

REACTION OF Q TO THERMAL METAMORPHISM IN THE PARENT BODIES: HIGH-PRESSURE EXPERIMENTS. A. B. Verchovsky¹, S. A. Hunt², W. Montgomery³ and M. A. Sephton³, ¹Department of Physical Sciences, Open University, Walton Hall, Milton Keynes, MK7 6AA UK (a.verchovsky@open.ac.uk); ²University Collage London, UK; ³Department of Earth and Engineering Sciences, Imperial College, London, UK.

Introduction: The nature of planetary noble gas carrier (Q) in meteorites remains uncertain. It is known that it is likely carbonaceous [1], but with properties distinct from the bulk meteoritic macromolecular material. Earlier we have shown [2] that Q is less susceptible to thermal parent body metamorphism in reducing conditions than most of other meteoritic carbonaceous matter. If the latter is graphitized, as has happened in the enstatite chondrite parent bodies, the former remains unaffected. In the present study we have tried to reproduce the parent body thermal metamorphism in the laboratory conditions applied to HF/HCl residue from Orgueil in order to see the reaction of Q and other carbonaceous phases to the treatment.

Methods: All together 3 high-pressure experiments have been done with variable T, P and time: 1) 300°C, 8GPa, 8^h; 2) 500°C, 1GPa, 48^h; 3) 700°C, 1GPa, 24^h. In the first experiment a diamond anvil cell (at the Swiss Light Source) which can accommodate only a few µg of the Orgueil residue was used. Two other HP experiments have been performed, at UCL, employing a piston cylinder apparatus which can accommodate orders of magnitude more sample material. After recovery from the high-pressure devices the samples have been analysed at OU on Finesse machine [2, 3] for C, N and noble gas isotopes simultaneously together with the original untreated sample. We also used micro Raman spectroscopy in order to identify any structural changes in the bulk macromolecular organics of the sample as a result of the high-pressure experiments.

Results: Since in the experiment at 300°C only ~7 µg of the material has been recovered we were not able to perform a detailed stepped combustion; instead only 3 temperature steps have been used. Being not particularly precise for the above reason the data nevertheless indicated that ³⁶Ar and C release patterns are almost identical. Also we found that ~70% of ³⁶Ar and ~40% of ¹³²Xe have been lost. However the Raman spectra and in particular position, relative abundance and width of the D and G bands remained almost identical for the treated and the original samples.

For two other experiments the amount of the recovered material was enough for high temperature resolution stepped combustion experiments. We use 100° increment in the temperature range from 200 to 1400°C. For both experiments there is a clear shift of

the noble gas release to higher temperature compared with the original sample, and the higher was the temperature of the HP experiment the higher the shift: ~100° for treated at 500°C and ~200° - at 700°C (Fig. 1a). However, the same temperature shift is observed for carbon release for the samples (Fig. 1b). The concentration of noble gases (except for ⁴He) in the sample treated to 500°C has not significantly changed while for the 700°C experiment is by a factor of 2 lower than in the original one.

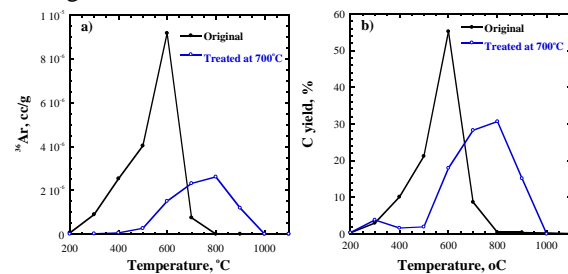


Figure 1. Release pattern of ³⁶Ar and carbon during stepped combustion of the HP treated and the original Orgueil HF/HCl residues.

The material treated at HP also shows a significant difference in Raman spectra compared to that observed for the original one (Fig 2). In particular, the height of the D and G peaks became equal in the sample treated at 700°C while in the original one the D peak is significantly lower than the G one. In addition the Raman signal intensity increased by an order of magnitude in the sample treated at 700°C compared to the original one (Fig. 2).

