THE FLENSBURG (C1-UNGROUPED) 2019 METEORITE FALL: RAMAN SPECTROSCOPY AND COMPILATION OF MAGNETIC SUSCEPTIBILITY DATA ON C - UNGROUPED FALLS/FINDS. V.H. Hoffmann[1], K. Wimmer[2], M. Kaliwoda[1,3], W. Schmahl[1,3], P. Schmitt-Kopplin[4]. [1]Faculty of Geosciences, Dep. Earth and Environmental Sciences, Univ. Munich; [2]Nördlingen; [3]Mineralogical State Collection Munich, SNSB; [4]Helmholtz-Center, Munich; Germany.

Introduction

In our contribution we will report new results on the Flensburg meteorite, a carbonaceous chondrite which fell in 2019. A fireball was observed by numerous inhabitants in Northern Germany and neighbored countries at September 12th, around 12.50. A small meteorite with a mass of 24.5 gr was found one day later by a Flensburg inhabitant in his garden. The meteorite was named Flensburg and classified as a very rare primitive carbonaceous chondrite of type C1 – ungrouped. For all further details we refer to [1,2,3].

The Flensburg carbonaceous chondrite plays a prominent role in terms of the Hayabusa 2 (successful sample return from asteroid Ryugu in december 2020) and Osiris Rex (sample return from asteroid Bennu planned in 2023) missions [4,5]. Both sampled asteroids belong to the C type asteroids and are believed to mainly consist of carbon rich material with a similar composition as primitive chondrites. In a parallel study we report on our pilot studies on two other carbonaceous chondrite falls from 2020, the CM 1/2 type meteorite Kolang and the C2 – ungrouped type meteorite Tarda [6-8].

Our investigations focus mainly on the rare / accessory mineralogical components and their distribution within the meteorite. Specifically we are interested on the carbon-bearing and magnetic phases.

We used LASER Micro Raman Spectroscopy (Horiba XploRa Raman System of MSM/SNSB) for our studies on the mineral phase composition which is perfectly suited for identifying and mapping minor/accessory phases. Being fully non-destructive, allowing high-resolution mapping on natural, broken surfaces without any preparation in 2D or 3D are some of the major advantages of this technique.
An updated compilation of the Magnetic Susceptibility (MAGSUS) data of all ungrouped carbonaceous chondrites is under development and will be provided in our poster.
The surface morphology of the uncoated sample was investigated using a Phenom ProX scanning electron microscope (SEM) in backscattered electron mode. This instrument is equipped with an energy dispersive X-ray spectrometer (EDS) for analyzing the surface elements with a constant 15 kV accelerating voltage.

Samples

We had one polished thin section (#19174) and one unprepared small fragment for our investigations, both kindly provided by Addi Bischoff from Institute of Planetology, University of Münster / Germany.

Fig.1 a: Main mass of the Flensburg meteorite (from [3]; b: Polished thin section (PTS) view, a set of relict chondrules can be recognized.

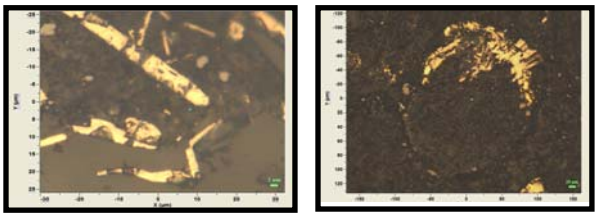
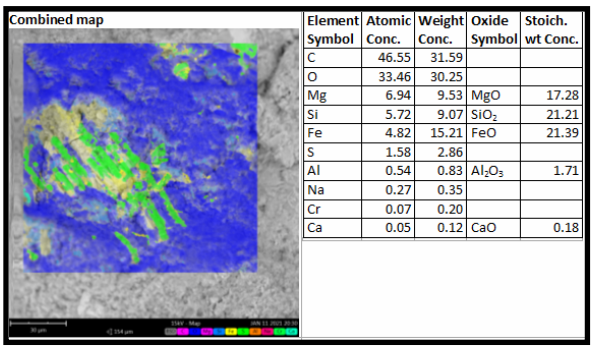


Fig. 2: Optical microscopy on the PTS: (a) Iron - sulfide (mainly troilite and pyrrhotites) laths, tiny magnetites and carbonates (lower part) are seen. (b) A relict chondrule is partly rimmed by a series of iron-sulfides including tochilinite-cronstedtite components (alteration products). Relict shapes of the original phases - barred olivines - still can be recognized – now altered to phyllosilicate, as well as iron-oxides such as magnetite.



