FLASH-HEATING OF PYRRHOTITE FROM ORGUEIL (CI): EVIDENCE FOR THE LOSS OF SULPHUR AND SELENIUM DURING ATMOSPHERIC ENTRY HEATING OF POLAR MICROMETEORITES.

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In order to simulate the atmospheric entry heating of micrometeorites we have carried out flash-heating experiments on 30-50 μm-sized pyrrhotite grains from Orgueil (CI). The particles were heated in air to temperatures ranging from 300° to 1150°C for 20 and 40s. Every fragment was analyzed by Synchrotron-X-Ray-Fluorescense (SXRF) and Analytical Scanning Electron Microscopy (ASEM) for volatile elements before and after heating. Our experiments demonstrate that sulphur and selenium are lost from pyrrhotites well below their melting temperature (1190°C). These findings compare well with the observed loss temperatures of S and Se for flash-heated Orgueil (CI) meteorite fragments. Because flash-heating of meteorite fragments causes considerable losses of S and Se we suggest that the observed S- and Se-depletion of polar micrometeorites is not only caused by weathering processes in the ice but also by atmospheric entry heating. At $T \geq 700°C$ all pyrrhotites are converted into Fe-oxides with high Ni-content. Ni-rich Fe-oxides found in micrometeorites could be explained as pyrrhotites transformed into magnetites by atmospheric entry heating.

INTRODUCTION. Analyses of melted and unmelted micrometeorites have shown that most of the particles are depleted in sulphur and selenium [e.g. 1-3]. This depletion is thought to be related to the leaching of the sulfides and other sulphur-bearing phases in the ice water [4, 5]. In heating experiments carried out on 100 μm sized fragments of the Orgueil (CI) meteorite we have also observed a strong loss of sulphur and selenium (Fig. 2) [6, 7]. Because pyrrhotite is one of the main sulphur-bearing mineral in micrometeorites it is important to understand its behaviour during atmospheric entry heating.

EXPERIMENTAL. For the separation of the pyrrhotite grains, a 2 mm fragment of Orgueil (CI) was crushed between two glass plates. After washing with ethanol 25 pyrrhotite grains were handpicked from the fine grained residue (Fig. 1). The individual particles were analyzed by ASEM and SXRF for major, minor, and trace elements. The pyrrhotites were then heated in a furnace in air to temperatures ranging from 300° to 1150°C for 20 and 40 seconds, respectively. After the heating experiments the particles were analyzed again by ASEM and SXRF and then polished for mineralogical studies.

RESULTS. Analyses carried out before the heating experiments show that the pyrrhotites contain ~ 48.5 at% Fe, ~ 50 at% S and ~ 1.0 at% Ni. Except for S, Fe, Se, and Ni no other element was detected in all the samples before heating. So, the pyrrhotites are not the host phases of other volatile elements like Ga, Ge or Zn, although minor amounts of each of these elements were detected in some of the pyrrhotites.

In our heating experiments we observe a loss of sulphur and selenium strongly dependent on temperature and time (Fig.2). The loss of sulphur takes place between 500° and 700°C. It starts at 500°C/40s and reaches about 99% at 800°C. For both the 20s and 40s heating experiments the Se-loss occurs between 600° and 900°C. About 95% of Se is lost at 900°C. So, the observed Se-loss is not quite as steep as the S-loss. ASEM-investigations indicate that all pyrrhotites heated to $T \geq 700°C$ are transformed into Ni-rich Fe-oxides.

DISCUSSION. Together with flash-heating experiments of 100 μm-sized meteorite fragments (Fig. 2) [6, 7] our experiments with iron-sulfides demonstrates that sulphur and selenium can be lost from micrometeorites by flash-heating at times and temperatures comparable to those during atmospheric entry heating. Therefore the observed depletion of S and Se in micrometeorites is not only caused by weathering processes but also by atmospheric entry heating. Compared to our previous experiments we see that at 700°C only 45% of S was lost from the meteorite fragments but about 95% from the pyrrhotites. In accordance with [8] this could indicate that pyrrhotite is not the main sulphur-bearing component in the Orgueil (CI) meteorite. A high percentage of magnetites found in micrometeorites have considerable amounts of Ni (0.5-1.0 wt.%). These iron oxides could be explained as pyrrhotites transformed into magnetites by atmospheric entry heating.

