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Carbon isotope charactersitics of iron-oxidizing bacterial mats, Jackson Creec, Bloomington, IN, USA.

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We have investigated the isotopic composition of iron-rich microbial mat deposits that formed at the outflow of a freshwater spring along Jackson Creek in SE Bloomington/Indiana. The spring waters are of near neutral pH and contain dissolved iron (Fe^{2+}) that is derived from oxidation of diagenetic pyrite in the Mississippian Borden Formation. Although one might assume that iron deposition is simply due to oxidation to Fe^{3+} and subsequent precipitation of iron hydroxides, iron deposition is directly correlated with a thriving community of iron bacteria. The bacteria form loaf-shaped and bulbous buildups up to 20cm diameter, as well as undulose mats of a few cm thickness that cover the creek bed. The sheath forming bacterium *Leptothrix* dominates, but spiral stalks of *Gallionella* are commonly present, as well as other currently unidentified microbes. Microbial growth

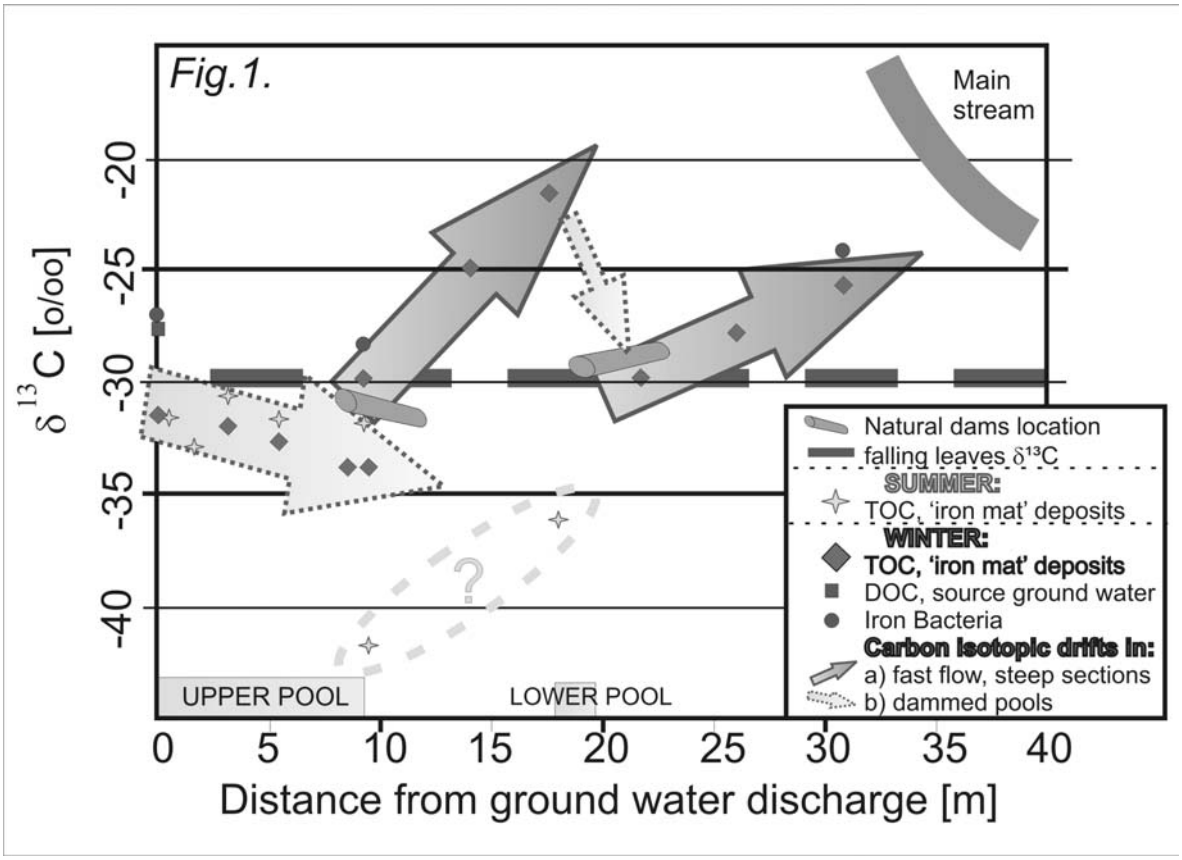

Fig.1. Changes in $\delta^{13}C$ values of organic carbon from microbial mats along the creek. Additionally $\delta^{13}C$ values of DOC in the spring, decaying leaves and of bacteria are shown.

forms are fragile and are flushed out entirely during peak runoff associated with heavy rains. However, regrowth of microbial mats is vigorous and full mat coverage can be achieved within a weeks of time.

