DISCOVERY OF THE FIRST D-ASTEROID SPECTRAL COUNTERPART: TAGISH LAKE METEORITE. T. Hiroi[1], M. E. Zolensky[2], and Carle M. Pieters[1]. [1]Dept. of Geological Sciences, Brown University, RI 02912, USA (takahiro_hiroi@brown.edu), [2]SN2, NASA Johnson Space Center, Houston, TX 77058, USA.

Introduction: Virtually all meteorites are believed to come from asteroids, excluding known lunar and martian meteorites, and the original asteroid of each meteorite class is usually determined through reflectance spectroscopy. However, there are several spectral types of asteroids whose meteorite counterparts have not been found. Among them are P and D asteroids which are by some believed to be made of "super-carbonaceous" chondrites [1]. Here we report a discovery of the first D asteroid spectral counterpart, Tagish Lake meteorite, a new ungrouped C2 chondrite [2].

Experimental: Two chip samples (ET01b and PM05c) of Tagish Lake carbonaceous chondrite were separately ground and sieved into powders of <125 µm in grain size. While both samples were found months after the fall and somewhat degraded, ET01b was still very unaltered. UV-Visible-NIR spectra and FT-IR spectra of the samples were measured [3].

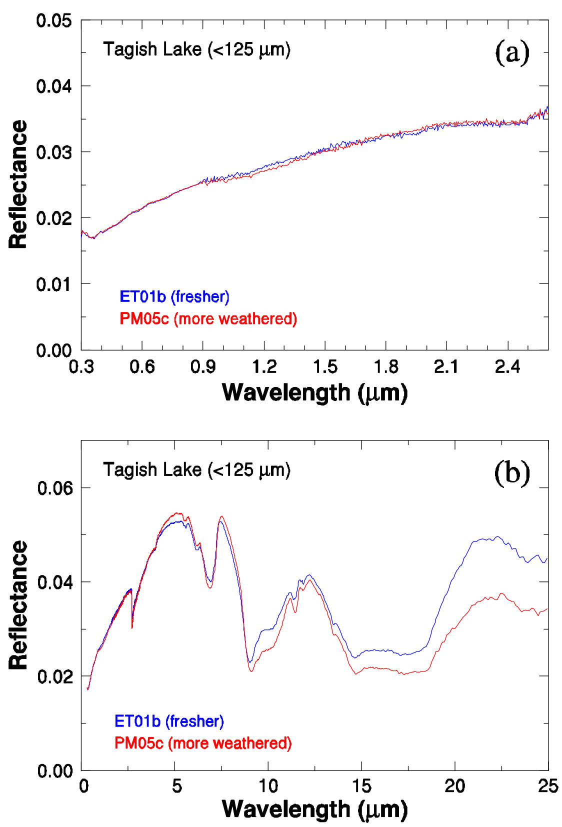

Fig. 1. Reflectance spectra of powder (<125 µm) samples of Tagish Lake meteorite of two different degrees of weathering.

Effects of terrestrial weathering: Reflectance spectra of the two samples are shown in Fig. 1. The two spectra seem to show almost identical features except for difference in absorption band strength around 1 and 10 µm. It is possible some of terrestrial weathering products were evaporated during open-air measurements or due to heating by FT-IR beam. Neither sample shows a typical oxidation feature around 0.5 µm nor strong water absorption features around 1.4 and 1.9 µm. Spectrally effects of terrestrial weathering for these samples are thus estimated to be small.

Spectral comparison with asteroid classes: Because reflectivity of Tagish Lake is very low (2-4 %), comparison of its reflectance spectrum was made only with dark asteroid spectra. Shown in Fig. 2 are average reflectance spectra of the G, B, C, F, T, P, and D asteroids [4, 5, 6] together with fresher sample of Tagish Lake. As easily seen from Fig. 2, either P or D asteroids are the best spectral match with Tagish Lake both in overall spectral shape and albedo. By careful observation of the visible (0.55 µm) spectral curvature tells us that the D asteroids are the best candidate.

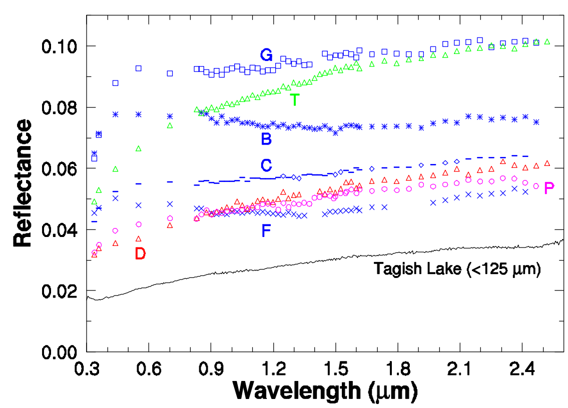

Fig. 2. Comparison of reflectance spectra of Tagish Lake meteorite sample (ET01b <125 µm) and averages of telescopic spectra of low-albedo asteroids [4, 5, 6].

