SIMULATION OF NITROGEN AND NOBLE GASES RELEASE DURING ATMOSPHERIC ENTRY OF MICROMETEORITES. A. Toppani 1,2, B. Marty 1, L. Zimmermann 1, and G. Libourel 1,3 CRPG-CNRS, 15 Rue Notre-Dame des Pauvres, B.P. 20, F-54501 Vandoeuvre Cedex, France, toppani@crpg.cnrs-nancy.fr, 2 MNHN, Paris, France, 3ENSG, Vandoeuvre-les-Nancy, France.

Introduction: Micrometeorites represent the largest mass flux of extraterrestrial matter on Earth, and could have contributed significantly to the budget of volatile and biogenic elements at the Earth’s surface in the past [1]. Previous studies have shown that Antarctic micrometeorites (AMMs) have variable, and sometimes very high noble gas contents up to one order of magnitude higher than Orgueil [2,3]. A coupled nitrogen-noble gas study of AMMs has shown that, contrary to noble gases, nitrogen is in low abundance in AMMs (about one tenth of chondritic) and does not seem to correlate well with indexes of atmospheric entry. However, correlation of noble gases or nitrogen concentration with degree of heating is difficult for natural MMs of unknown initial composition.

Recent experiments have shown that during their deceleration in the Earth atmosphere, MMs underwent frictional heating leading to significant textural, mineralogical and chemical modifications [4]. Hence delivery of extraterrestrial volatiles by AMMs and the possible preservation of organics advocated by some authors as potential precursors of terrestrial biogenic matter needs to be studied by laboratory experiments aimed to reproduce such conditions.

Experimental: Pulse-heating experiments were carried out using fragments of the Orgueil (CI1) chondrite [4]. Experiments were run in a 1-atm vertical furnace, at a temperature of 1350°C, in air for different run times from 2s to 120s. These run times were chosen according to our previous work [4] in order to sample the different textures of the MMs: the non-vesicular fine-grained MMs (1350°C-2s), the vesicular fine-grained MMs (1350°C-5s), the scoriaceous MMs (1350°C-10s) and the cosmic spherules (1350°C-120s).

Analytical: Unheated Orgueil fragments and heated Orgueil charges (0.1-1 mg) were loaded in a sample holder, baked over night at a mild temperature of 80 °C, and were left under pumping for several weeks before analysis for allowing further degassing of terrestrial contamination. Samples were heated to ~1600°C using a de-focused CO2 laser beam and analyzed for rare gases and nitrogen by static mass spectrometry using the procedure described in [5]. Most steps were duplicated and mean values are used in the following.

Results: The noble gas and nitrogen contents of the samples that were not heated are fully compatible with literature data (in particular, N = 1300 ppm, δ15N = 35 ‰), showing that the handling procedure did not alter the data. The results are displayed in Fig. 1 as the remaining fractions of each gas (normalized to the 0 s abundance) as a function of heating duration. They show that noble gases and nitrogen are drastically lost even for short duration of heating: about 50-90 % gases are already lost after 2 s and > 97 % after 10 s for He and N. The 120s experiments show that longer heating duration does not lead to further loss. Noble gases present similar patterns of degassing showing increasing gas loss with decreasing atomic weight or radius. By contrast, the nitrogen has a very different pattern.

Figure 1: Gas content normalized to unheated Orgueil sample as a function of heating time.

The evolution of noble gas isotopic ratios shows that the degassing trends of each volatile are different.

Helium: The evolution of the isotopic ratios of helium indicates that between 2 and 5s, most 3He is lost (no detectable 3He remaining after 10 s) and the remaining isotopic signature is atmospheric.

Neon: Isopic evolution shows a significant decrease in 21Ne/22Ne ratio between 2 and 5s toward the air value.
**Argon:** The $^{40}$Ar/$^{36}$Ar ratios increase from 25.6 to 267 close to the atmospheric ratio of 295.5, with heating duration, indicating equilibration with atmospheric gases. By contrast to Helium and Neon, equilibration with air seems more progressive.

**Nitrogen:** Even if nitrogen content decrease drastically with time, the nitrogen isotopic composition remains constant.

**Discussion:**

*Process of degassing:* The efficient loss of Helium could reflect two processes (i) part of He is surface-correlated from corpuscular irradiation, and (ii) He diffusion from matrix to growing vesicles plays a role. Neon and argon contents have comparable behaviors suggesting limited diffusion and loss during bubble nucleation and growth. Furthermore, the different patterns between the noble gases and the nitrogen suggest that rare gases and nitrogen are hosted in different phases, in agreement with previous study on MMs [3].

*Application to MMs:* These results show that main degassing of both rare gases and nitrogen occur for very short heating-pulses (2-5s) corresponding at the experimental temperature of 1350°C to fine-grained MM texture [4]. As MMs consist mainly of scoriceous and cosmic spherules, this experimental study therefore suggest that most of the noble gases and nitrogen of pristine extraterrestrial material were degassed in the upper atmosphere. Finally, combining the present study to the analyses of natural AMMs [3], it is of note that crystalline MMs containing high amount of noble gases do not have the same origin than other textural types of MMs.