FE-NI SULFIDES IN CONCORDIA ANTARCTIC MICROMETEORITES. C. Engrand[1], J. Duprat[1], M. Maurette[1], M. Gounelle[2], [1]CSNSM - CNRS Univ. Paris Sud, bat. 104, 91405 ORSAY Campus, France (engrand@csnsm.in2p3.fr), [2]LEME – CNRS, MNHN, 61 Rue Buffon, 75005 Paris Cedex.

Introduction: Fe-Ni sulfides are abundant in Concordia micrometeorites (MMs) collected in the snow of Dome C in Antarctica by our team since 2000 [1]. Fe-Ni sulfides are observed in stratospheric interplanetary dust particles (IDPs) and in meteorites but were present in less than 10% of Greenland or Antarctic MMs collected in the ice. Their presence was reported in the MMs collected from snow at Dome Fuji, but no detailed characterization was made [2]. In this abstract, we compare the Fe-Ni sulfide compositions of Concordia MMs with that of primitive meteorites, IDPs, and available analyses of comet Wild2 dust particles returned by the Stardust mission. The population of Fe-Ni sulfides in Concordia micrometeorites is dominated by troilite, which is believed to be the first sulfur containing mineral to have formed in the solar nebula [3].

Samples and Methods: Polished sections of MMs from the Concordia collection were investigated by scanning electron microscopy. The Fe-Ni sulfide compositions were measured with the CAMPARIS Cameca SX100 electron microprobe (EMPA) at Université Paris VI at 15 kV and 4 to 10 nA. Concordia Fe-Ni sulfides are generally too small to be analyzed by EMPA (Figure 1) as the analyses often overlapp surrounding material. In this abstract, only sulfides with sizes larger than a few micrometers could be analyzed and we took into account the analyses with analytical totals comprised between 97 and 102%.

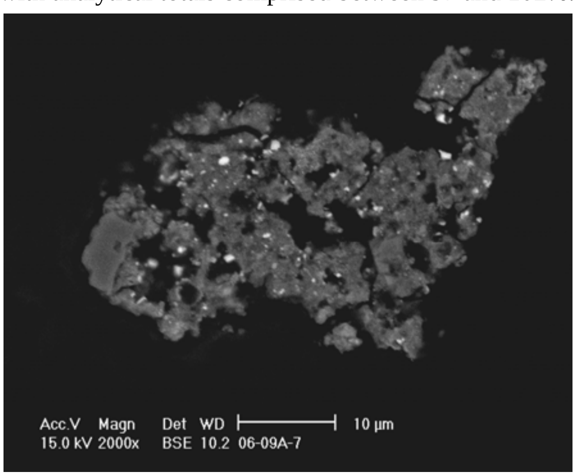

Figure 1: BSE image of a polished fragment of a fine-grained fluffly Concordia micrometeorite exhibiting small Fe-Ni sulfides (bright spots).

Results and discussion : Thirty three sulfides from nineteen Concordia MMs were investigated. The MM textural types range from unmelted fine-grained (Figure 2) to partially melted scoriaceous MMs. Sixteen of the MMs analyzed here are unmelted, with some of them showing moderate heating features. Only three MMs have a clear scoriaceous texture.

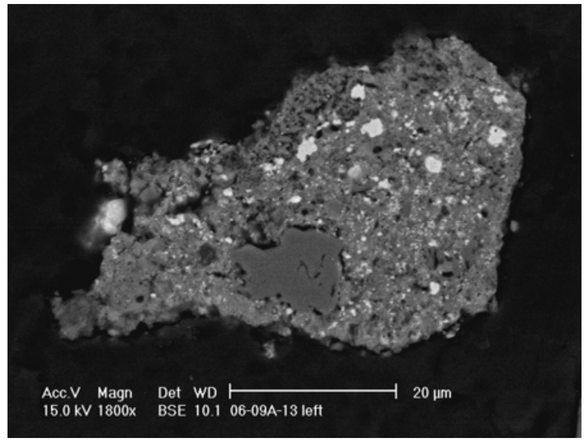

Figure 2 : BSE image of a polished fragment of an unmelted Concordia MM containing Fe-Ni sulfides large enough to be analyzed by EMPA.

