PETROGRAPHY AND MINERAL CHEMISTRY OF THE CHONDRULE, INCLUSION AND OLIVINE POPULATIONS IN THE TAGISH LAKE CARBONACEOUS CHONDRITE. S. B. Simon[1] and L. Grossman[1,2], [1]Dept. of the Geophysical Sciences, 5734 S. Ellis Ave., [2]Enrico Fermi Institute, The University of Chicago, Chicago, IL 60637. (sbs8@midway.uchicago.edu)

Introduction: The Tagish Lake carbonaceous chondrite fell in the Yukon Territory, Canada on January 18, 2000. It is black, matrix-rich, and very friable. Preliminary descriptions [1, 2] and details of its recovery [3] are available elsewhere. It has been described as intermediate between CI and CM chondrites. We subjected a small amount of Tagish Lake to freeze-thaw disaggregation to isolate the dense, presumably high-temperature, fraction, as we have done previously with the CM chondrite Murchison [4]. This technique is an efficient way to recover chondrules, inclusions, and anhydrous crystals. Study of this population of objects and comparison with that in CMs is an important step in the evaluation of how different Tagish Lake is from other carbonaceous chondrites.

Procedure: We immersed 1.15 g of Tagish Lake chips and powder in distilled water. After just two freeze-thaw cycles, the material was almost completely reduced to a fine powder. By comparison, we typically require ~20 cycles to disaggregate Murchison. Material that was suspended in water after ultrasonic treatment was decanted, and the remaining material (0.935 g) placed in methylene iodide (d=3.3 g/cm^3, diluted with acetone to < 3.2 g/cm^3 to cause forsterite to sink). The material that floated weighed 0.788 g, and the dense fraction weighed 0.147 g, from which a total of 143 objects were hand-picked, mounted in epoxy and polished for petrographic study.

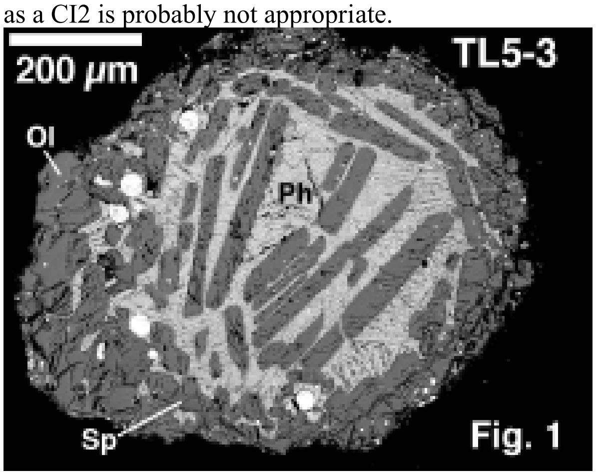
Results: Each recovered object was examined with a scanning electron microscope. We classified the objects as follows: single olivine crystals (46.8%), forsterite aggregates (19.6); polycrystalline olivine inclusions (12.6); chondrules (e.g., Fig. 1) and chondrule fragments (6.3), phosphate-rich objects (2.1), and other (12.6). The latter comprises 18 objects, including a true refractory component represented by two Mg-Al spinel-rich aggregates, and a spinel spherule with fine perovskite (Fig. 2). Also of interest are two occurrences of olivine with Cr-spinel, an object rich in spinel, forsterite and enstatite, and an object consisting of coarse phyllosilicate enclosed in fine Mg-Al spinel.

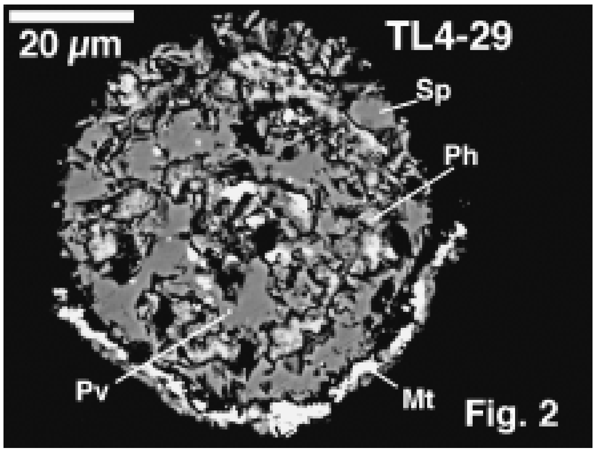
Petrography: Single crystals of olivine are anhedral to subhedral. Many have inclusions of metal and/or Ca-Al silicates. We recognized several kinds of polycrystalline, olivine-dominated objects. Rounded or irregularly-shaped objects with phyllosilicate between grains were classified as chondrules or chondrule fragments, and we found nine: six porphyritic olivine, one barred olivine, one porphyritic olivine + pyroxene, and one cryptocrystalline. Forsterite aggregates are generally porous objects consisting of anhedral grains of non-refractory (low-CaO) forsterite, typically ~10 µm across, ± magnetite, pentlandite, or troilite. These objects may be analogous to the loosely aggregated ("Type 2") Murchison inclusions described by Fuchs et al. [5]. Objects consisting of olivine grains contiguous with each other, i.e., no void space or phyllosilicate between grains, were classified as polycrystalline olivine inclusions. These objects tend to have irregular shapes and consist of anhedral olivine. The spinel spherule (Fig. 2), 60 µm across, consists of anhedral Mg-Al spinel grains separated by patches of phyllosilicate. The spinels enclose round, µm-sized perovskite grains. Magnetite is present in the interior and in a partial rim at the edge of the inclusion. Spinel-, perovskite-rich spherules are also found in Murchison. Two irregularly-shaped objects have textures similar to that of the spherule and are termed spinel-rich aggregates. One contains a tiny, acicular crystal of a Ca-, Al-rich oxide, probably hibonite.

