Detection of a Water Soluble Component of the Tagish Lake Meteorite. S. Wirick[1], G. Cody[2], G. J. Flynn[3], C. Jacobsen[1], L. P. Keller[4], K. Nakamura[4], M. Zolensky[4], [1]Physics Depart., SUNY, StonyBrook, NY 11974, (swirick@bnl.gov), [2]Geophysical Lab., Carnegie Institute, Washington, DC., [3] Depart. Of Physics, SUNY Plattsburgh, NY 12901, [4] NASA Johnson Space Center, Houston, TX 77058

Introduction: The Tagish Lake meteorite is a highly carbonaceous meteorite, with a carbon content of approximately 5% by weight [1]. Its composition and mineralogy suggest it lies between a CI1 and CM2 chondrite [2]. Part of the meteorite [the pristine fraction] was collected from the ice on Tagish Lake within one week of its landfall on Jan. 18, 2000 and this sample is considered to be the most pristine meteorite samples collected to date with regard to organic terrestrial contamination. It has been reported that only 100 ppm of the organic matter in the Tagish Lake meteorite is water soluble [3].

Instrumentation: Using the scanning transmission X-ray microscope (STXM) at The X1A beamline, National Synchrotron Light Source [4] both absorption images and X-ray absorption near edge structure (XANES) spectra were collected on the pristine Tagish Lake sample on both crushed and microtomed samples. Two microtomed samples were prepared by embedding a small chip of the meteorite into molten elemental sulfur and slicing 80nm thick sections. Five crushed samples were prepared by placing a small piece of the meteorite between 2 clean glass slides and crushing it. The larger pieces were tapped off of the glass slide and the finer pieces remaining on the slide were suspended in 6µl of sterilized, filtered water (Sigma. No. W3500). and 3 µl of this solution were dropped onto a silicon monoxide backed copper TEM grid and air dried. This technique selects for particle sizes less than about 3 microns and any water soluble compounds.

Results: Preparing one of the five crushed samples resulted in the formation of a thin film across a large area of the copper TEM grid. Approximately 1mg of sample is crushed between 2 clean glass slides but only approximately 0.1 mg or less of sample actually remains on the slide and is suspended in the 6µl of sterilized, filtered water. There were only a few particles that dried on the edge of the thin film. Figure 1 shows a carbon map of one of the microtomed sections and the spectra from both the thin film (black) and the microtomed section (red). There is some variability in the spectra, the microtomed section spectrum has a small absorbance at 285 eV, meaning there is a C=C present and the thin film absorbance at this energy is significantly smaller. Both spectra have an absorbance at 286 eV but again this is less in the soluble component. The soluble component has a greater absorbance in the sigma bonding region between 290-300 eV suggesting that the soluble material contains more CH/CH2/CH3 bonds than the microtomed piece.

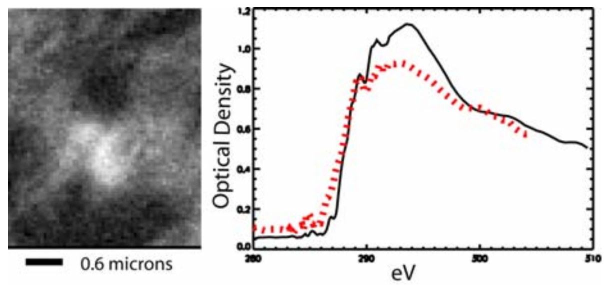

Figure 1. X-ray absorption carbon map of a microtomed section of the Tagish Lake meteorite and carbon XANES spectra from the white area in the carbon map (red) and a spectrum from the thin film formed from a crushed sample (black).

Figure 2 is a spectrum of the soluble component in the Tagish Lake meteorite and a spectrum of 1-palmitoyl-2-myristoyl-sn-glycero-3-phosphocholine, whose core structure consists of 2 fatty acids, glycerol and phosphate linked by an ester bond to an alcohol. The phosphate is linked to a nitrogen bond to four carbons (fig. 3).

