

**PRESOLAR TRACE ELEMENT SIGNATURE IN P-RICH SULFIDE FROM A CM CHONDRITE CLAST IN THE EREVAN HOWARDITE?** M. A. Nazarov<sup>1</sup>, P. Hoppe<sup>2</sup>, F. Brandstaetter<sup>3</sup> and G. Kurat<sup>3</sup>; <sup>1</sup> Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, 117975, Russia; <sup>2</sup>Physikalisches Institut, Universität Bern, CH-3012 Bern, Switzerland; <sup>3</sup>Naturhistorisches Museum, Postfach 417, A-1014 Vienna, Austria.

P-rich Fe, Ni sulfide is a characteristic accessory phase in CM chondrites [1-3]. The highly unusual and still insufficiently characterized phase was believed to be of solar nebular origin and to be a main primary carrier for P and K in CM chondrite matter. The major element composition of this sulfide from representative CM chondrites is well known [1-3]. However, no trace element data have yet been reported for this phase. Here we report the first trace element data for this sulfide as obtained by ion microprobe. Results are surprising and show that the P-rich Fe, Ni sulfide is enriched in s-process elements. This suggests that the P-rich sulfide could be of interstellar origin or least contains presolar relicts of nucleogenetic processes.

**Results.** Trace elements were measured in a P-rich sulfide fragment previously described from a CM clast from the Erevan howardite [4]. This fragment measures 40x100 µm and contains cross-cutting veins of tochilinite and serpentine. Major element contents as determined by electron microprobe are (in wt%): Na - 0.71, Mg - 0.12, Si - 0.05, P - 4.00, S - 28.5, K - 0.46, Ca - 0.09, Cr - 0.32, Mn - 0.06, Fe - 32.4, Co - 1.77, Ni - 28.1. Sulfur isotope studies [5] on this fragment indicate a hint for a <sup>36</sup>S negative isotopic anomaly, which, however, needs to be confirmed.

Trace element contents were determined in three areas of the fragment. The results differ slightly because of a contamination by the vein material. However, the differences are not significant. Analysis # 3 is richest in Co, Cr and K and is closest to the electron microprobe analyses. This area contains [ppm, (1sigma error)]: Li -0.20 (0.02), K -5430 (75), Sc - 0.83 (0.05), Ti -178 (4), V - 66 (1), Cr - 3630 (50), Co - 5690 (80), Sr - 28.7 (0.6), Y - 1.07 (0.08), Zr - 9.9 (0.5), Nb - 1.2 (0.1), Ba - 91.0 (0.8), La - 0.10 (0.02), Ce - 0.17 (0.03), Pr - 0.03 (0.01), Nd - 0.12 (0.02), Sm - 0.07(0.03), Dy - 0.03 (0.01). The Co content is much lower than that determined by electron microprobe. A reason for this discrepancy is not obvious. Major and trace element contents are shown in Fig.1 normalized to CI element abundances. The element pattern is strongly fractionated. When compared to CI abundances, the sulfide is enriched in moderately volatile elements, except for Li, Mg and Mn, and depleted in refractory elements, except for Sr, Ba, Zr and Nb.

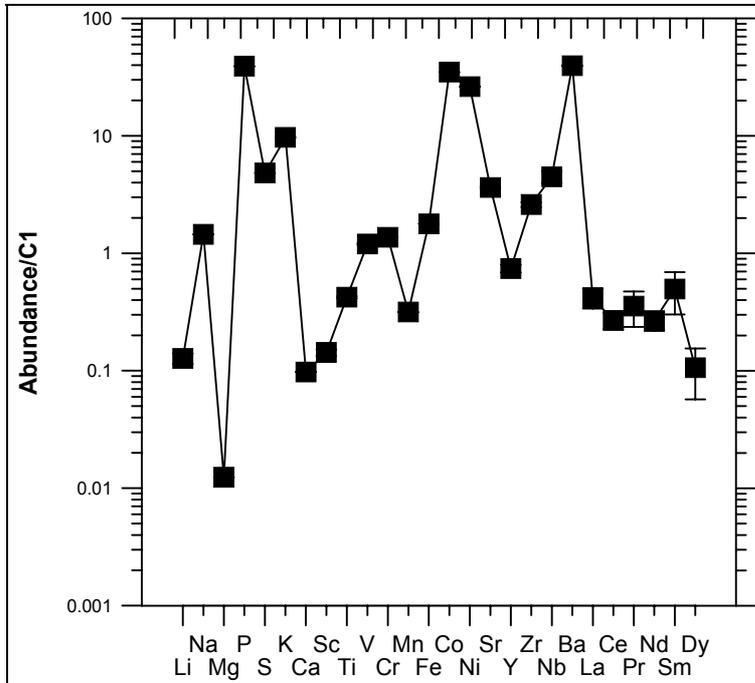
**Discussion.** Mineralogical data [6] suggest a condensation origin of P-rich sulfides, following the formation of CAIs and preceding or contemporaneously with forsterite. The elemental pattern (Fig.1) confirms this suggestion. In fact, the general depletion in refractory elements, as compared to the moderately volatile elements such as P, K, Co and Ni, indicates that the vapor from which the sulfide could have condensed was depleted in refractory elements.