The sulfide sizes range from < 1µm to a maximum dimension of ~ 15 µm (Figure 3). Smaller Fe-Ni sulfides present in the matrix are too small to be analyzed by electron microprobe.

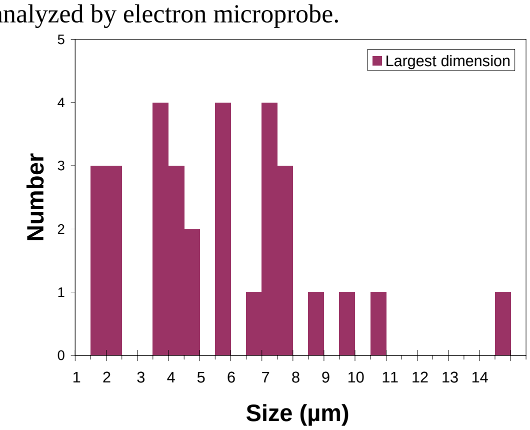

Figure 3: distribution of the largest dimension of the analyzed Fe-Ni sulfides.

Troilite (FeS), pyrrhotite ($\{Fe,Ni\}_{1-x}S$ with x = 0.08 -0.12) and pentlandite ($\{Fe,Ni\}_9S_8$) are present among the Concordia MM sulfides, as seen on the Fe-S-Ni ternary diagram in Figure 4. Two pentlandite grains are observed and several sulfides plot on a mixing trend between the pentlandite and pyrrhotite stability fields. One sulfide has a very Ni-rich composition (45.9 at% Ni).

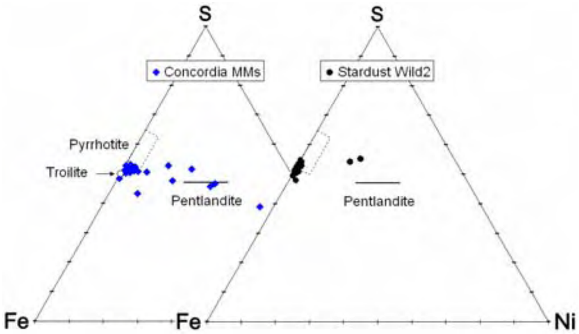

Figure 4 : Fe-S-Ni ternary diagrams (at%) for Concordia micrometeorite and Wild2 (Stardust) Fe-Ni sulfides. Only the presumed unaltered data for Stardust is represented [4].

The four sulfides showing the highest Ni enrichment (19.7 < Ni at% < 45.9) are found in three severely heated scoriaceous MMs. We interpret the extreme Ni enrichment (45.9 at% Ni, 0.8 at% Co, 0.3 at% Cu) as the result of atmospheric entry heating alteration of a primary sulfide. This observation could also suggest that the two pentlandite grains found in the scoriaceous MMs formed during the flash heating of primary phases during atmospheric entry.

Twenty four out of the thirty three sulfide grains contain less than 5 at% of Ni (from 0.2 to 4.8 at%). When plotted along the Fe-S axis, the distribution of their sulfur atomic composition shows that the population of low-Ni sulfides is dominated by troilite, with a minor pyrrhotite contribution (Figure 5).