Chemoheterotrophs like *Leptothrix* are not considered true iron oxidizers, and precipitation of iron is considered spontaneous without providing energy to the organism. But some authors suggest that *Gallionella* (chemoatuotroph) may gain energy from the process and in addition gets carbon for building its cells from CO_2 as shown in the reaction:

$$4Fe^{++} + HCO_3^- + 10H_2O \rightarrow 4Fe(OH)_3 + [CH_2O] + 7H^+$$

However, the apparent independence of the mat formers in our study from seasonal variations in organic matter supply (their growth rate shows no change with seasonal fluctuations), as well as their occurrence only near a source of iron-rich (12.5 ppm Fe) waters, seems to suggest that iron availability confers a tangible benefit. This benefit could be energy gain or alternatively a reduction of ambient pO2 because *Leptothrix and Gallionella are* considered microaerophilic. This open question may be answered in the near future through an ongoing examination of iron isotopes.

Carbon isotope data from terrestrial iron bacteria mats show fractionation relative to the composition of the likely source material. Also we have observed very high ability of these bacterial colonies to drift its carbon isotopic values in order of 1‰ per 1 meter down the creek. Observed dirfts occure in both directions and the direction depends on flow regime and availability of carbon supply. On fig.1 one can notice that in dammed pools in the creek isotopic shifts toward more negative values are observed due to organic matter build up and recycling. Contrary in the fast flow sections the situation of limited nutrient supply occurs as the water flows down, thus the remaining portion of DOC flowing down the creek gets heavier and heavier as bacteria preferentially uptake isotopically lighter nutrients. These observations were confirmed by the relationship of TOC content in the mats and its carbon isotopic composition. When there is plenty of DOC we observe higher TOC content in colonies and more negative $\delta^{13}C$ values. Again, contrary in zones with regime of limited DOC supply we observe lower TOC content in the colonies and less negative $\delta^{13}C$ (fig.2).

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Thus, carbon isotope fractionation may be used as a potential biosignature for identifying microbial involvement in fossil equivalents. Microbial recycling of initially produced organic compounds may impart further fractionation, and can produce broad and perhaps erratic appearing C-isotope signatures. Also primitivness and self-sufficiency as well-as well compounds on which these organism rely (especially *Gallionella*) makes them a good candidate for extraterrestrial forms of live that could have been evolved in similar environments to the Early Earth, like with high probability Mars was 3.5 billion years ago.

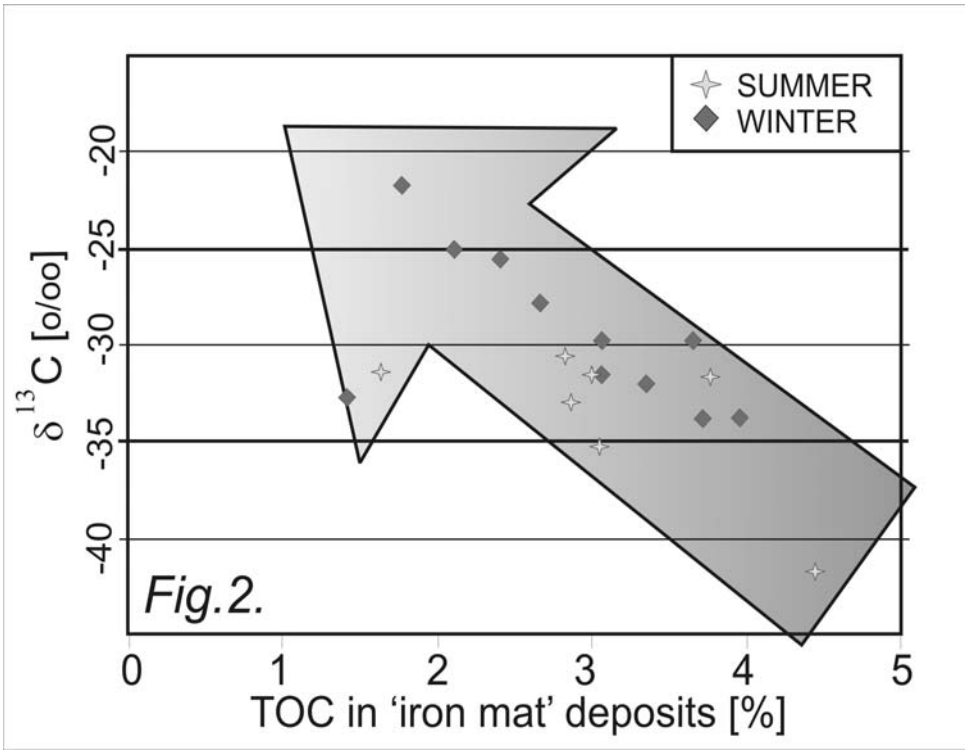

Fig.2. Inversely proportional relationship between TOC abundance in the mat material and its $\delta^{13}C$ values.