Geophysical Research Abstracts
Vol. 12, EGU2010-6122, 2010
EGU General Assembly 2010

Would acetate (or its derivatives) be the most reliable guide to life on terraqueous globes?

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At bottom life hydrogenates carbon dioxide. But so does serpentinization—to methane—hence the problem of diagnosing its source (Mumma et al. 2009). However, this abiotic process does not appear to produce acetate or acetic acid (CH_3COOH) in measurable quantities—only the acetogenic and sulfate-reducing bacteria do that. On the early Earth it seems that the homoacetogens were the first to resolve the tension between CO_2 and H_2 via the autotrophic acetyl coenzyme-A pathway. The acetyl co-A pathway employs two separate redox controlled tributaries—one Ni-Fe-directed, merely reduces CO_2 to CO, while the other, initially molybdenum-directed, reduces CO_2 through to a methyl group. The CO and the $-CH_3$ are then assembled on the nickel-bearing acetyl coenzyme-A synthase. Such a complex dual delivery system from contrasting redox conditions could not be prefigured by serpentinization but required a chemiosmotic drive, as did the origin of life itself (Nitschke and Russell 2009). Homoacetogens can compete successfully against the methanoarchaea for H_2 and CO_2 in the cold, as can the sulfate-reducing acetate-generating bacteria (Krumholz et al. 1999). Thus we argue that acetate or acetic acid effluent (depending on pH) from putative microbes on wet rocky planets would be a more reliable indicator of life.

What are the difficulties? The most critical is that in ground-waters and oceans with $pH > 5$ acetate remains in solution and would therefore not be detectable remotely. Even were the waters acidic enough to release volatile acetic acid, it would be prone to photo- and chemical oxidation. However, apart from CO_2 and CH_4, the products are formic (HCOOH), glycolic ($HOCH_2.COOH$) and tartaric (HOOC.HCOH.HOCH.COOH) acids (Ogata et al. 1981). Remote sensing in the ultraviolet to near-infrared might be used for detection of all these acids, especially when their concentrations are enhanced in plumes. In situ techniques would be required for acetate detection.

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