

**EVOLVED GAS ANALYSIS OF HYDRATED PHASES IN MURCHISON AND ORGUEIL.** A. A. Morris, L. Baker, I.A. Franchi and I. P. Wright. Planetary and Space Science Research Institute, The Open University, Milton Keynes, MK7 6AA (a.a.morris@open.ac.uk).

**Introduction:** Chondritic meteorites represent some of the most primitive material in the Solar System and thus can provide a central role in understanding its early history. Many chondrites have experienced secondary processing; aqueous alteration is one of the most widespread. Recognition and characterization of such processes offer valuable insight into the early stages of planetesimal formation and evolution. Aqueous alteration can generate large isotopic fractionation of oxygen isotopes [e.g. 1], a key parameter in the study of meteoritic material. Therefore it is important to have detailed knowledge about the minerals present and the isotopic variability within these complex meteorites. However, the carbonaceous chondrites are fine grained, complex mineral assemblages making unequivocal mineral specific isotopic analyses difficult. Baker et al [2] have attempted to determine the isotopic composition of hydrated phases directly from measurement of the structural OH groups in the phyllosilicates in carbonaceous chondrites using a stepped heating extraction procedure to resolve terrestrial contamination and characterize the host phases.

The aim of this work is to apply Evolved Gas Analysis (EGA) with combined Thermogravimetric (TG) and Differential Scanning Calorimetry (DSC) to carbonaceous chondrite matrices to better characterize the hydrated mineral phases present and their OH thermal release characteristics. This is particularly important when attempting to unravel the isotopic fractionations found in these rocks. This study presents preliminary findings from EGA of OH for Murchison (CM) and Orgueil (CI).

**Background:** *Mineralogical Products of Aqueous Alteration.* Secondary matrix phases include Mg-, and Fe-bearing phyllosilicates, chlorites, smectites, hydroxides, oxides, and carbonates [3]. A recent study by Bland *et al.* [4] has ascertained the modal mineralogy of individual phases from selected unequilibrated chondrites including Murchison and Orgueil, summarised in Table 1.

*Evolved Gas Analysis (EGA).* Dehydration of a sample at relatively low temperatures (100-250°C) will remove relatively weakly bonded water from minerals, this includes water that is adsorbed to surfaces, inter-layer water and water of hydration. At higher temperatures, above 300°C, dehydroxylation takes place where strongly bonded hydroxyl (OH) groups are removed from the structure (lattice water) [5]. The peak release temperature is related to the nature of the hydroxylated

phase, and thus to its structure and chemistry [5]. Dehydroxylation temperatures may then be assigned to specific minerals so allowing a preliminary identification of the phases present.

**Table 1: Summary of the modal distribution of hydrated phases in two chondritic meteorites [4]**

Phase	Murchison (wt%)	Orgueil (wt%)
Mg-phyllosil (Serpentine)	22.8	7.3
Fe-phyllosil (Cronstedtite)	58.5	-
Saponite-Serpentine	-	64.2
Ferrihydrite	-	5.0

**Method:** All samples except the minerals chrysotile and chamosite were analysed as powders. Samples were placed into platinum buckets and loaded into a Netzsch STA 449 C Jupiter for TG and DSC analysis; interfaced to a Hiden Analytical HPR20 Residual Gas Analyser for EGA. Samples (6-18mg) were run at a ramp rate of 10°C/minute.

**Results** The EGA profile of Murchison is shown in Fig 1. The low temperature peak (103°C) is likely to be adsorbed water. Although Mg-rich serpentine is a major component in Murchison, terrestrial examples of such serpentine polymorphs have peak OH releases at temperatures above 600°C – much higher than any release observed in Murchison. However, the major release in Murchison (417°C) does match that of cronstedtite (416°C) (Fig 2) – consistent with previous work (Table 1) [4]. The peak observed at 539°C may be caused by the presence of an Fe-bearing chlorite (chamosite?) which peaks at 540°C, although a second characteristic high temperature release  $\approx 720^\circ\text{C}$  was not found for Murchison.

