XRD, EPMA and CL Study of the Lithologies within the Tagish Lake Meteorite

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Summary and Introduction

The present study continues previous efforts (e.g., Blinova et al., 2009) to mineralogically describe prominent lithological variations of the Tagish Lake meteorite, and correlate them to macroscopic characteristics (e.g., Herd and Herd 2007). This meteorite is a brecciated carbonaceous Type 2 chondrite that consists of several lithological variations (e.g., Zolensky et al. 2002; Blinova et al. 2009).

In addition to samples 5b and 11i (see Blinova et al., 2009), two other samples, 11v and 11h, were selected on the basis of macroscopic characteristics (e.g., Herd and Herd, 2007). The macroscopic characteristics of samples 5b and 11i were previously shown to be representative of lithological variations (Blinova et al. 2009). Sample 11v is a "grab-bag" pristine sample, i.e., disaggregated material of Tagish Lake meteorite that was collected a few days after the fall and stored in a Ziploc bag. From a macroscopic view sample 11h is similar to 11i (the so-called "dark, dusty" lithology).

Method

A JEOL 8900 Electron Microprobe (EPMA) and a Rigaku Geigerflex Power Diffractometer with a Co tube and a graphite monochromator (XRD) were used for mineral analyses and bulk rock mineralogy. Both are housed in the Department of Earth and Atmospheric Sciences at the University of Alberta. A Gatan Chroma cathodoluminescence (CL) detector mounted on Zeiss EVO 15 scanning electron microscope (SEM) and housed at the CCIM, was used for mapping the overall compositional and structural heterogeneity of olivines.

EPMA analyses:

Sample 5b: Overall, lithology 5b is similar in its mineralogy, alteration and abundance of chondrule-like objects to CM chondrites. This sample contains abundant chondrule-like objects set in a phyllosilicate-rich matrix. The chondrule-like objects (most are circular but some are compacted) can reach up-to 500 μm in diameter and are surrounded by fine-grained, heavily-altered accretionary rims (20 to 100 μm in thickness). All exhibit porphyritic textures and are primarily composed of olivine (Fo_{99} to Fo_{95}), rare Ca-rich pyroxene, magnetite, sulfides and possible Cr-bearing spinels, as indicated by Cr,Mg,Al-rich 'hot spots' on X-ray elemental maps. Within the altered matrix, several grains of isolated refractory euhedral to angular forsterite ($Fo_{99.8-99.9}$) (size up to 400 μm) and rare Ca-rich pyroxene grains (~30 μm) have been identified. Carbonates are fairly abundant (up to 2-3%) within the matrix, reaching ~5-10 μm size and dominated by Ca-carbonate. A large (~2000 μm diameter) chondrule fell out of the porous matrix during processing of sample 5b (Fig. 1). This chondrule is nearly perfectly spherical and is only moderately altered on its exterior. It is a porphyritic type I (Fe-poor) chondrule dominated by Ca-pyroxene and olivine (Fo_{95-96}) set in an Al-rich mesostasis. Three Cr-bearing spinels (largest ~15 μm) have been identified. Several areas of this chondrule are under investigation, including numerous Ca,Cr-rich and Si-poor spots mostly around forsterites, and a Ca,Al-rich 'hot spot' surrounding one forsterite grain.

Sample 11i: This sample contains fewer chondrule-like objects and is mostly dominated by altered matrix. Most of the remnant chondrules (~200 μm in diameter) are dominated by magnetite, Fe-Ni sulfide and clusters of small olivines. The matrix is dominated by abundant framboidal magnetite, Fe-Ni sulfides and phyllosilicates with dispersed lithic fragments of the same mineralogy but finer-grained. Ca-carbonates are more abundant than in 5b (up to 4 wt% on the basis of Ca X-ray mapping). A large Mg-rich phosphate (~30 μm in largest dimension) has been identified only within this lithology. A unique porphyritic chondule with zoned olivines has been found within 11i (Fig. 2). The largest olivine has a euhedral shape and exhibits oscillatory zoning. Other olivine grains within this chondrule show normal zoning with Mg-rich cores (Fo_{79-99}) and Fe-rich rims (Fo_{61-74}).

Sample 11v: Although two chips of the same lithology were mounted for EPMA, both contain different proportions of chondrule-like objects. One is almost devoid of these objects. The matrix of this sample is phyllosilicate-rich with a high abundance of framboidal magnetite clusters with rare Fe-Ni sulfides and Ca-carbonates. The largest chondrule (~150 μm) in the one chip with more abundant chondrule-like objects is porphyritic, dominated by olivine, and contains fairly large 'hot spots' of Cr,Fe-rich and Si-poor areas (possibly Fe-rich chromites).

