnitude depending on environmental conditions, the size of the cells being made and the relative abundance of the biomolecules that make it up.

Power supply. The amount of power available to microbial communities as a result of water reactions is dependent on numerous factors such as the rock type involved, temperature and pressure, the surface area of the reactive interface and the fluid flow rate. For a variety of electron acceptors, we will show how much H_2 must be produced by serpentinizing fluids in order to sustain microbrial communities observed to be in serpentinizing fluids (e.g., [2]), and how much it would take for the population to double over various time scales.

References: [1] LaRowe D. E. and Amend J. P. (2015) *AJS, 315,* 37p. [2] Morrill et al., (2013) *GCA, 109, 222-240.*