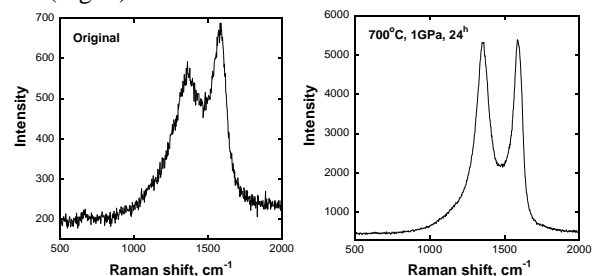


Figure 2. Raman spectra showing D (at 1350 cm⁻¹) and G (at 1590 cm⁻¹) bands for the original and treated at 700°C, 1 GPa for 24^h samples of the Orgueil HF/HCl residues.

Discussion: The Raman data indicate that the HP experiment conducted at 700°C definitely resulted in a certain modification of the organic matter present in the Orgueil HF/HCl residue. The significantly more

intense Raman signal detected in the treated sample suggests that the organic material in the sample became more coarse-grained compared to the original one. The increase of the relative abundance of D band (compared to G) usually points out to a higher degree of disorder of carbonaceous matter. Thus, at 700°C, 1 GPa and during 24^h the organic material has not been graphitized at any significant degree. Instead, the organics became more amorphous after the HP treatment that is in agreement with the HP experiments applied to pure organic compounds [4]. Probably, graphitization requires a high temperature and/or longer time. The increase of combustion temperature is likely to be associated with the changing in the grain size of the treated material.

Approximately half of noble gases have been lost during this HP experiment. However this has not resulted in any significant separation of the organic carbon and the noble gases (Fig. 3). Since the total concentration of C in the treated samples has not reduced but rather increased, the loss of noble gases cannot be explained by oxidation of Q during the HT experiments because Q and other carbonaceous phases present in the sample are oxidized with molecular oxygen at the same temperature (see Fig. 1). The ³⁶Ar/C ratio in the treated sample is lower by more than a factor of 3 in the original, but the release profile shows almost the same pattern (Fig. 3). This suggests that combustion temperature of Q and insoluble organic material has changed similarly as the result of the HP experiment. For instance, this could happen if Q became coarser grained in the same extent as the other organics or Q is encaged within the organic matrix and can be combusted only along with the matrix.

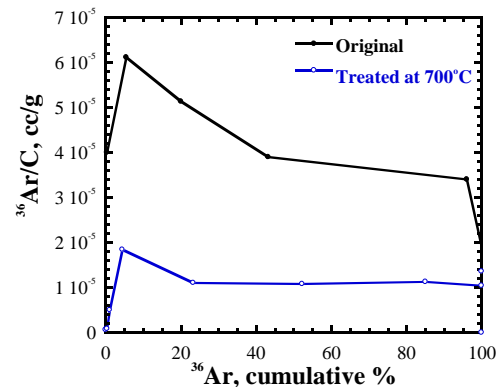


Figure 3. Variations of the ³⁶Ar/C ratio during stepped combustion of the original and treated at HP Orgueil HF/HCl residues.

Conclusions: Thus, we conclude that Q has lost a significant fraction of its original noble gases during the HP experiment conducted at 700°C, 1 GPa during 24^h. This has accompanied by a changing in the Q combustion temperature by a similar way as for most of the other carbonaceous phases present in the sample analyzed. In the sense this is not what was expected to happened for the Q combustion T compared to that occurred during parent body metamorphism [2]. However the organic material of the HF/HCl residue was only modified to a certain extent during the HT treatment, but not graphitized as has happened to the organic matter presented in the enstatite chondrites parent bodies. Therefore, until graphitization is not achieved in the laboratory conditions, it is not possible to make a firm conclusion regarding the reaction of Q to the parent body metamorphism.

1. **References:** [1] Schelhaas N., Ott U., Begemann F. (1990) *Goechim. Cosmochim. Acta* **54**, 2869-2882. [2] Verchovsky A. B. et al. (2002) *Earth Planet. Sci. Lett.* **199**, 243-255. [3] Verchovsky A. B. et al. (1997) *MAPS* **32**, A131-A132. [4] Montgomery W. et al. (2005) *J. Phys. Chem. B* **109**, 19443-19447.