LASER RAMAN SPECTROSCOPY ON AGUAS ZARCAS (CM2) – THE 2019 METEORITE FALL FROM COSTA RICA. V.H. Hoffmann[1], M. Kaliwoda[1,2], M. Junge[2], W.W. Schmahl[1,2]. [1]Faculty of Geosciences, Dep. Earth and Environmental Sciences, Univ. Munich; [2]Mineralogical State Collection Munich, SNSB, Germany.

Introduction

In April 2019 a significant fireball followed by a large meteorite fall was registered in Costa Rica. Luckily, a number of kg-masses and numerous smaller mostly crusted individuals could be found and collected before the first rain (pre-rain samples) [1-4]. This could guarantee perfect conditions without significant terrestrial alterations for all coming scientific investigations, many of these focused on preparations for returned asteroidal materials from Hayabusa 2 (asteroid Ryugu) and Osiris Rex (asteroid Bennu) missions [5-7].

The new meteorite was classified as a carbonaceous chondrite CM2 and named Aguas Zarcas [1,8]. Details on the mineralogy and petrology of Aguas Zarcas and the CM meteorites in general were reported by [8-13]. Aguas Zarcas was found to represent a complex breccia dominated by chondrule rich and chondrule poor lithologies. A number of different clasts have been identified belonging to various carbonaceous chondrite types.

Methods, techniques, samples

In extension of our earlier projects on a set of recent carbonaceous chondrite falls we have included Aguas Zarcas in our systematic LASER Raman spectroscopy investigations.

In figure 1 the Aguas Zarcas 3.25 gr slice is shown which we have used for our investigations. A large CAI inclusion can be recognized near the center of the slice.

All Raman experiments have been performed without further preparation (only cutting) 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 (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 / submicron 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 Aguas Zarcas is dominated by several phases of the serpentine mineral group. This is a common feature of all CM chondrites and also of C1-C2 ungrouped CC such as Flensburg, Tarda or Tagish Lake [1-3, 10]. On many matrix spots and different clasts the serpentine group member cronstedtite could be detected, generally intimately intergrown with the iron sulfide tochilinite [14,15].

Summarizing, the following phases and components could be found:

- Serpentine group members
- Cronstedtite
- Troilite, pyrrhotite?
- Tochilinite
- Pyroxene (OPX)
- Olivine (forsterite and a Fa-rich component)
- Carbonate (calcite)
- Carbon phases (no or poor crystallinity)
- CAI

We could not find any effects or influence of terrestrial alteration which confirms the high quality of the material (pre-rain). Further Raman experiments focus on the minor / accessory phases, the chondrule components and on CAI. The results are in good agreement with earlier data [1,8].

Generally, performing successful LASER Raman spectroscopy experiments on carbonaceous chondrites, (in our recent projects on the Mukundpura, Flensburg, Tarda, Kolang and now Aguas Zarcas meteorite falls) requires the design of a highly sophisticated experimental setup 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. Due to the significant brecciation and very fine grained matrix / phases, experiments are quite complex. Generally, several phases which have been detected in these primitive carbonaceous chondrites are extremely sensitive against (even minor) local heating effects, and therefore any kind of preparation (cutting/grinding etc.), specifically in terrestrial atmospheric conditions has to be minimized.

In order to avoid any such effects 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 samples / fragments.

Consequently, 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 provided us directly with unique fresh analogue materials for Hayabusa 2 (Ryugu) and Osiris Rex (Bennu) asteroidal samples in our laboratories.

Acknowledgments
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