However, the excesses of Zr, Nb, Sr, and Ba as compared to other lithophile elements cannot be explained by gas-crystal fractionation processes. Zirconium and Nb, which are as refractory as Ti, show commonly similar gas-solid/liquid partitioning, and, therefore, the high Zr/Ti and Nb/Ti ratios as compared to those in CI chondrites demand enrichments in Zr and Nb in the vapor from which the sulfides formed. Strontium and Ba are less refractory than Zr and Nb. They are closely related to Ca in CAIs [7] and reduced condensates [8], which both have solar Sr/Ca and Ba/Ca ratios. However, these ratios are non-solar and high in the P-rich sulfide and, hence, point to Ba and Sr enrichments of the gas from which the sulfide was condensed. Even if Ba would be as volatile as K, and the P-rich sulfide does not fractionate these elements from each other, then the Ba/K ratio of the sulfides indicates also a high Ba abundance in the source gas. Thus, the P-rich sulfide apparently was formed from a gas enriched in Zr, Nb, Ba and Sr relatively to solar abundances. These elements are typical s-process elements. Yttrium and REEs, which are also products of the s-process, should also have been enriched in the vapor because the ratios of these elements to Ca and Sc are higher in the sulfide than the solar values. The enrichment in s-process elements is a characteristic of SiC grains which are believed to have originated from AGB star material. The elemental pattern of class II SiC grains [8, 9] is indeed very similar to that of the P-rich sulfide (Fig.2). This pattern has been modeled [8] by a removal of 90-99% of high-temperature condensates from a gas that is 10 times richer in s-process elements than the solar system matter.

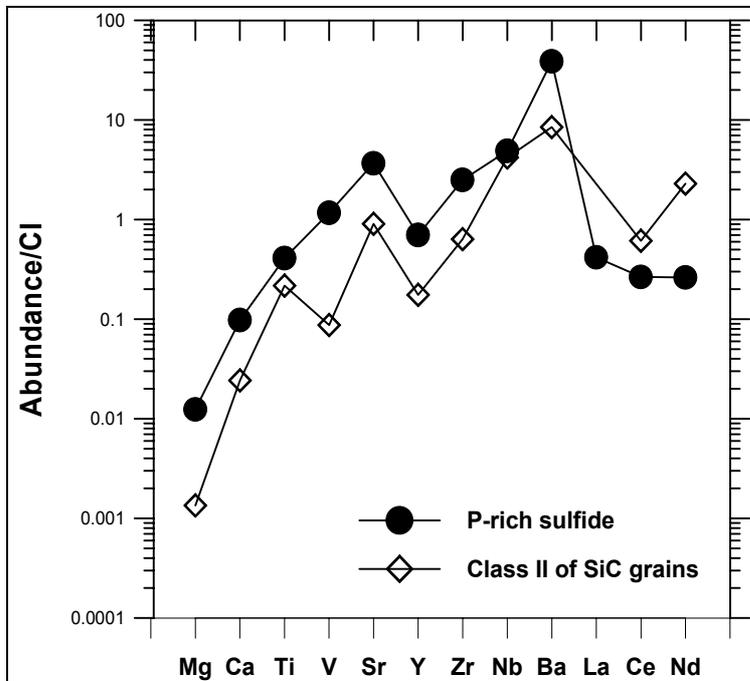
P-rich sulfides have trace element contents which are directly comparable to those of interstellar SiC. They, therefore, appear to be either a new type of interstellar matter which survived reprocessing in the solar nebula or they represent pure reprocessing products of aggregates of such grains. However, further work is clearly needed to proof this hypothesis. In particular, the knowledge of isotopic compositions is crucial in order to confirm the presolar origin of these phases.

**Acknowledgments.** This work was supported by the Austrian FWF and the Austrian Academy of Sciences.

**References.** [1] M. A. Nazarov et al. (1997) LPSC **XXVIII**, 1003-1004; [2] B. Devouard and P. R. Busek (1997) Meteoritics **32**, A34; [3] M. A. Nazarov et al. (1998) This volume; [4] M. A. Nazarov et al. (1993) LPSC **XXVI**, 1053-1054; [5] S. Sahijpal et al. (1995) LPSC **XXVI**, 1213-1214; [6] M. A. Nazarov (1994) LPSC **XXV**, 979-980; [7] L. Grossman (1980) Ann. Rev. EPS **8**, 559-608; [8] K. Lodders and B. Fegley, Jr. (1995) Meteoritics **30**, 661-678; [9] S. Amari et al. (1995) Meteoritics, **30**, 679-93.



**Figure 1:** Elemental abundances (normalized to CI) of a P-rich sulfide fragment from a CM clast in the Erevan howardite. Abundances of Na, Mg, P, S, Ca, Mn, Fe, Co and Ni were determined by electron microprobe, all others are ion probe data.



**Figure 2:** Comparison of refractory element abundances (normalized to CI) of class II SiC grains [9] with those of a P-rich sulfide fragment from a CM clast in the Erevan howardite .