SPECTRAL REFLECTANCE PROPERTIES OF THE C2-UNGROUPED TARDA METEORITE. D. M. Applin[1], D. L. Schrader[2], E. A. Cloutis[1], T. Nakamura[3], and M. Matsuoka[4]. [1]Centre for Terrestrial and Planetary Exploration, University of Winnipeg, Winnipeg, Manitoba R3B 2E9, Canada (daniel.m.applin@gmail.com), [2]Buseck Center for Meteorite Studies, School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287, USA., [3]Department of Earth and Planetary Material Sciences, Faculty of Science, Tohoku University, Aoba, Sendai, Miyagi 980-8578, Japan., [4]Laboratoire d'Etudes Spatiales et d'Instrumentation en Astrophysique (LESIA), Observatoire de Paris, 92195 Meudon, France.

Introduction: The Tarda meteorite fell in Morocco on August 25th, 2020 [1]. Analyses have found Tarda to be dominated by phyllosilicates, with minor amounts of olivine, magnetite, Fe-sulfides, and dolomite. Tarda is distinct from CI and CY chondrites; and displays no evidence for heating [2,3]. Bulk isotopic composition [2,3] is similar to that found in Tagish Lake, which suggests that Tarda is similar to the C2-ungrouped Tagish Lake and the Tagish Lake-like meteorites Meteorite Hills (MET) 00432 and Wisconsin Range (WIS) 91600 [4–7]. To extend understanding of the connection of Tarda to this putative meteorite group, [8] studied the petrography, bulk H-C-N abundance and isotopic compositions, and in situ chemical compositions of the metals, sulfides, and chondrule silicates of Tarda and found that it shares a genetic relationship with Tagish Lake.

The spectral reflectance properties of the Tagish Lake-like meteorites; albedo, spectral slope, and VIS shape, have led to suggestions that they may be samples from D-type asteroid(s), which potentially formed in the outer Solar System between 8 and 13 AU [3,4,6,9]. Here, we study the spectral reflectance properties of the Tarda meteorite in order to assess similarities to the Tagish Lake-like meteorites and its possible provenance.

Samples and Experimental Procedure: We analyzed an aliquot of unsorted Tarda powder made from 1.03 g of homogenized fusion crust free fragments that were collected within days of the fall. This is the same powder used by [8] to show the genetic relationship with Tagish Lake. We also analyzed a 0.2384 g fusion crust free chip.

Reflectance spectra from 350 to 2500 nm were measured relative to a calibrated Fluorilon standard with an Analytical Spectral Devices LabSpec4 Hi-Res spectrometer at i=30°, e=0°. Reflectance from both a fine unsorted powder and a small, flat chip of the stone were collected. The powder was packed into an aluminum sample cup by first gently pouring, then tapping the cup several times, and finally scraping the excess off with a glass slide held away from the sample at 45°. The powder was repacked in its sample cup three times, and no significant variation in the reflectance was observed. The field of view for all measurements was roughly 4 mm in diameter.

Results: The reflectance spectra of the Tarda meteorite powder are shown in Figures 1–3. The spectra show an overall low reflectance (<0.03 in the visible region), a relatively strong spectral red slope, and an upper concave shape in the visible region. Continuum-removed spectra from the ~1 micron region reveal possible weak absorption bands (<3%), but these do not appear to significantly match with any phyllosilicates or other carbonaceous chondrite groups. Of the known groups, the reflectance spectra appear most like those of the CIs in terms of spectral shapes [e.g., 10], but without any strong matches. Overall, the VNIR spectral properties of Tarda are best matched by WIS 91600 and the other Tagish Lake-like meteorites that have been measured.

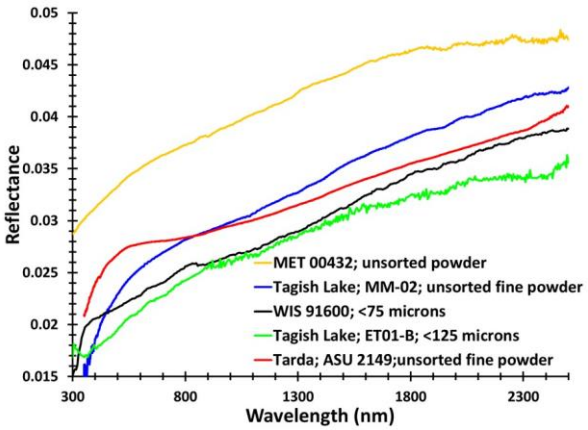

Figure 1. Reflectance spectra of Tarda and other Tagish Lake-like meteorites.

Discussion and Conclusions: In comparison with Tagish Lake and WIS 91600, the reflectance spectra of Tarda have a less red spectral slope. The spectral slope is closer to that of MET 00432 [from 11], but this may be due to a potentially coarser grain size distribution of MET 00432. The overall albedo of Tarda is very similar Tagish Lake and WIS 91600, which may be expected, given the relatively similar concentration of opaque materials [8]. The most noticeable difference between Tarda and the other Tagish Lake-like meteorites is the existence of the upward concave spectral shape.

