An electron/carbon cycle in an acidothermophilic microbial community

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Iron –oxidizing microbial communities of limited diversity inhabit acidic thermal springs (pH ~3, >65 ºC) in the Norris Geyser Basin of Yellowstone National Park. These systems are generally depleted in carbon (dissolved organic carbon content of ≤ 0.6 ppmC and ~ 1 wt% C within the mat itself) and show low autotroph abundance (~ 75 % of microbial sequences are associated with strict heterotrophy), suggesting a high demand for organic compounds produced by autotrophic processes within the system. *Metallosphaera yellowstonensis* is an Archaean comprising up to 20 % of the communities in these systems (based on sequence reads from several springs). Previous work with *M. yellowstonensis* (Jennings *et al*, Appl. Environ, Microbiol., in review) demonstrates the organism is a facultative autotroph. Further, when cultured under autotrophic conditions, *M.* yellowstonensis secretes formaldehyde. We sought to understand whether, given the low bioavailability of carbon in these systems, formaldehyde secreted by *M. yellowstonensis* could be a carbon currency in its native microbial mat.

We used a ^{13}C label approach to track formaldehyde uptake and fate in the mat under *ex situ* incubations. We observed formaldehyde oxidation to CO_2 in these incubations suggesting its utilization as a metabolic electron donor. Further, we measured conversion of formaldehyde carbon into microbial biomass, suggesting it may also be a carbon source for a heterotrophic component within the system. In both cases, conversion of formaldehyde to CO_2 or biomass exceeded that observed in killed controls suggesting bioactivity. Analysis of metagenomic data revealed the presence of the tetrahydrofolate formaldehyde pathway, which can catalyze oxidation or assimilation (through a formate intermediate) of formaldehyde. This pathway is housed in an operon associated with a *Thaumarchaeota* genome observed in the system. Our data thus suggests formaldehyde may act as a carbon and electron shuttle between two different members of this community; an autotrophic and heterotrophic component suggestive of a direct interaction between *M. yellowstonensis* and a *Thaumarchaeota sp*.