Clearly the results from Murchison remain only partially understood. The mis-match between the terrestrial serpentines and any peaks from Murchison may be the result of subsequent processing or chemical differences. In particular, the Murchison serpentines are particularly Fe-rich [6]. Characterisation of additional terrestrial standards may improve the identification the serpentine phases. The possibility that the 539°C release in Murchison is related at least partially

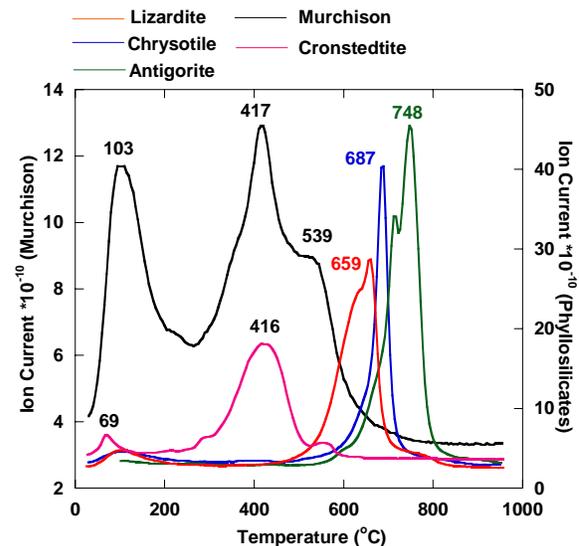
to a chlorite can not be overlooked. One of the main aqueous alteration phases of chondrule mesostasis in CMs is a mixture of Mg, Fe-rich phyllosilicates, *spinach*; with progressive alteration *spinach* changes from Fe-chlorite to intermediate chlorite, and finally to magnesian serpentine, approaching that in the matrix [7]. Bland *et al* [4], using XRD/Mossbauer, do not report the presence of any Fe-chlorite; however using EGA this study may indicate the presence of such a phase.

The EGA profile of Orgueil is shown in Fig 2. The large low temperature release (doublet at 122°C and 229°C) is likely to be a combination of adsorbed water, interlayer water and dehydration of gypsum (120-150°C) and ferrihydrite (235°C [8]). Ferrihydrite has been reported [4,6] as being a component of the CI matrix which is intimately associated with fine-grained phyllosilicates. The high temperature release of Orgueil is composed of 3 discrete components – at 450, 553 and 720°C. Either brucite (451°C) or nontronite (451°C) could correspond to the 450°C peak in Orgueil. The 553°C peak is not consistent with any expected phases it is however similar to that of chamosite, a phase not previously reported in CIs. The 720°C peak is close to the 714°C release identified from saponite, however the higher temperature component from saponite is not evident.

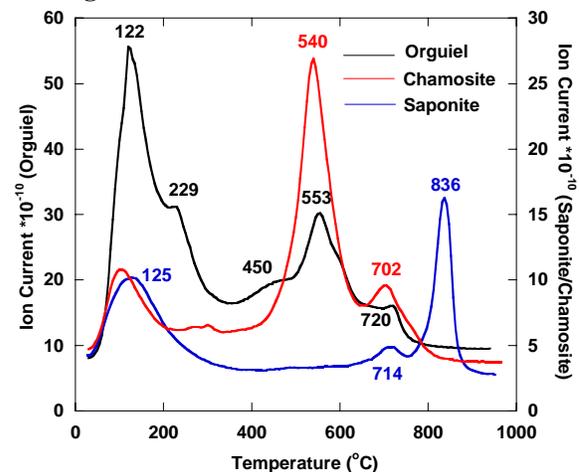
The main phase reported by Bland *et al* [4] is a saponite-serpentine mix identified previously by Tomeoka and Buseck [6]. A number of saponite samples analysed for this study revealed a major release around 836°C – much higher than any release observed in the meteorites. However, the saponite-serpentine phase in Orgueil is usually described as a disordered interstratified phase where the saponite and serpentine are intergrown and occur as poorly crystallised platelets [6]. Such a fine grain size and disordered state could have a marked lowering affect on the release temperature for the OH groups.

**Summary:** While there is some apparent success at matching the release water from OH groups in Murchison and Orgueil with terrestrial standards a number of major peaks remain poorly matched. Further work is aimed at better matching terrestrial standards to matrix phases and addressing the effects of any post-formation, parent body aqueous alteration (e.g. gentle metamorphism), which may have affected the water (OH) release profile from hydrated minerals.

**Figure 1 Peak EGA temperatures for Murchison and Mg, Fe-phyllosilicates**



**Figure 2 Peak EGA temperatures for chamosite and Orgueil**



**References:** [1] Clayton R. N., and Mayeda T.K. (1999) *GCA*, 63, 2089–2104. [2] Baker *et al* (2002) *MAPS*, 37, 977-985. [3] Zolensky M. E. and McSween H.Y., JR. (1988) In *Meteorites and the Early Solar System.*, 114-143. [4] Bland *et al.* (2004) *MAPS* 39, 3-16. [5] Wicks F.J. and Ramik R.A. (1990). In *Thermal Analysis in Clay Science.* 160-189. [6] Tomeoka K and Buseck P.R. (1988) *GCA*, 52, 1627-1640. [7] Brearly A. J. and Jones R.H. (1998) In *Planetary Materials, Vol.43.* [8] Lauer *et al* (2000) *LPSC XXXI Abstract #1990*

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