A Series of Recent Falls of Carbonaceous Chondrites - Perfect Analogues for Returned Hayabusa 2 and Osiris Rex Asteroidal Materials

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 recent years, a series of meteorite falls have been reported which produced various types of primitive chondrites. In our contribution we will focus on samples of the following witnessed falls: Flensburg (2019), Kolang and Tarda (both 2020), while Mukundpura (fall 2017) was topic of our earlier studies [1-3]. These meteorites belong to the class of carbonaceous chondrites and play 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 probed asteroids belong to the C type asteroids and are believed to mainly consist of carbon rich materials with a similar composition as primitive chondrites.

The Flensburg meteorite fell in September 2019 in Northern Germany and was classified as a C1 ungrouped carbonaceous chondrite, the first reported fall of this type. Only one small stone was found so far (24.5 gr). For all further details we refer to [2]. The Tarda meteorite fall was reported from Southern Morocco in august 2020, the meteorite (about 4 kg total mass) was classified as a C2 ungrouped carbonaceous chondrite [1,2,6,7]. Only four witnessed falls of this type are known, whereby Tagish Lake is probably the most famous one (fall 2000, [1]). The Kolang meteorite fireball and fall was reportedly observed in Indonesia in august 2020 (four stones with a total mass of 2550 gr). Kolang was classified as a CM 1/2 chondrite and is the first and only witnessed fall known from this meteorite group [8,9].

In our contribution (poster) we will compile our earlier and provide new results of detailed and systematic investigations on the mineral phase composition and distribution of three new meteorite falls [10,11]. Our focus was mainly on the rare/accessory mineralogical components of these meteorites. Specifically we are interested on the carbon-bearing and the magnetic phases. Several unprepared fragments and one individual of Tarda were used for our studies, and additionally one small unprepared fragment of Kolang. Concerning Flensburg, we had a small fragment and a PTS (provided by A. Bischoff, Univ. Münster). We used optical microscopy, LASER Micro Raman Spectroscopy (Horiba XploRa Raman System, MSM/ SNSB) for our study 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. The surface morphology and mineralogy of the uncoated samples was investigated using a Phenom ProX scanning electron microscope (SEM) in backscattered electron mode equipped with an energy dispersive X-ray spectrometer (EDS) for analyzing the element composition. Magnetic susceptibility was investigated systematically by an SM30 (Hulka Comp., CR).

The results of our Raman spectroscopy experiments on Kolang have to be seen as preliminary as we had only one small fragment for our project. Generally, performing successful LASER Raman experiments on carbonaceous chondrites, here specifically on Flensburg, Tarda and Kolang, required 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 on Kolang are quite complex. Generally, several phases which have been detected in these primitive carbonaceous chondrites are extremely sensitive against (even minor) 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 (PTS of Flensburg is a necessary exception because of representativity but we also had a fragment). 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. Our experiences from the earlier investigations on Hayabusa 1 materials (asteroid Itokawa) were highly profitable in this context [12-14].

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 and Bennu asteroidal samples in our laboratories. We plan to extend our investigations in near future to additional recent falls such as Aquas Zarcas (2019, Costa Rica, CM2) or most recently Winchcombe (2021, England/UK, CM2) [1,3].

References

[1] Meteor. Bull. Database 10/2021: Flensburg , Tarda, Kolang, Aquas Zarcas, Winchcombe, Mukundpura, Tagish Lake.

[2] Bischoff A. et al., 2021. The old, unique C1 chondrite Flensburg – Insight into the first processes of aqueous alteration, brecciation, and the diversity of water-bearing parent bodies and lithologies. Geochem. Cosmochem. Acta, 293, 142-186.

[3] https://www.karmaka.de (10/2021)

[4] Hayabusa 2 mission to asteroid Ryugu (finished 12/2020), JAXA: https://www.hayabusa2.jaxa.jp/en/

[5] Osiris Rex mission to asteroid Bennu, NASA: https://www.nasa.gov/osiris-rex

[6] Chennaoui H.A., et al., 2021. Tarda (C2-ung): a new and unusual carbonaceous chondrite meteorite fall from Morocco. 52nd LPSC 2021, #1928.

[7] Dey S., et al., 2021. Exploring the planetary genealogy of Tarda – a unique new carbonaceous chondrite. 52nd LPSC 2021, # 2517.

[8] King A.J., et al., 2021. The bulk mineralogy and water contents of the carbonaceous chondrite falls Kolang and Tarda. 52nd LPSC 2021, #1909.

[9] Jenkins L.E., et al., 2021. Identification of clasts in CM chondrite fall Kolang with S and Ca. 84th Meteor. Soc. Conf., #6161.

[10] Hoffmann V., et al., 2021. The Kolang (CM1/2) and Tarda (C2 ungrouped) meteorite falls from 2020: first systematic mineralogical investigations by LASER Raman spectroscopy and SEM/EDX. 52nd LPSC 2021, # 2458.

[11] Hoffmann V., et al., 2021. The Flensburg (C1 ungrouped) 2019 meteorite fall: Raman spectroscopy and compilation of magnetic susceptibility data on C-ungrouped falls/finds. 52nd LPSC 2021, # 2443.

[12] Mikouchi T., Hoffmann V.H. et. al., 2014. Mineralogy and crystallography of some Itokawa particles returned by the Hayabusa mission. LPSC 2021, #2239.

[13] Mikouchi T., Hoffmann V.H., et al., 2013. Mineralogy and crystallography of Itokawa particles by electron beam and synchrotron radiation X-ray analyses. Hayabusa Conf. 2013.

[14] Mikouchi T. and Hayabusa Consortium, 2014. Mineralogy and crystallography of some Itokawa particles returned by the Hayabusa asteroidal sample return mission. Earth, Planets and Space, 66/82, 9pp.