Best spectral counterpart of Tagish Lake: After comparing the Tagish Lake spectrum with each one of asteroid spectra used for calculating the average P and D asteroid spectra (P asteroids 46, 65, 76, 153, and 476; D asteroids 336, 368, and 773), it became clear that the asteroid 368 Haidea is the best match with Tagish Lake if the asteroid spectrum is scaled for the best fit as shown in Fig. 3. Although there is a slight mismatch around 0.4 µm, the match is far better than any other asteroid. The IRAS albedo [7] of 368 Haidea is 3.2 %, which is somewhat higher than the optimized reflectivity 2.1 % at 0.55 µm. This discrepancy may either mean that the surface regolith of 368 Haidea is more fine grained than this Tagish Lake sample or that the asteroid surface returned more specular reflection. Because estimating the relationship between the visible reflectance at a certain viewing geometry and asteroid albedo involves many parameters such as optical phase function of each component particles, addressing the significance of this brightness difference is premature at this point.

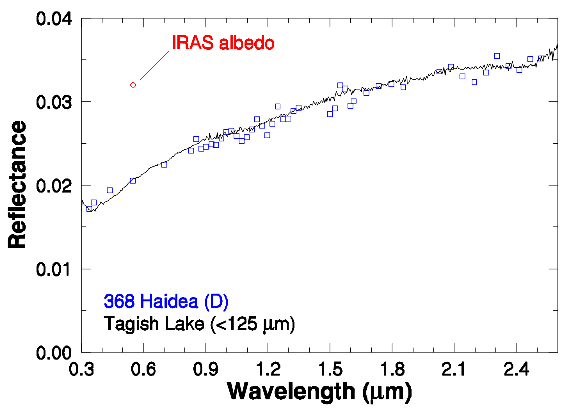

Fig. 3. A D asteroid 368 Haidea scaled for the best fit with Tagish Lake meteorite sample (ET01b <125 µm). Reflectance spectrum of Haidea is plot in open squares, and its IRAS albedo [7] in an open circle.

Parent body of Tagish Lake meteorite: Because Tagish Lake shows a reflectance spectrum most similar to the D asteroids among all the asteroid observations, if we are to look for its parent body, a D asteroid would be the best bet. As shown in Fig. 4, the D asteroids distribute widely in the main belt while they are relatively abundant in the outer belt and beyond. Because of such biased abundance of large D asteroids, it was often presumed that meteorites may not come to the Earth from the D aseteroids. However, presence of large D asteroids even among the main belt near resonances with Jupiter suggests that Tagish Lake meteorite could really come from a D asteroid.

Assuming Tagish Lake came from a D asteroid, one possible parent body is a D asteroid not well observed in a near-Earth orbit or in resonance with Jupiter. However, there is a possibility that asteroid 368 Haidea is the very parent body of Tagish Lake if we accept that asteroid 4 Vesta is the source of HED meteorites. Haidea is located at about 0.2 AU inside a huge asteroid vacancy at the 2:1 mean motion resonance with Jupiter. Its location is very similar to that of Vesta which is about 0.2 AU inside the 3:1 mean motion resonance region with Jupiter. The mechanism can be the same as that of HEDs delivered from Vesta such as Yarkovsky effect which works the more strongly, the smaller the asteroid is.

Of course, discoveries of a huge crater of Vesta [8] and Vestoids [9] which strengthened connection between Vesta and HED meteorites do not exist in the case of Tagish Lake meteorite. It is a similar situation to many other unusual CI/CM chondrites which have been found to resemble spectrally many low-albedo asteroids [10].

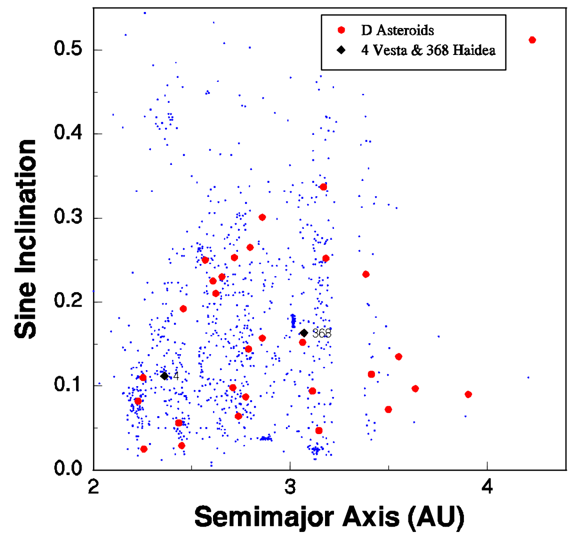

Fig. 4. A plot of semimajor axis and sine inclination of asteroids showing distribution of the D asteroids and locations of asteroids 4 Vesta and 368 Haidea.

Conclusion: Tagish Lake is likely to have come from one of the D asteroids, and its possible parent body is asteroid 368 Haidea.

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References: [1] Bell J. F. *et al.* (1989) In *Asteroids II*, 921 (Univ. Arizona Press). [2] Zolensky M. E. *et al.* (2001) *This volume*. [3] Pieters C. M. (1983) *JGR 98*, 20817. [4] Tholen D. J. (1984) Ph.D. Thesis, Univ. Arizona. [5] Zellner B. *et al.* (1985) *Icarus 61*, 335. [6] Bell J. F. *et al.* (1989) *LPS XIX*, 57. [7] Tedesco E. F. (1989) In *Asteroids II*, 1090 (Univ. Arizona Press). [8] Thomas P. C. *et al.* (1997) *Science 277*, 1492. [9] Binzel R. P. and Xu S. (1993) Science 260, 186. [10] Hiroi T. *et al.* (1993) *Science 261*, 1016.