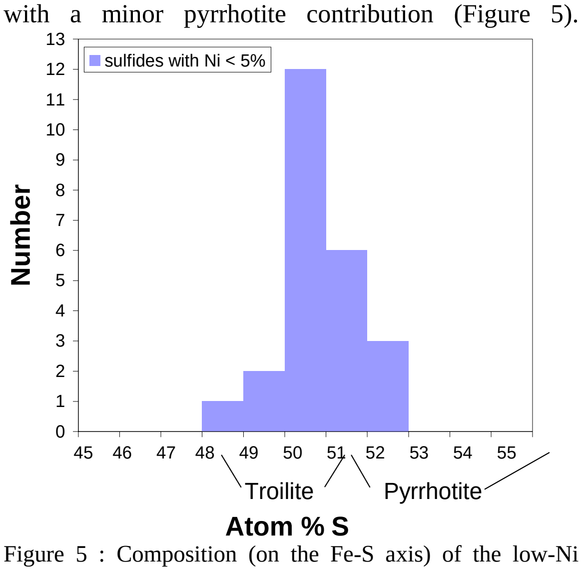

Figure 5 : Composition (on the Fe-S axis) of the low-Ni sulfides (< 5 atomic % Ni) in Concordia micrometeorites.

For the sixteen unmelted Concordia MMs, there is no correlation between a metamorphic index based on their textural classification and the composition of the sulfides. This supports the fact that the predominance of troilite grains found in the Concordia MMs is a primary characteristic and was not influenced by atmospheric entry effects.

Troilite is believed to be the first sulfur containing mineral to form in the solar nebula from the sulfurization of Fe-Ni metal grains by H_2S, S_2, or other S-bearing gas species [3]. Pyrrhotite would likely result from aqueous alteration of primary troilite on the parent body [5]. Pentlandite is frequently interpreted as an indicator of low temperature metamorphism under oxidizing conditions and/or aqueous alteration on the chondritic parent bodies [6] or could be formed during primary sulfurization [7].

In primitive chondrites, pyrrhotite and pentlandite are present, with a clear predominance of the pyrrhotite abundance [e.g. 8 and references therein]. In IDPs, troilite, pyrrhotite and pentlandite are present and pyrrhotite dominates the sulfide population in the 15nm – 10µm size range [6]. Pentlandite is only present in hydrous IDPs and is not found in anhydrous IDPs. Given the primitive nature of IDPs, the authors propose that pyrrhotite could be a nebular phase as well as troilite [6]. The sulfide compositions of Stardust dust samples are altered during impact in the aerogel, but a few troilite, pyrrhotite and pentlandite grains seem to have preserved their original composition (Figure 4) [4]. The proportion of troilite to pyrrothite in Wild2 dust is not available yet, but no sulfide of composition between pentlandite and pyrrothite were observed in the Stardust samples [4]. The Fe-Ni sulfide compositions of Wild2 samples is compatible with that of anhydrous IDPs and with that of a large proportion of Concordia sulfides (Figure 4).

Summary : Concordia MMs exhibit a population of Fe-Ni sulfides which is dominated by troilite. We argue that this troilite abundance is primary and would not result from atmospheric entry effects, as no correlation is observed between textural classification and the sulfur concentration of the sulfides. This suggests that Concordia micrometeorites are among the best preserved samples of interplanetary dust available on Earth, likely related to cometary samples. We propose to further investigate the possibility of pentlandite formation during a flash heating event like atmospheric entry heating and will investigate the Fe-Ni sulfides at the TEM scale to further compare with IDPs and Wild2 samples.

References: [1] Duprat J., *et al.* (2007) *Adv. Space. Res.*, in press. [2] Nakamura K., *et al.* (2001) *GCA* **65**, 4385-4397. [3] Lauretta D. S. and Fegley B., Jr. (1994) *Meteoritics* **29**, 490. [4] Zolensky M. E., *et al.* (2006) *Science* **314**, 1735-1739. [5] Herndon J. M., *et al.* (1975) *Nature* **253**, 516-518. [6] Zolensky M. E. and Thomas K. L. (1995) *GCA* **59**, 4707-4712. [7] Lauretta D. S., *et al.* (1996) *AMR* **9**, 97-110. [8] Bullock E. S., *et al.* (2005) *GCA* **69**, 2687-2700.