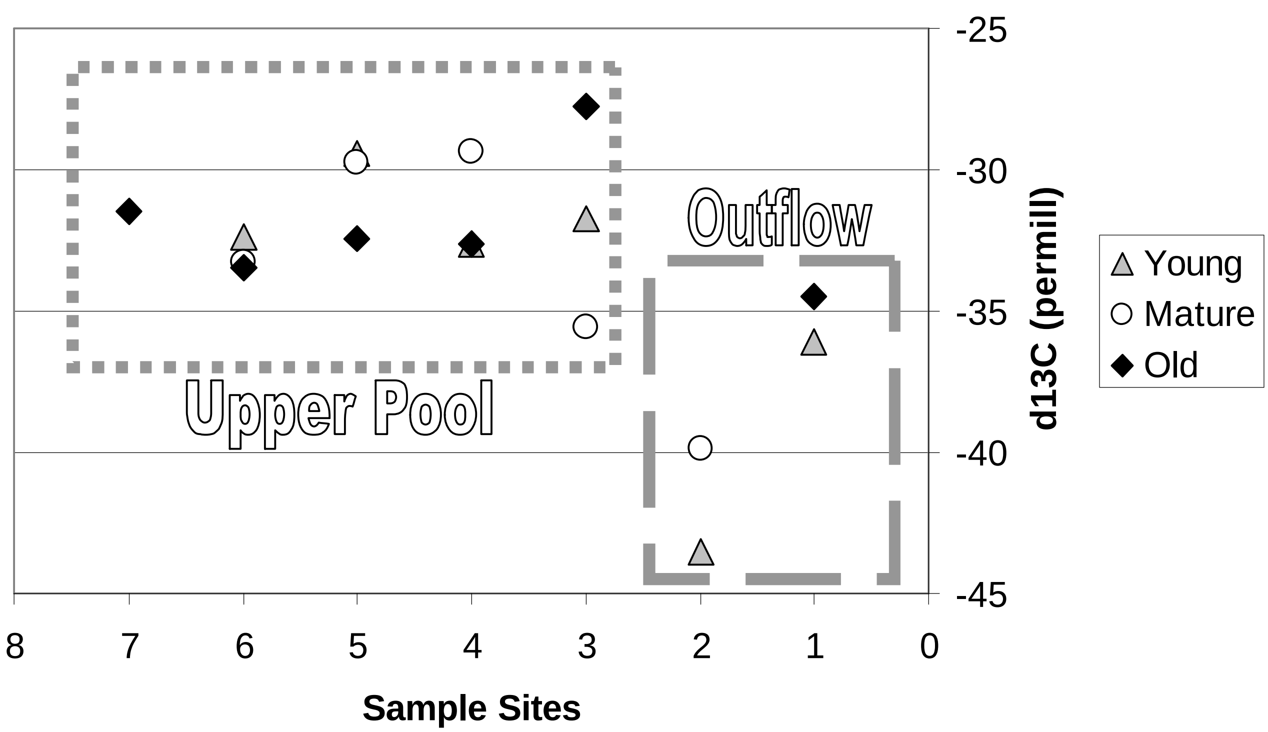
CARBON ISOTOPE CHARACTERISTICS OF SPRING-FED IRON-PRECIPITATING MICROBIAL MATS: D. Strapoc and J. Schieber, Department of Geological Sciences, Indiana University, Bloomington, Indiana 47405, dstrapoc@indiana.edu.

Introduction: 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 build-ups 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 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 time.

Growth Patterns: Within 5 days after mat erosion most of the creek bed is again covered with a velvety, buff colored microbial mat layer, and within a week to 10 days domal and bulbous morphologies are common. Three types of mat growth can be distinguished: (1) young growth, buff colored, dominated by active *Leptothrix* filaments and sheaths in the beginning stages of mineralization; (2) mature growth, with a larger proportion of well mineralized sheaths; and (3) old growth, dominated by iron mineralized sheaths and few active *Leptothrix* filaments. When the latter stage is reached the mats start to decay and break up into cm-size flocs that are washed further downstream. This growth pattern, where living Leptothrix filaments continuously abandon their old sheaths is well documented from experiments [1].

