HIGH RESOLUTION MICRO RAMAN SPECTROSCOPY ON THE WINCHCOMBE CARBONACEOUS CHONDRITE (CM2)

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Introduction

The Winchcombe meteorite fireball and fall from 28th February 2021 was the first reported meteorite fall of a carbonaceous chondrite in the UK [1-7].The next day after the fireball the first finds were made in the private yard of local people (Wilcock family) followed by a number of further finds in the Winchcombe area (reported mass about 602gr in total). Most of the finds were not influenced by any rains. We obtained fragment(s) of the first find made by the Wilcock family for our investigations. For all further details concerning the Winchcombe meteorite fall and find we refer to [7].

Methods and techniques

The (surface) morphology and mineralogy of the samples was pre-investigated by digital microscopy followed by detailed and systematic investigations with Micro Raman Spectroscopy [8]. All Raman experiments have been performed without further preparation in order to avoid any unwanted effects (e.g. alterations). The obtained results should be representative because we did a large number of mappings in different scales on matrix and further components/clasts. We used the 532nm LASER, Raman shifts were detected between 50-2500 (up to 4500 for water content) cm^{-1} with a precision of +/- 1-2 cm^{-1}, and magnifications of 100-1000x (long distance lenses only), and a lateral resolution of 0.1 µm. Large maps up to 15x15 points in 2D/3D at high resolution allowed to also detect accessory phases / sub-micron particles and inclusions. Acquisition times of 1-3 sec and accumulation numbers of up to 5 have been used which allowed to obtain large numbers of Raman spectra in short times within the high resolution mappings, and therefore the results should be representative. Si and graphite standards were used for calibration measures, in most cases we applied a 6th degree polynomial for background subtraction.

Results

The matrix of Winchcombe is dominated by phases of the serpentine mineral group which is a common feature of the CM chondrites and also of C1-C2 ungrouped CC such as Flensburg, Tarda or Tagish Lake [1]. On many matrix spots and different clasts the serpentine group member cronstedtite could be detected, generally intimately intergrown with the iron sulfide tochilinite (TCI).

Summarizing, the following phases and components could be found in our preliminary studies:

- Serpentine group members (main matrix component)
- Cronstedtite / tochilinite aggregates (CTI)
- Troilite, pyrrhotite?
- Orthopyroxene (OPX)
- Olivine (near forsterite)
- Mn - enriched olivine – tephroite like phase (as in Aguas Zarcas)
- Carbon phases (no or poor crystallinity)
- CAI, calcite bearing
- A significant H_2O content, more details elsewhere

We could not find any effects or influence of terrestrial alteration which confirms the high quality of the material. Further Raman experiments will focus on the minor / accessory phases, the chondrule components and on CAI. Summarizing, the found phase composition of our Winchcombe sample(s) reflects the typical composition of a CM2 carbonaceous chondrite.

Mn-enriched, Fe- (fayalite-) poor olivines – reflecting the typical tephroite like Raman spectrum – are still under investigation.

To be able to perform successful Micro Raman Spectroscopy experiments on carbonaceous chondrites, (in our recent projects on Mukundpura, Flensburg, Tarda, Kolang, Aguas Zarcas and here Winchcombe meteorite falls) requires the design of a highly sophisticated experimental setup [1,9,10] . Such an approach is basic condition in order to avoid or at least minimize alteration effects already during the measurements on the one hand and to guarantee a reasonable signal/noise relationship on the other.

Therefore we decided to investigate only naturally broken unprepared sample materials whenever possible. The representativity of the data obtained on the available sample material was also topic of our studies: large sets of high resolution mappings in 2D/3D can help to overcome the problem of tiny sam-

ples / fragments. Our main interests were on optimizing and fine tuning our experimental setup. So the series of recent meteorite falls which produced a new set of primitive carbonaceous chondrites – with Winchcombe CM2 as the most recent one - provided us directly with unique fresh analogue materials for Hayabusa 2 (Ryugu) and Osiris Rex (Bennu) asteroidal samples in our laboratories[11,12] .

References:

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Figures:

Figure 1: Samples under investigation in our project:
(a) 3D digital microscopy: fragment(s) of the Wilcock find, heavily brecciated, relicts of chondrules and CAI;
(b) Large Olivine particle - near forsterite in composition - in the very fine grained phyllosilicate (serpentine) matrix.

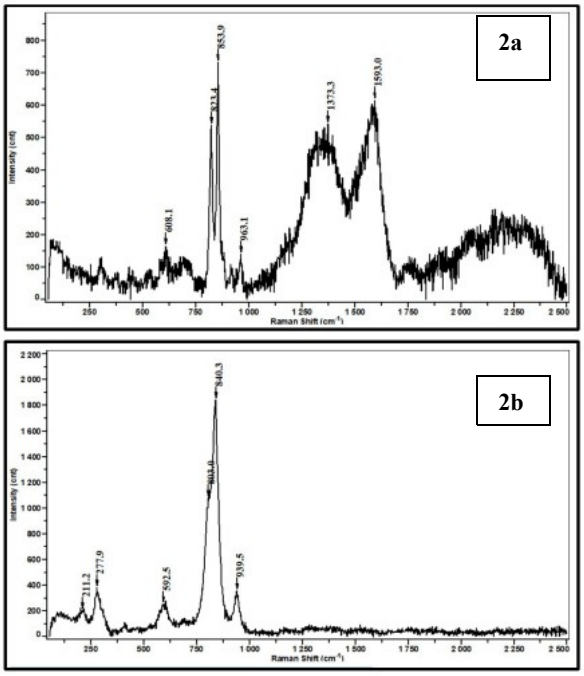

Figure 2: Representative Raman spectra:
(a) Olivine particle – near forsterite in composition and a significant concentration of non-crystalline carbon phases;
(b) Raman spectrum of a tephroite – like olivine group phase which we also could find for example in Aguas Zarcas (CM2). The background of Mn- enriched olivines in primitive carbonaceous chondrites is part of ongoing investigations and will be reported in detail elsewhere.