Element Symbol	Atomic Conc.	Weight Conc.	Oxide Symbol	Stoich. wt Conc.
C	46.55	31.59		
O	33.46	30.25		
Mg	6.94	9.53	MgO	17.28
Si	5.72	9.07	SiO_2	21.21
Fe	4.82	15.21	FeO	21.39
S	1.58	2.86		
Al	0.54	0.83	Al_2O_3	1.71
Na	0.27	0.35		
Cr	0.07	0.20		
Ca	0.05	0.12	CaO	0.18

Fig. 3: SEM/EDX on a relict chondrule: iron sulfide laths (green) within a phyllosilicate matrix (blue) can be recognized, a typical feature found in Flensburg..

Phase composition and distribution by LASER Raman spectroscopy

The following phases could be identified and mapped:

- Phyllosilicates (such as serpentine)
- Troilite
- Various pyrrhotites and other iron-sulfides
- Merrilite
- Carbonates of various compositions
- Various carbon-phases
- Iron – oxides such as magnetite

Members of the tochilinite-cronstedtite group (TCG) could be detected on the outer rims of relict chondrules or as nodules within relict chondrule interiors. We also found regions probably filled with TCG which have shapes similar to those normally occupied by kamacite blebs [9-11]. TCG's are not easily detectable by Raman Spectroscopy because they tend to alter quickly already during the measurements. Additionally more and better standard Raman data are required, that is why the extension of our own Raman database is a major part of our projects.

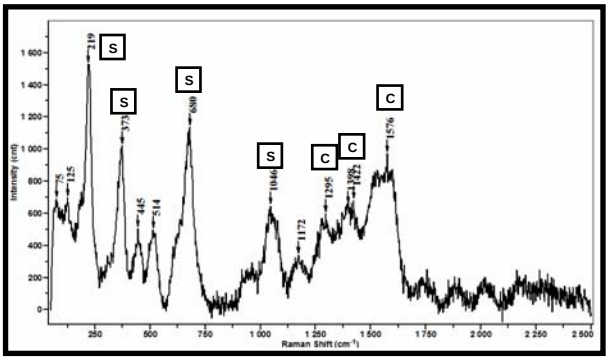
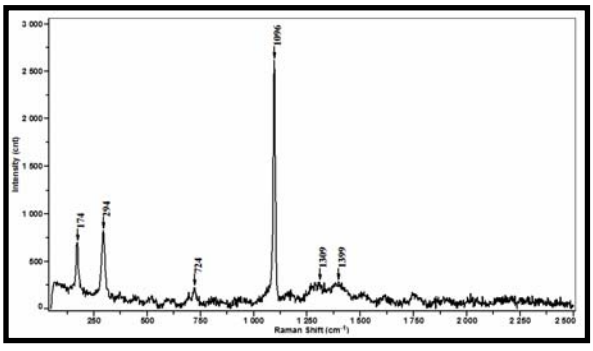
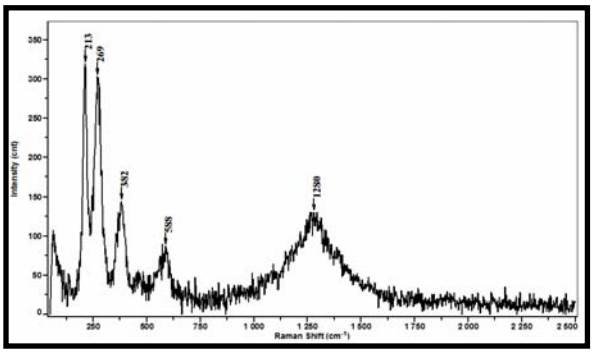


Fig 3: Typical matrix Raman spectrum showing phyllosilicates (serpentine, S) and a set of carbon phases (C).



(a)



(b)

Fig 4: Representative Raman spectra of (a) carbonate phases (Ca-Mg carbonate) and (b) the iron-sulfide troilite.

Summarizing, the Flensburg C1 – ungrouped carbonaceous chondrite represents a perfect test material in terms of the planed investigations on the returned samples from the asteroids Ryugu and Bennu.

Further details will be presented in our online – poster contribution.

References

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