Fe-Ni Sulphides within a CM1 clast in Tagish Lake

Conference or Workshop Item

FE-NI SULPHIDES WITHIN A CM1 CLAST IN TAGISH LAKE E. S. Bullock[1], M. M. Grady[1], S. S. Russell[1], M. Gounelle[1,2]. [1] Department of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD. [2] CSNSM - Université Paris 11, Bâtiment 104, 91 405 Orsay Campus, France. E-mail e.bullock@nhm.ac.uk.

Introduction: The Tagish Lake meteorite fell in Canada in January 2000, and has been classified as a type 2 chondrite [1]. Tagish Lake shares similarities with CI and CM chondrites, but is not similar enough to either to be incorporated into these groups, [2,3,4,5]. Tagish Lake consists of two different lithologies – a carbonate-poor lithology, and a carbonate-rich lithology. The carbonate-poor lithology is the dominant lithology, and grades into the carbonate-rich lithology, indicating that they are genetically related [2]. In addition to these two lithologies, a clast of CM1-like material has been identified in two thin sections [2]. The CM1 clast is more extensively altered than the rest of the meteorite. The boundary between the CM1 lithology and the carbonate-rich and carbonate-poor lithologies is not observed in this section – however it has been suggested that the CM1 clast is not genetically related to the carbonate-rich or carbonate-poor lithologies [2]. This abstract compares the Fe-Ni sulphides in the CM1 clast with the carbonate-rich and carbonate-poor lithologies, as well as the Fe-Ni sulphides found in CI and CM chondrites.

Method: A section of the CM1 lithology of Tagish Lake from the Johnson Space Center, Houston, was studied using a Jeol 5900LV scanning electron microscope operating at 20kV and 1nA, and a working distance of 10mm. This allowed us to look at the morphology and mineral associations of the grains, and to obtain major element analyses of the sulphides. Elemental mapping of the section was also carried out on the SEM. Quantitative data were obtained using a Cameca SX50 Electron Microprobe operating at 20kV and 20nA.

Results and Discussion: The surface quality of the CM1 section is poor: attempts to probe the sulphides in the sample resulted in low analytical totals. Normalising the results, and looking at element maps of the grains, can at least allow us to distinguish between pyrrhotite and pentlandite grains. The majority of the sulphide grains are pyrrhotite, with minor amounts of pentlandite present. Large grains are common. The sulphide mineral associations are complex: sulphides form rims around silicate grains, intergrowths with magnetite and metal, and even veins.

Some grains in this clast consist of alternating sulphide and magnetite layers, suggesting fluctuations in sulphur and oxygen fugacities on the parent body. It is difficult to say whether sulphide deposition or magnetite deposition occurred last - in some cases magnetite rims are found on the outside of sulphide grains (fig. 1) and remnant chondrules; in other cases the outer rim is sulphur-rich (fig. 2). One of the most striking and unusual features of the CM1 lithology of Tagish Lake is the presence of a pyrrhotite vein that runs through the sample (fig. 3). The vein crosscuts chondrules, and lacks a magnetite rim, indicating that it is a late-stage feature.

One grain in Tagish Lake appears to be a remnant metal grain that has been altered to form magnetite and sulphide. The large irregular grain (fig. 1) contains small metal grains that were not oxidised to form magnetite, while a later period of S-rich conditions has formed a Ni- and S-rich rim around the grain.

It has been suggested by [2] that the CM1 lithology is genetically unrelated to the other two lithologies. Certainly, in terms of the sulphides, there are significant differences. The CM1 lithology contains a sulphide vein that runs through the sample, a feature not seen in either of the other lithologies of Tagish Lake, but one that is noted in the CM1 lithology of the brecciated meteorite Kaidun. Although attempts to probe the vein were unsuccessful because of the poor quality of the sample surface, element mapping of the sample was undertaken. This shows that the vein is made up of pyrrhotite, with only minor amounts of Ni present.

The presence of remnants of metal grains within a magnetite-sulphide grain indicate that some of the sulphides in the CM1 clast of Tagish Lake could have formed through the sulphidization of metal grains, with periods of oxidation altering either the metal or the sulphide to magnetite. In the case of the grain seen in fig. 3, it appears as though the metal was oxidised to magnetite, with a later period of sulphidization forming the sulphide rim.

In terms of composition, size and morphology, the sulphides in the carbonate-rich and carbonate-poor lithologies of Tagish Lake are more similar to those found in CM chondrites than CI chondrites [6]. The Fe-Ni sulphides found in the CM1 lithology of Tagish Lake are unlike those seen in the carbonate-rich or carbonate-poor lithologies of Tagish Lake, or in CI chondrites (small, hexagonal or rectangular grains of pyrrhotite, sometimes with inclusions of pentlandite but without inclusions of metal). The Fe-Ni sulphide grains are also dissimilar to those found in many CM chondrites, as they are closely intergrown with magnetite, and sulphide veins are very rare in other CM chondrites. The only other known occurrence of a sulphide vein is in a CM1 clast in the brecciated meteorite Kaidun; in that case, the sulphide vein consists of pentlandite rather than pyrrhotite.