Sample 11h: The sample is very friable, and upon processing it shattered into numerous pieces. Elemental maps of three such pieces have been completed thus far. Based on these maps this sample is similar to 11i and to the chondrule-absent chip of 11v. The matrix is fine-grained, altered with dispersed magnetite. Isolated clusters of fine-grained olivines are present. A large (~150 μm) remnant chondrule fragment was found, that preserves a porphyritic texture with no visible accretionary rim. It also contains fairly large 'hot spots' of high Cr concentrations.

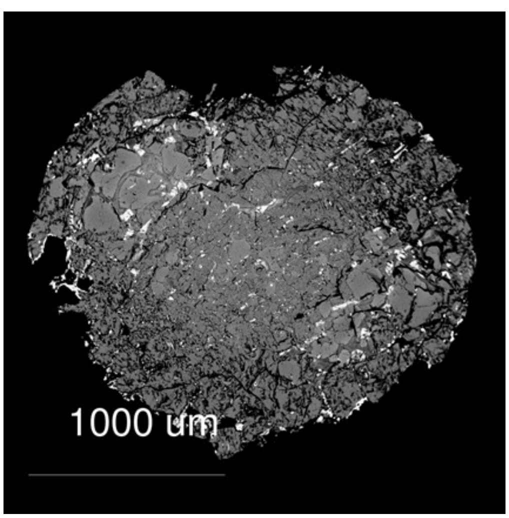

Figure 1: BSE image of large chondrule (sample 5b).

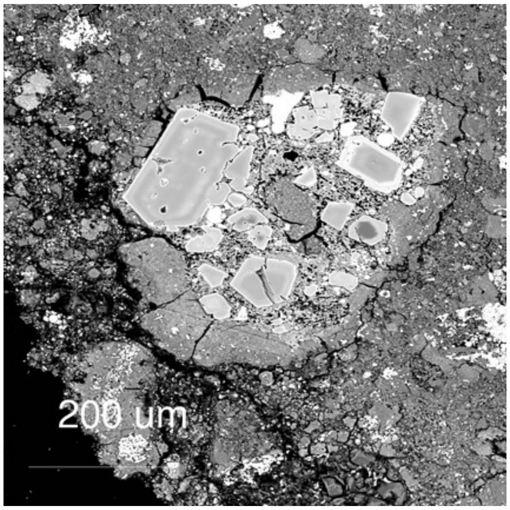

Figure 2: BSE image of oscillatory zoned and normally zoned olivines in a chondrule remnant in sample 11i. Darker bands (zones) are Mg-rich, lighter Fe-rich.

XRD analyses:

Two samples (11v and 11h) were analyzed for bulk rock mineral identification by XRD. Based on preliminary data both of these samples contain abundant forsterite and magnetite. Sample 11h contains both types of carbonate material: Fe-rich (siderite) and Ca-rich (calcite), whereas 11v has a peak for siderite only. In addition, sample 11h appears to contain smectite and serpentine minerals, whereas in 11i clay minerals were not detected.

CL analyses:

Preliminary CL analyses were performed on a zoned remnant chondrule from sample 11i (Fig. 2). Only the core of one zoned olivine (Fo_{99} core and Fo_{71} rim) exhibited red luminescence under CL (Fig. 3). Other Fe-rich olivines did not exhibit detectable CL emission.

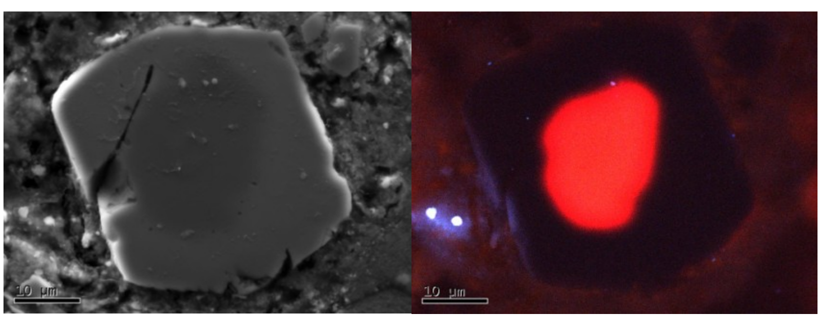

Figure 3: Cathodoluminescence (right) and SE image (left) of zoned olivine from a chondrule remnant in sample 11i (Fig. 2). Fo_{99} core exhibits red luminescence whereas Fo_{71} rim does not. Two bright blue dots on the lower left (right image) are unidentified.

Conclusions

So far, lithologies that we have identified present some unique mineralogical components such as olivines with oscillatory zoning and potential primary chromites within chondrule relicts. The relative proportions of these components and matrix, and bulk mineralogy (for example, relative proportions of Ca- and Fe-carbonate) aid in defining lithologies. More work is on-going on these components and lithologies that can shed light not only on the alteration history of Tagish Lake parent body, but on processes that operated in the early solar nebula.

Acknowledgements

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