MICROSTRUCTURE-SPECIFIC CARBON ISOTOPIC SIGNATURE OF ORGANIC MATTER SUPPORTS BIOLOGIC ORIGIN IN ~3.5 GA CHERTS OF THE PILBARA CRATON. Navot Morag[1], Kenneth H. Williford[1,2], Kouki Kitajima[1], Pascal Philippot[3], Martin J. Van Kranendonk[4], Kevin Lepot[1,5], John W. Valley[1], [1]NASA Astrobiology Institute, WiscSIMS, Department of Geoscience, University of Wisconsin, 1215 W. Dayton St., Madison, WI 53706, USA, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA, [3]Institut de Physique du Globe de Paris, CNRS and Université Denis Diderot, 4 place Jussieu, 75005 Paris cedex, France, [4]Australian Centre for Astrobiology, Univ. New S. Wales, Kensington 2052, Australia, [5]Université Lille 1, Laboratoire Géosystèmes, CNRS UMR8217, 59655 Villeneuve d'Ascq, France.

The Dresser Formation from the North Pole Dome of the Pilbara Craton (Western Australia) contains some of the oldest evidence for life on Earth, dated to ~3.5 Ga [e.g. 1–4]. Here, we present a detailed study of microstructures and carbon isotopic analysis of organic matter (OM) preserved in the Dresser Formation's bedded cherts and hydrothermal chert veins using in situ Secondary-Ion Mass Spectrometry (SIMS). The OM in these rocks occurs mainly as amorphous clots, which, together with minor fine OM layers and laminae, are considered primary textures formed prior to the host rock lithification. Other than rare OM-rich stylolites, no evidence was found for later OM migration beyond the micron scale. OM microstructures were analyzed using ~15 µm spot size and standardized against a natural OM-bearing chert standard, with spot-to-spot heterogeneity yielding external precision ("reproducibility") of 2–4‰. Individual values of $\delta^{13}C(OM)$ in all studied samples range between -24.4 and -37.8‰. No correlation is seen between measured $\delta^{13}C$ values and H/C ratios in the studied OM microstructures. This lack of correlation and the very low metamorphic grade of the rocks studied argue against significant modification of the OM isotopic composition by later metamorphic/hydrothermal alteration [e.g. 5]. It is thus concluded that the range of $\delta^{13}C(OM)$ values found in the samples represent indigenous OM isotopic heterogeneity. Average $\delta^{13}C(OM)$ values in specific microstructural types range between -32.7‰ and -25.7‰ (Fig. 1), and when compared with associated carbonate (ankerite) $\delta^{13}C$ values result in C isotopic fractionation [$\Delta^{13}C(Ank–OM)$] of 25–32‰, which translate to dissolved CO_2–OM isotopic fractionation [$\Delta^{13}C(CO_2–OM)$] = 20–27‰. This range of $\Delta^{13}C(CO_2–OM)$ is compatible with the range of isotopic fractionation observed in modern photoautotrophs utilizing the Calvin cycle and chemoautotrophs utilizing the reductive acetyl-CoA pathway [6]. The possibility of chemoautotrophic primary productivity is supported by the potentially hot, dark, reducing environment inferred for the Dresser hydrothermal veins, which is similar to modern environments where such organisms thrive. Although simple abiotic hydrocarbons (namely methane) may have been present in the hydrothermal fluids, the possibility that the studied OM was formed by abiotic precipitation/condensation of these compounds is inconsistent with its distribution, microstructures and range of $\delta^{13}C(OM)$ values reported here. OM clots found in all of the samples studied show a texture consistent with a polymerized residue of degraded microbial biomass. The lowest $\delta^{13}C$ values found in this study are recorded within denser OM domains preserved in some of the clots, which probably represent the most pristine, less degraded form of the original OM. The observed range of higher $\delta^{13}C$ values may therefore represent varying degrees of heterotrophic degradation of the original chemoautotrophic biomass, indicating the existence of a complex microbial ecology in the upper (~20 m) part the Dresser hydrothermal system and nearby seafloor sediments.

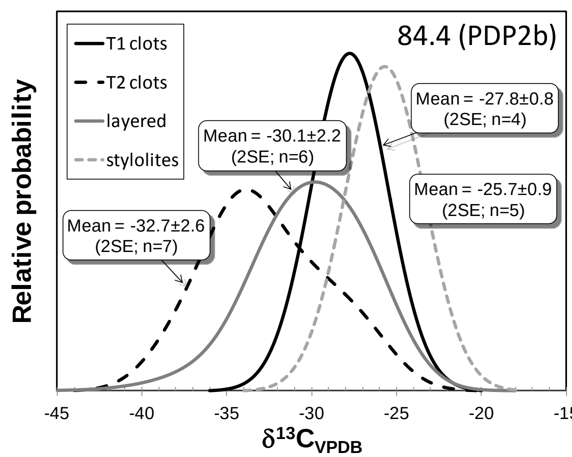

Figure 1: Relative probability diagrams of $\delta^{13}C(OM)$ values (‰ VPDB) in one of the studied samples.

References: [1] Walter M. et al. (1980) *Nature, 284*, 443–445. [2] Awramik S. et al. (1983) *Precam. Res., 20*, 357–374. [3] Philippot P. et al. (2007) *Science, 317*, 1534–1537. [4] Van Kranendonk M. J. et al. (2008) *Precam. Res., 167*, 93–124. [5] Lepot K. et al. (2013) *GCA, 112*, 66–86. [6] House C. H. et al. (2003) *Org. Geochem., 34*, 345–356.