DISTRIBUTION OF TERRESTRIAL AND EXTRATERRESTRIAL ORGANIC COMPOUNDS IN THE C2 UNGROUPED TARDA CARBONACEOUS CHONDRITE. L. D. Tunney[1], P. J. A. Hill[1], C. D. K. Herd[1], R. W. Hilts[2], and M. C. Holt[1], [1]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E3, Canada, Email: ltunney@ualberta.ca, [2]Department of Physical Sciences, MacEwan University, Edmonton, Alberta T5J 4S2, Canada.

Introduction: Studies of organic matter in astromaterials can provide a significant amount of information about the chemistry of the solar system and the processes that occur within it. This information can include insights into processes in the interstellar medium, solar nebula, and asteroidal parent bodies, and yield clues to the origin of life [1]. To determine and understand a meteorite's intrinsic properties, the processes they experience after formation need to be taken into account. In particular, processes at the Earth's surface can alter extraterrestrial organic material by modifying or destroying intrinsic organic compounds [2]. Although meteoritic organic compounds often have an identical terrestrial counterpart, each source has its own unique set of chemical signatures [3]. This makes distinguishing between extraterrestrial and contaminant compounds very important as it can dramatically change the conclusions we draw from organic matter analyses of astromaterials.

On August 25, 2020 the Tarda C2 ungrouped carbonaceous chondrite fall was reported in Morocco with a strewn field centralized around 31°49'35"N, 4°40'46"W. Over a couple days thereafter, thousands of small, friable stones were collected which were reported to have a charcoal-like odor [4]. Descriptions of the stones and their macroscopic characteristics are similar to those described for Tagish Lake [5].

The fall of the Tarda meteorite represents an opportunity to test the best methods for distinguishing between intrinsic and contaminant organic compounds, and develop protocols to minimize potential contamination during curation. Since organic matter signatures can be a mixture of terrestrial and extraterrestrial sources, sampling the terrestrial environment of the fall area can aid in characterizing the terrestrial components [6,7]. Here we present preliminary results of the soluble organic analysis on two Tarda meteorite fragments that were collected shortly after the fall, along with sand collected from where the meteorites fell.

Materials and Methods: Two Tarda specimens, weighing 3.64 g (UAlberta Collection #MET11800/1; "Tarda A") and 3.69 g (MET11800/2; "Tarda B"), along with a 7.61 g sand sample (Figure 1) from the collection area were obtained from Juan Poblador. The majority of each stone is enclosed in fusion crust; however, both have an exposed face of the interior. The fusion crust of the exteriors of both specimens were rinsed with 5 mL dichloromethane (DCM) then subsampled within a Class 1000 cleanroom in the University of Alberta Meteorite Curation Facility. Approximately 0.60 g from the interior of each specimen was powdered using a previously-combusted ceramic mortar and pestle. The powdered samples and ~1.5 g of the sand were each extracted with 5 mL of DCM 4 times at room temperature. All rinses and extractions were then evaporated to 0.2 mL and analyzed by gas chromatography – mass spectrometry (GC-MS) to determine the detectable DCM-soluble organic compounds present [8]. The GC-MS analysis was performed on an Agilent 5975C using a HP-5MS column (30 m length, 0.25 μm film thickness, 250 μm internal diameter) at MacEwan University. Detection was executed with an Agilent 5975C mass selective detector (MSD). Two blanks were processed with identical steps to monitor potential contamination introduced during the rinse and extraction. All materials used in the subsampling, rinsing, and extraction processes were cleaned with ultrapure water and HPLC grade DCM, and if possible, were combusted at 450°C for >6 hours. DCM extractions of swabs from surfaces within the curation facility were also analyzed to determine the base level of contamination that could influence the Tarda results.

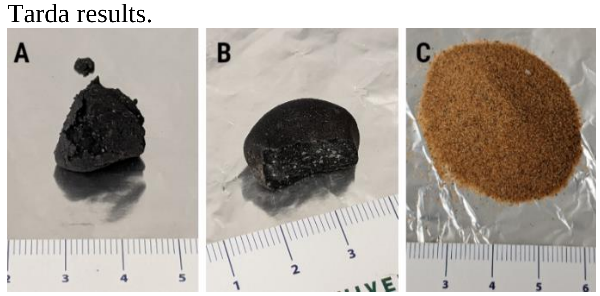

Figure 1. Images of Tarda A (A), Tarda B (B) and sand from the collection area (C) prior to subsampling. Scale bar in cm.

