Compound specific isotope analysis and the challenge for identifying life: the role of biosignatures and abiosignatures

B. SHERWOD LOLLAR[1], G. LACRAMPE-COULOUME[1], J. TELLING[1], T.M. McCOLLOM[2] AND G.F. SLATER[3]

[1] Dept. of Geology, University of Toronto, Onatrio Canada M5S 3B1; bslollar@chem.utoronto.ca

[2]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder CO; mccollom@lasp.colorado.edu

[3]School of Geography and Earth Sciences, McMaster University, Hamilton, Ontario Canada L8S 4K1

A number of recent studies have suggested that if isotopically depleted delta 13C values are measured for CH4 in the atmosphere of Mars [1] or in fluid inclusions in Precambrian rocks [2], such measurements would be a definitive indicator of life. Yet recent evidence for significant depletion in delta 13C values for experimentally synthesized abiogenic hydrocarbons and for indigenous hydrocarbons in carbonaceous chondrites has confirmed that isotopically depleted delta 13C values are not the sole purview of biological processes.

In fact the use of isotope geochemistry to identify or rule out extinct or extant life requires not just an unambiguous understanding of what constitute biosignatures, but the ability to definitively identify non-biological processes as well, so-called abiosignatures. To that end, we present a mechanistic model describing carbon isotope variation in CH4 and higher hydrocarbons through to pentane produced by abiogenic polymerization. We demonstrate the ability of the model to account for proposed abiogenic hydrocarbons in a variety of different geological settings. We discuss the implications of this model for identifying the origin of CH4 in both terrestrial and extra-terrestrial systems, and for evaluating recent suggestions that gas-water-rock reactions such as serpentinization may support chemoautotrophic life in novel microbial ecosystems such as the Lost City hydrothermal vents [3]. Rather than a comparison of absolute ranges of delta 13C values, this approach emphasizes process-based models of isotopic variation patterns between hydrocarbons in proposed reaction series. Future progress will require such mechanistic models of isotopic fractionation in both biological and non-biological systems if we are to definitively distinguish abiogenic processes from the signatures of extinct and extant life, both on earth and elsewhere in the solar system.

References

[1] Oze C and Sharma M. (2005) *GRL* **32,** L10203 doi:10.1029/2005GL022691. [2] Ueno Y., Yamada K., Yoshida N., Maruyama S., and Isozaki Y. (2006) *Nature* **440,** 516-519. [3] Kelley D.A. et al. (2005) *Science* **307,** 1428-1434.