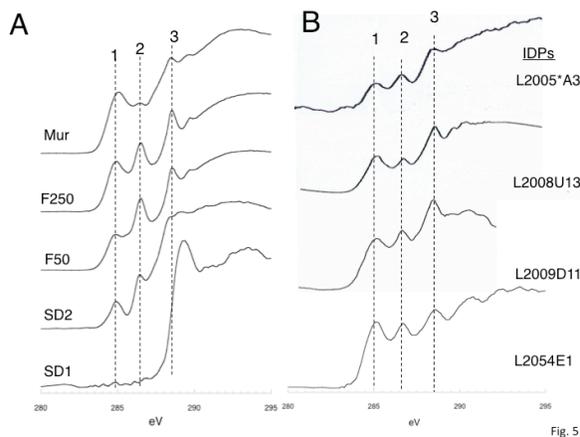


**TOWARDS A SELF-CONSISTENT EXPLANATION OF DEUTERIUM ABUNDANCE IN ORGANIC SOLIDS CONTAINED WITHIN PRIMITIVE SOLAR SYSTEM BODIES.** G. D. Cody<sup>1</sup>, Y. Wang<sup>1</sup>, Y. Kebukawa<sup>1</sup>, M. L. Fogel<sup>1</sup>, and C. M. O'D. Alexander<sup>2</sup>, <sup>1</sup>Geophysical Laboratory, Carnegie Institution for Science (5251 Broad Branch Rd., Washington, DC, USA. gcody@ciw.edu), <sup>2</sup>Department of Terrestrial Magnetism (5241, Broad Branch Rd., Washington, DC, USA).

**Introduction:** Primitive solar system objects, comets, chondritic asteroids (and meteoroids derived from them), and interplanetary dust particles (IDPs) contain a significant amount of so-called refractory organic solids, i.e., non volatile organic matter or insoluble organic matter, IOM. The origin of such solids has intrigued scientists for decades. Recently, it has been shown via molecular spectroscopy that the organic solids in outer solar system objects, comets (samples of Comet 81P/Wild 2 via the Stardust mission) and IDPs (captured in the Earth's stratosphere and derived from comets) are chemically related to organic solids contained within carbonaceous chondritic meteorites (obtained from meteorite falls and finds) and share a common origin. The precursor to organic solids in each of these Solar System objects is most likely interstellar formaldehyde that, during a post accretionary stage, has polymerized into a highly complex organic macromolecule [1]. Laboratory based synthesis of formaldehyde polymer and molecular spectroscopic comparison with genuine extraterrestrial organic solids lends considerable support to this conclusion (e.g. Fig. 1).

Isotopic analysis of extraterrestrial organic solids associated with type 1 and 2 chondrites and Interplanetary Dust Particles (IDPs) reveal enrichment in deuterium relative to terrestrial water, in some cases as much a 4 or more times so [2]. The origin of such enrichment has predominantly been accepted to be a signature of a very low temperature origin of organic solids and/or their lower molecular weight precursors. However, no simple relationship is observed when one attempts to correlate molecular structure with bulk D/H [3]. Furthermore, interstellar formaldehyde is typically very enriched in D/H [4], therefore, even "high" D/H extraterrestrial organics solids are actually much closer to solar D/H. This suggests that part of the Solar System D/H story, with regards to organic solids, is the loss of deuterium. In order to understand what D/H in Solar System organics actually is telling us we initiated a multi-pronged approach; first, we developed direct analysis of site specific D/H in chondritic organic solids. Second, we initiated laboratory based experimentation to understand the molecular nature of D/H abundances in context with gaining insight on evolution of volatiles during early Solar System evolution. We find that there are several stages that influence the ultimate D/H ratio in Solar System organic solids and lead to the complexity in interpreting bulk D/H. First, during post accretionary formaldehyde polymerization phase, the D/H of the associated H<sub>2</sub>O strongly influences the D/H of the formaldehyde polymer. Subsequent, post lithification asteroidal processes lead to a particularly systematic and unique trajectory in D/H evolution. Finally, D abundances can be reset once more during thermal metamorphism. We found that the first and last stages of organic D/H evolution will strongly control the D/H of the associated water; thus there is a strong connection between the origin and evolution of organic solids and the D/H of associated water. These results may help to explain the wide variation of deuterium abundances in cometary water.



**Fig. 1. A.** Carbon X-ray Absorption Near Edge Structure (C-XANES) spectra of organic solids from Comet 81P/Wild 2 (SD1 and SD2), laboratory formaldehyde polymer (F50 and F250) and organic solids from a carbonaceous chondrite (MUR). **B.** C-XANES spectra of various IDPs. Peaks 1, 2, and 3 correspond to aromatic, ene-ketone, and carboxyl functional groups (see [1] for details).

**Acknowledgments:** We are grateful for support from NASA's Astrobiology program, grant to CIW.

**References:** [1] Cody G. D. et al (2011) *Proc. Nat. Acad. Sci.* 108,19171-19176. [2] Alexander C. M. O'D. (2010) *GCA* 74, 4417-4443. [3] Cody G. D. et al. (2008) 39<sup>th</sup> LPS 1391 [4] Millar T. J. et al (1989) *ApJ* 340, 906-920