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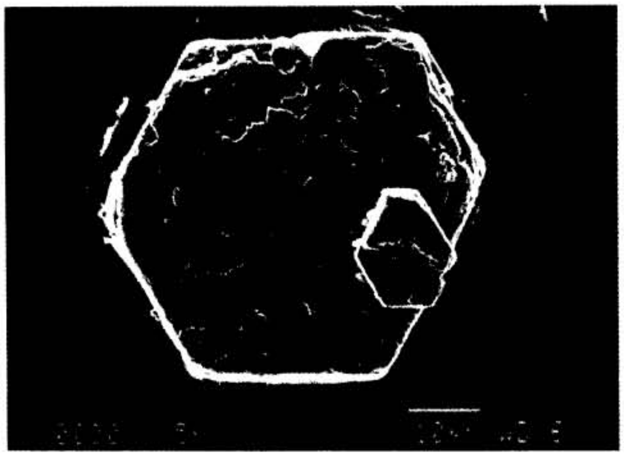

Fig. 1. SE-image of a pyrrhotite grain from Orgueil (CI)

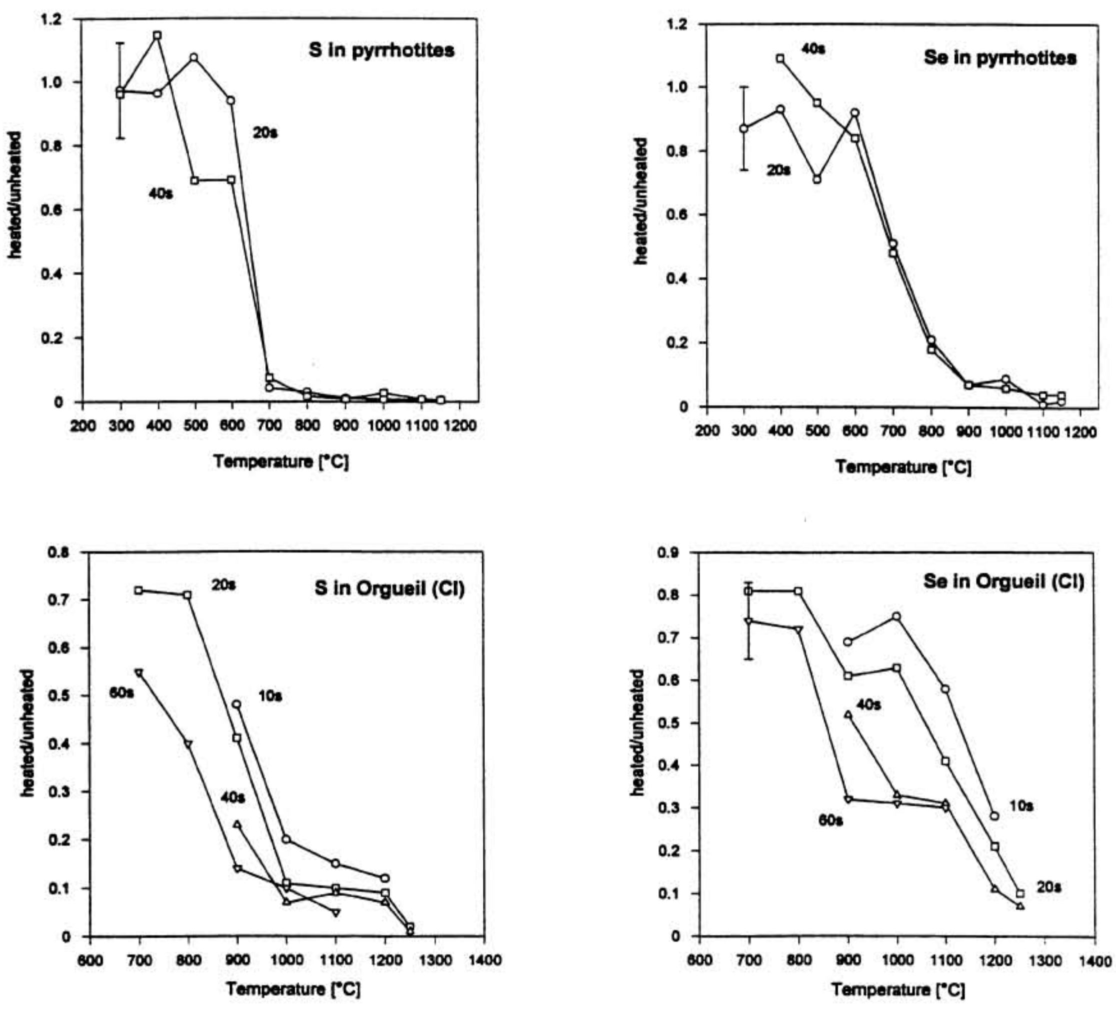

Figure 2. Sulphur and selenium in heated pyrrhotite and Orgueil meteorite fragments.