These results suggest that Tarda has strong similarities with the Tagish Lake-like meteorites, yet exhibits some spectral differences that are expressed as

subtle CI/CM similarities. It remains to be seen whether multiple lithologies of the Tarda meteorites exhibit different spectral reflectance properties, which may be expected, given the spectral diversity in Tagish Lake lithologies [Figure 1; and refs 4 and 12].

Previous work has shown that some P-type asteroids exhibit reflectance spectra that can be described as intermediate between CI/CM chondrites and Tagish Lake [13]. Given the strong spectral similarities of Tarda to the Tagish Lake-like meteorites, yet subtle similarities to CI spectra, Tarda could be described as a meteorite that falls within this space.

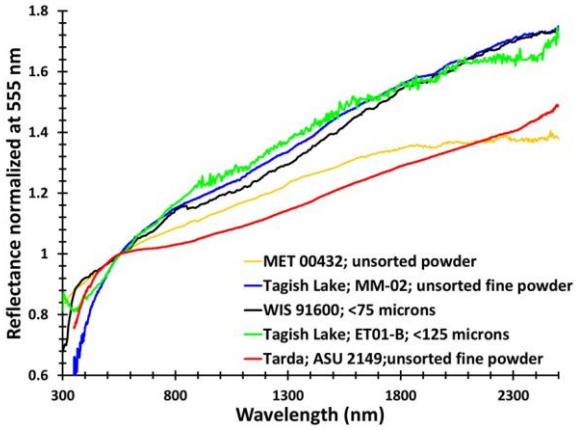

Figure 2. The same as Figure 1, but normalized.

As seen in Figure 3, the spectral slope and shape of the Tarda meteorite spectra share affinities with some Tholen P-type and/or Bus X/Xc-type asteroids, with a medium spectral slope, a upper concave VIS shape and no resolvable absorption band between 400 and 500 nm [e.g., 14]. The reflectance spectra from both asteroids 65 Cybele and 76 Freia fall between the spectral slopes of the Tarda powder and chip, which may suggest that variations in grain size distribution of Tholen P-type asteroid surfaces should not strongly affect the applicability of Tarda as an analogue material, or vice versa. The visible spectral shape of these two asteroids also resemble that exhibited by Tarda. Given the similarities in spectral slope and visible spectral shape, it likely the Tarda and these asteroid surfaces are made of similar materials.

The results presented by [8] show a strong possibility that Tarda originated from the same outer Solar System asteroid as Tagish Lake. If not the same asteroid, it formed under similar conditions with similar precursor materials. Here, we find that the spectral reflectance properties of Tarda most closely resemble those of the Tagish Lake-like meteorites, yet exhibit some affinities for CI/CM meteorites. The reflectance spectra from this lithology of Tarda appear to be a closer match to some Tholen P-type asteroids than to Tholen D-types. Should further lithologies exhibit similar reflectance properties, it may be that Tarda could represent the first sample of a P-type asteroid surface. These results are not contradictory, but highlight that numerous other possible scenarios exist; including that very subtle compositional differences could explain variations in spectral taxonomies of asteroids. This also highlights that these subtle differences also affect meteorite reflectance spectra and that isolating the controlling variables of materials bearing multiple opaque phases with variations in chemical compositions is complex.

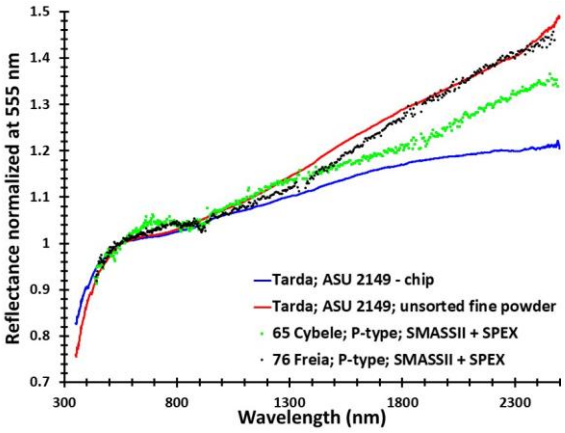

Figure 3. A comparison with the Tarda reflectance spectra with some Tholen P-type asteroid spectra, which are from [15, 16].

Acknowledgments: We thank the ASU Buseck Center for Meteorite Studies for the samples used in this study and NASA grant NNX17AE53G (DLS PI, TJZ Co-I) for funding a portion of this research. This study was also supported by the Canadian Space Agency, NSERC, and the U. of Winnipeg. The C-TAPE was established with funding from the Canada Foundation for Innovation, the Manitoba Research Innovations Fund, and the CSA.

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