Results: The GC-MS results for Tarda were compared to the organic compounds detected in the sand sample and on laboratory materials to determine the source of non-intrinsic compounds (i.e., contamination).

Extraterrestrial Organic Compounds. The only, DCM-soluble, extraterrestrial organic compounds detected thus far in Tarda are two allotropes of elemental sulfur in the extractions of their interiors. Tarda A contained cyclic octaatomic sulfur (S8) whereas Tarda B contained both hexathiane (S6) and cyclic octaatomic sulfur. Elemental sulfur, such as S6 and S8, have been previously found in other carbonaceous chondrites like Tagish Lake and Aguas Zarcas [9,10]. No intrinsic organic compounds were observed on the rinses of the Tarda specimen exteriors.

Contaminants – Exterior Rinse. No contaminants were detected on the fusion crust of Tarda A. One contaminant, phthalic acid, di(2-propylpentyl) ester, commonly used in plasticizers, was found on Tarda B.

Contaminants – Interior Extraction. Tarda A contained one contaminant of a long chain saturated hydrocarbon, which was also in the Tarda sand extract. Tarda B was found to have 14 contaminants in total, 5 of which were also in the sand sample, and were either long chain saturated hydrocarbons or derivatives of phthalates. Compounds shared between the Tarda stones and the sand sample confirm their terrestrial surface origin. The additional compounds in Tarda B that were not detected in the sand (Table 1) are commonly used in agricultural products, fuels, pharmaceuticals, and plasticizers and are therefore likely terrestrial contaminants. These contaminants could be from the surface where the meteorites were recovered, as terrestrial surface contamination cannot be assumed uniform across the collection area, or resulted from handling conditions thereafter.

Table 1. Organic compounds found in Tarda B that are likely terrestrially sourced. The common terrestrial uses are listed for each.

Compound	Common Terrestrial Source
Bicyclo[4.1.0]heptane, 7-(1-methylethylidene)-	Pharmaceuticals and resins
Cholesta-3,5-diene	Pharmaceuticals
Cyclohexanol, 5-methyl-2-(1-methylethyl)-	Feedstock and plasticizers
Diethyl Phthalate	Plasticizers
Dihydropyrimidine-2-methyl thiosulfuric acid	Agricultural products and pharmaceuticals
o-Cymene	Fragrances and pesticides
Phenol, 2-[4-(2-hydroxyethylamino)-2-quinazolinyl]-	Disinfectant, pesticides, pharmaceuticals, and resins
Phthalic acid, isobutyl non-5-yn-3-yl ester	Plasticizers
Propanol, 2-methyl-3-phenyl-	Agricultural products, disinfectants, fragrances, fuels, and pharmaceuticals

Contaminants – Laboratory Materials. No organic compounds originating from materials used within the laboratory were detected on either of the Tarda specimens or within the sand sample. The absence of contaminants, or those below our detection limits, in the laboratory setting suggests that all the terrestrial organic compounds are sourced from the terrestrial surface or handling prior to arrival in the curation facility. This is further confirmed by finding contaminants in common between the sand sample and the Tarda specimen extractions.

Conclusions and Next Steps: The susceptibility of astromaterials to be contaminated highlights the importance of proper techniques when recovering and handling astromaterials in order to manage terrestrial contamination and preserve intrinsic properties for future research [11,12]. To accurately ascertain the source of organic compounds in astromaterials, collection of samples from the environment near the meteorite fall location is key. Not only is documenting terrestrial surface contamination crucial, but exploring how meteorite components interact with the surface provides important insights into how contamination occurs. This can include the percentage of the stone covered by fusion crust that may act as a barrier against contamination. In the case of Tarda, terrestrial organic compounds may have entered the meteorite through the exposed interior (where the fusion crust was removed during the fall). This conclusion is supported by the lack of significant contaminants found in the washes of the exteriors.

Future work on the Tarda meteorite and sand sample will include a hot water extraction for amino acid determination as well as petrographic analysis of each specimen to provide context for soluble organic studies. Methods are in development to improve detection limits. This work, along with further organic studies, will enable comparisons with Tagish Lake, a similar C2-ungrouped meteorite.

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