Figure 1: Jackson Creek Iron Spring Mats



Sampling and Analysis: Seven sets of samples (young, mature, old) were collected along the course of the stream for carbon isotope analysis. Samples were sieved to remove detrital organic matter (plant debris mostly), freeze dried, acidified to remove sedimentary carbonate particles, and analysed for ?^{13}C. In addition, samples of leaf litter and woody particles were collected from the stream and analysed for ?^{13}C.

Results: Fig. 1 shows the carbon isotope data for the sample sets taken along the course of the stream. There is not much variability for sample sets 3 through 7. The average ?^{13}C value for young mat is -31.5 permill, -32 permill for mature mat, and -31.6 permill for old mat. The ?^{13}C values for sample sets 1 amd 2 are generally lower, with -39.8 permill for young mat, -39.9 for mature mat, and -34.5 permill for old mat. Decaying plant matter collected from the stream has an average ?^{13}C value of -29.8 permill, and detrital carbonate grains (from Borden Formation) average -0.5 permill.

Sample sets 3 though 7 come from a portion of the creek that is dammed by obstacles and forms a shallow pool (“upper pool”, Fig. 1) that is directly fed by the iron-rich spring. After an erosive event mat growth occurs simultaneously over the entire pool, indicating that growth conditions are uniform for the pool area. The dominant iron bacterium in the mats, Leptothrix, is a chemoheterotroph and uses preexisting organic substances as both carbon and energy sources [2].

Microbially mediated precipitation of minerals typically imparts an isotopic shift in those elements that are involved in the microorganisms metabolic functions. For terrestrial microorganisms a preference for ^{12}C commonly leads to a negative shift in ?^{13}C. The shift to negative ?^{13}C values relative to the detrital organic matter may thus indicate that dissolved organic compounds derived from decay of leaf litter may be the organic matter source for the mats. However, growth rates of mats are unchanged between times of the year when we have abundant organic detritus in the creek (fall-winter), and times when we have greatly dimished supply (spring-summeer), suggesting that perhaps dissolved organic matter in the spring waters is the source of organic compounds. The uniform average ?^{13}C values for the different growth stages of the “upper pool” suggest a source of uniform composition. Work is underway to resolve the question whether this source is dissolved organic matter in the spring waters, or microbially driven decay of plant debris.

The water in the “upper pool” is moving slowly and organic detritus (leaf litter etc.) stays trapped. In contrast, the water of the outflow stream flows swiftly (~1m/s) and does not allow accumulation of plant debris in the flow channel. Organic matter that washes down the channel is primarily old mat material from the “upper pool”, explaining the similarity in ?^{13}C values between old mat material in the outflow channel and the “upper pool” area. The shift to more negative ?^{13}C values for young and mature mats in the outflow channel probably reflects recycling of organic matter from flocs of old mat material from the “upper pool”.

Discussion: Chemoheterotrophs like *Leptothrix* are not considered true iron oxidizers, and precipitation of iron is considered spontaneous without providing energy to the organism [2]. 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 (13 ppm Fe) waters, seems to suggest that iron availability confers a tangible benefit. This benefit could be energy gain [3] or alternatively a reduction of ambient pO_2 [2] because *Leptothrix* is considered microaerophilic. This open question may be answered in the near future through an ongoing examination of iron isotopes [4].

Conclusion: .Carbon isotope data from terrestrial iron bacteria mats show fractionation relative to the composition of the likely source material. Thus, C-isotope fractionation may be used as one 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.

References: [1] Mulder, E.G., and Deinema, M.H. (1981) in *The Prokaryotes*, Springer, 425-441. [2] Nealson, K.H. (1982) in *Mineral Deposits and the Evolution of the Biosphere*, Springer, 51-65. [3] Robbins, E.I. et al. (1987) in *Precambrian Iron Formations*, Theophrastus, 69-125. [4] Beard, B.L. et al. (2003) *Chemical Geology*, 195, 87-117.