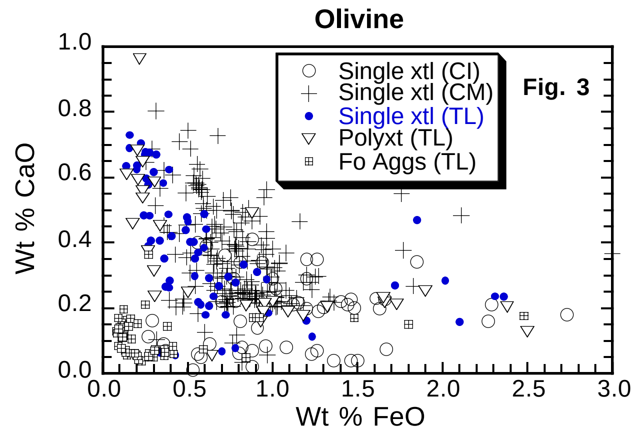
Mineral chemistry: Pure forsterite (>99 mol%) dominates the olivine population, as previously reported for this meteorite [1, 2] as well as for Orgueil (CI) [6] and Murchison [5]. The crystals are typically unzoned, though some grains are enriched in FeO (to Fo_{60-65}) at their rims and others have irregular, patchy FeO enrichments in their interiors. As shown in Figs. 3 and 4, minor element relationships in the olivines are more like those seen in the CM population than in CIs. For example, electron probe analyses of the Tagish Lake single crystals clearly show the presence of a relatively Ca-, Al-rich "refractory" forsterite component (with > 0.5 wt % CaO and < 1 wt % FeO) like that recognized in CM and CV chondrites [7,8] but absent from CI chondrites [9]. Refractory forsterite is also found in Tagish Lake polycrystalline olivine inclusions (Polyxt) and chondrules, but not in the forsterite aggregates (Fo Aggs), in which the olivine has very low minor element contents. In addition, MnO-FeO relationships (Fig. 4) in Tagish Lake olivine are like those in CMs. Tagish Lake seems to lack the relatively MnO-rich, FeO-poor olivine that is found in CIs.

Spinel in the spherule and in spinel aggregates is near-end-member Mg-Al spinel, but the spherule spinel has higher contents of TiO_2 (0.5-1.0 wt %), Cr_2O_3 (~0.5 %) and FeO (~0.2-0.3%) than that in the aggregates (all < 0.3 wt. %). In contrast, the Cr-bearing spinel that occurs with olivine in two objects contains between 6 and 9 wt % Cr_2O_3 and ~1.5-2.0 wt % FeO. These values overlap with compositions of petrographically similar grains found in Murchison [10].

Discussion: We have found, as have others [1,2], that Tagish Lake is not like previously described CIs or CMs. Because chondrules and inclusions are absent from CIs, and even olivine is considered rare [6], a very small dense fraction would be expected for a CI meteorite, whereas CMs are estimated to contain about 50 wt % olivine + inclusions [11]. Our recovery of a dense fraction equivalent to ~13% of the starting material is greater than that expected for a CI, but less than that estimated for CMs. Our petrographic results, however, show that Tagish Lake has several features in common with CMs, namely the presence of chondrules, spinel-rich spherules and aggregates, refractory forsterite, and Cr-bearing spinel like that found in Murchison. Unless the metamorphism experienced by CIs can make these CM-like components completely unrecognizable, destroy refractory forsterite and generate MnO-rich forsterite, the anhydrous fraction of Tagish Lake must be considered distinct from that of CIs. It is therefore unlikely that Tagish Lake is a lightly altered CI or a CI precursor, and classification as a CI2 is probably not appropriate.







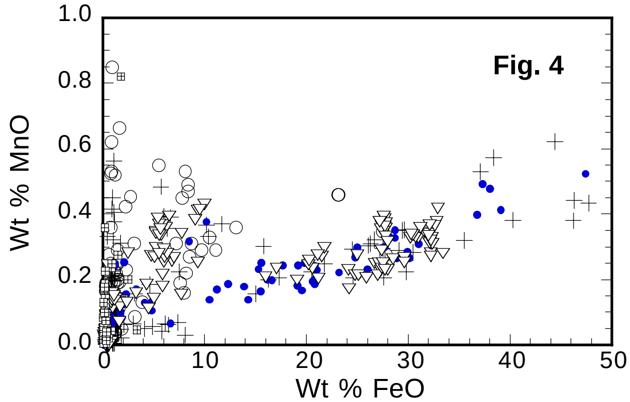


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Fig 1. Backscatterred electron image (BEI) of an altered porphyritic olivine (Ol) chondrule with spinel (Sp) and phyllosilicate (Ph). **Fig. 2.** BEI of a spinel spherule with perovskite (Pv), magnetite (Mt) and phyllosilicate (Ph). **Figs. 3 and 4.** Electron probe analyses of olivine single crystals (CI, CM, and Tagish Lake, TL), olivine in polycrystalline inclusions (Polyxt), and in forsterite aggregates (Fo Aggs) from Tagish Lake (TL). Note the overlap between the Tagish Lake and CM single crystals, the lack of Ca-rich forsterite among the forsterite aggregates and the CI single crystals (Fig. 3), and the lack of MnO-rich, FeO-poor grains among the CM and Tagish Lake single crystals (Fig.4).