

## THERMAL RELEASE OF WATER FROM CM2 CHONDRITES: INSIGHT FROM MASS SPECTROMETRIC EVOLVED GAS ANALYSIS (DEGAS)

D. Harries, R. Fürst, and F. Langenhorst, Friedrich Schiller University Jena, Institut für Geowissenschaften, Carl-Zeiss-Promenade 10, 07745 Jena, Germany (dennis.harries@uni-jena.de).

**Introduction:** The hydrous minerals serpentine and tochilinite are important constituents in primitive meteorites, such as CI1, CM2, and CR2 chondrites, and hydrous interplanetary dust particles (IDPs). Meteoritic evidence indicates that some CM- and CI-like chondrites have experienced heating and water loss. Compared to typical CM2 and CI1 chondrites, the mineralogical and geochemical characteristics of these rocks range from subtle dehydration effects (e.g., Yamato 793321, Sutter's Mill, Jbilet Winselwan; [1-3]) to petrologically distinct lithologies (e.g., Yamato 86720, Belgica 7904, Yamato 980115; Belgica grouplet or 'CY chondrites' [4,5]). The mechanism of heating is currently unknown but of interest to the ongoing Hayabusa2 and OSIRIS-REx space mission to C-group asteroids. Radiogenic heat production, impact-induced heating or solar irradiation are possible processes that could have contributed to water loss within parent bodies or in their surface regolith. In order to better understand the thermal decomposition of hydrous minerals in CM2 chondrites we have conducted heating experiments in a high vacuum furnace equipped with a mass spectrometer to analyze the evolved gases.

**Samples and Methods:** The samples investigated in this study are Mg-rich serpentine (lizardite/polygonal serpentine [6]) from Totalp (Davos, Switzerland), cronstedtite from Hohe Warte mine (Gernrode, Germany), tochilinite from Otamo quarry (Siikainen, Finland), and the CM2 chondrites Murchison (MUR) and Jbilet Winselwan (JW).

The experimental technique uses a directly coupled evolved gas analysis system (DEGAS) custom-built at FSU Jena [7]. The samples (2-50 mg) are heated in Al<sub>2</sub>O<sub>3</sub> crucibles in high vacuum (<10<sup>-6</sup> mbar based pressure) generated by two turbomolecular pumps (255 and 230 l/sec). The crucibles are placed on a sensitive thermogravimetric balance (Netzsch STA 429) and can be heated to 1450 °C at controlled rates. The evolved gases are analyzed by a quadrupole mass spectrometer (Balzers QMA-125), which is directly coupled to the furnace chamber without differential pressure apertures. This increases sensitivity and largely avoids re-equilibration of evolved gases compared to techniques working in inert atmospheres. Experimental runs were conducted at heating rates of 5 and 10 K/min.

**Results:** The pure minerals show distinct dehydroxylation peaks at  $m/z = 18$  for H<sub>2</sub>O<sup>+</sup>. The Mg-rich serpentine shows an onset of H<sub>2</sub>O release at 400–500 °C with a peak at 620–630 °C. In cronstedtite H<sub>2</sub>O release starts at ~200 °C and peaks at 310–320 °C. Tochilinite shows an onset of H<sub>2</sub>O release at ~100 °C and a first peak at ~210 °C. The main H<sub>2</sub>O release occurs at 350–360 °C. Evaluation of the mass spectra recorded during heating of the CM2 chondrites indicates significant differences among MUR and JW (Fig. 1). MUR shows incipient H<sub>2</sub>O release immediately after the start of heating. The release peaks at about 200 °C and then grades into a second, dominant release peak at 320–350 °C. Also JW starts to release H<sub>2</sub>O immediately after the start of heating, but shows two well separated release peaks at 170–210 °C and at 430–480 °C, separated by a release minimum at 350–380 °C.

**Discussion:** The release at ~200 °C most likely results from terrestrial weathering products [3], but higher temperatures release indigenous water from phyllosilicates and tochilinite. The contrasting release minima and maxima at 320–380 °C in JW and MUR, respectively, suggest that JW was naturally heated to a maximum temperature of about 400 °C consistent with XRD results [8,9]. The release profile indicates that JW lost most of its indigenous water during this process, despite little textural effects and subtle mineralogical changes limited to the formation of amorphous or poorly crystalline silicates. This suggests a brief heating event with incomplete phase equilibration. The release of carbon-bearing species is currently being analyzed to better understand the fate of organic materials and carbonates during the transient heating event(s).

**References:** [1] Nakamura T. (2006) *Earth and Planetary Science Letters* 242:26–38. [2] Zolensky M. E. et al. (2014) *Meteoritics & Planetary Science* 49:1997–2016. [3] King A. J. et al. (2019) *Meteoritics & Planetary Science* 54:521–543. [4] Ikeda Y. et al. (1992) *NIPR Symposium on Antarctic Meteorites* 5:49–73. [5] King A. J. and Russell S. S. (2019) *50<sup>th</sup> LPSC*, abstract #1386. [6] Harries D. et al. (2019), this meeting. [7] Heide K. et al. (2000) *Thermo-chimica Acta* 354:165–172. [8] Nakamura T. (2005) *Journal of Mineralogical and Petrological Sciences* 6:260–272. [9] Mogi K. et al. (2017) *80<sup>th</sup> Meteoritical Society Meeting*, abstract #6225.

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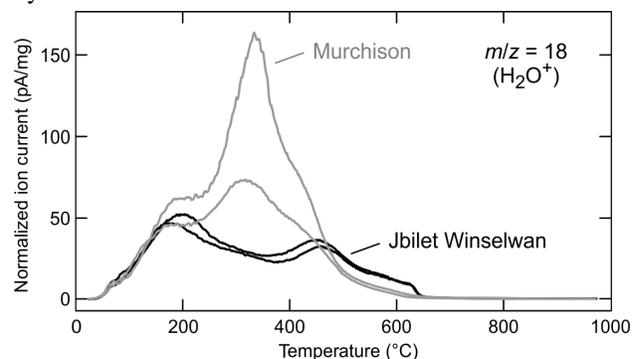


Fig. 1: DEGAS release profiles of H<sub>2</sub>O from Murchison and Jbilet Winselwan (heating at 10 K/min, 2 replicates each).