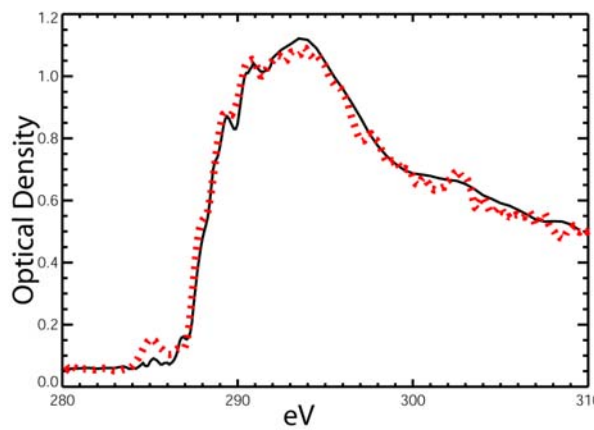

Figure.2. Spectrum from soluble component of the Tagish Lake meteorite (black) and spectrum from 1-palmitoyl-2-myristoyl-sn-glycerol-3-phosphocholine.

This spectrum was the best fit to the soluble material from our standard database.

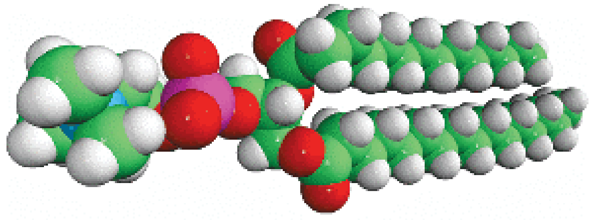

Figure3.Structure1-palmitoyl-2-myristoyl-sn-glycero-3-phosphocholine.

Discussion: Using carbon XANES spectroscopy we have analyzed the acid extracted organic material from 6 different meteorites; the indigenous organics in the Murchison CM2 meteorite; and over 30 chondritic interplanetary dust particles and we have not observed a spectrum in any of these similar to both the microtomed section or the soluble material from the crushed sample of the Tagish Lake meteorite. The differences between the material in the microtomed section and the soluble material suggest that they are either slightly different in structure or that water alters the structure of the material in the microtomed section. The piece of material in the microtomed section is very small, approximately 500nm in size, the method we used for the crushed sample selects for small particle size, < 3microns. If the soluble component in the Tagish Lake meteorite has a very small particle size, than our method of sample preparation would select for this.

Also, the microtomed section's spectrum has a stronger absorbance at 285 eV, suggesting that this contains more unsaturated carbon bonds and would therefore be more soluble than the thin film. Pizzerello, et al. [3] have reported that 100ppm of the organic matter in the Tagish Lake meteorite is soluble and of this 100ppm more than 70ppm of this organic carbon is carboxylic acids, dicarboxylic acids, pyridine carboxylic acids and dicarboximdes. We know from our standard spectrum of the 1-palmitoyl-2-myristoyl-sn-glycerol-3-phosphocholine that we have two asymmetric saturated fatty acids, a glycerol, and a phosphate linked by an ester bond to an alcohol and the phosphate is linked to a tetramine. We also know that the carbon number for this compound varies between 14-16 and it is not soluble in water. The soluble component in the Tagish Lake meteorite was very soluble with a conservative estimate of its solubility being on the order of 30g. per 100 g. water. Therefore, we know that either the carbon chains on this molecule have carbon numbers between 3-8 and/or it is more branched than our standard compound. The carbon chains are also saturated and contain no C=C. It is also likely that the carbon chains of the soluble component are linked through an ester, and that it also contains a glycerol.

Conclusions: It is known that the Tagish Lake meteorite contains water soluble compounds. We have measured carbon XANES on a thin film made from dissolving a size fractionated sample of the Tagish Lake meteorite in water. We have discovered a similar spectrum in a microtomed section and both of these spectra when compared to spectra from other meteorites and interplanetary dust particles are unique. The best standard fit suggests that this soluble component contains two fatty acids, and a glycerol linked by an ester bond to an alcohol to another molecule similar in structure to a phosphate.

References: [1] Grady, M. M. , et al (2001), Lunar and Planetary Sci. (XXXII), [2] Zolensky, M. E., et al (2002), Meteoritic and Planetary Sci, 37, 737-761. [3] Pizzarello, S., et al (23 Aug, 2001) Science, 1-10 [4] Jacobsen, C. et al (2000) J. of Microscopy, 197, 173-184.