Like the carbonate-poor and carbonate-rich lithologies, the extensive alteration undergone by this clast has mobilised sulphur and reprecipitated it to form new sulphide grains.

References: [1] Brown, P. G. *et al.* (2002) *Science* **290**, p320-325 [2] Zolensky, M. E. *et al.* (2002) *MAPS* **37**, p737-761 [3] Grady, M. M. *et al* (2002) *MAPS* **37**, p713-735 [4] Mittlefehldt, D. W. (2002) *MAPS* **37** p703-712 [5] Simon, S. B. & Grossman, L. (2003) *MAPS* **38**, p813-825 [6] Bullock, E. S. *et al.* (2002) *MAPS* **37** A27

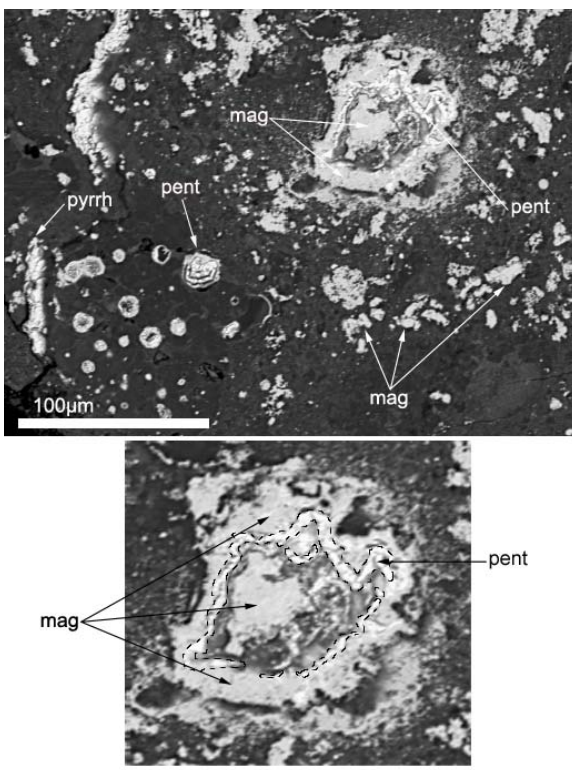

Figure 1. Magnetite grain in the CM1 lithology of Tagish Lake, enclosing a layer of pentlandite. The pentlandite has been outlined in the lower image.

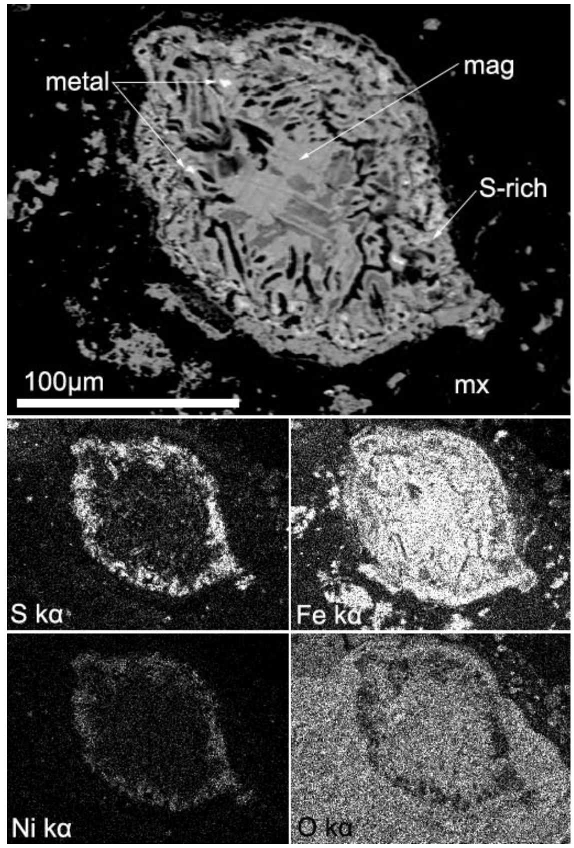

Figure 2. Complex grain consisting of metal (bright white), magnetite (mid-dark grey) and sulphide. The sulphide rim shows up more clearly in an element map – the kα maps for S, O, Fe and Ni are given here.

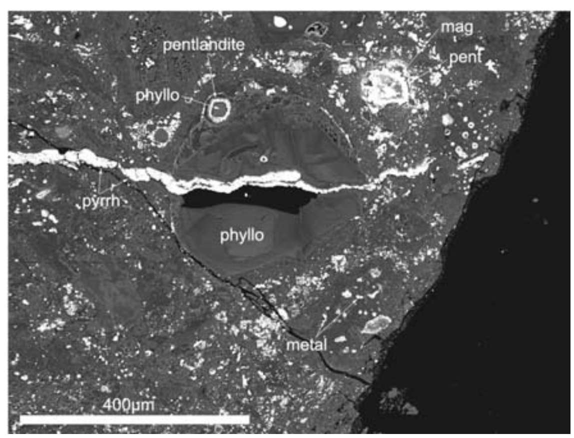

Figure 3. Part of the pyrrhotite vein that runs through the CM1 lithology of Tagish Lake. The vein crosscuts a remnant chondrule, and lacks a magnetite rim, indicating it is a late-stage feature.