THE KOLANG (CM 1/2) AND TARDA (C2 UNGROUPED) METEORITE FALLS FROM 2020: FIRST SYSTEMATIC MINERALOGICAL INVESTIGATIONS BY LASER RAMAN SPECTROSCOPY AND SEM/EDX. V.H. Hoffmann[1], M. Kaliwoda[1,2], W. Schmahl[1,2], K. Wimmer[3], P. Schmitt-Kopplin[4]; [1]Faculty of Geosciences, Dep. Earth- and Environmental Sciences, Univ. Munich; [2]Mineralogical State Collection Munich, SNSB; [3]Nördlingen, Germany; [4]Helmholtz-Center, Munich, Germany.

Introduction

We report the first detailed and systematic investigations on the mineral phase composition and distribution of two new meteorite falls from 2020. Both 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 dec 2020) and Osiris Rex (sample return from asteroid Bennu planned in 2023) missions [1,2]. Both sampled asteroids belong to 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 pilot results on a third carbonaceous chondrite fall from 2019, the C1 - ungrouped type meteorite Flensburg [3].

The Kolang meteorite fireball and fall was reportedly observed in Indonesia on 1st of August 2020 by numerous residents in northwest Sumatra (Central Tapanuli Regency). Four stones have been found 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 [4].

The Tarda meteorite fireball and fall occurred in Southern Marocco on 25th of august and was also observed by numerous local inhabitants. Immediate searches by local nomads delivered about 4 kg (total mass) of numerous mainly small and often crusted stones. Tarda was classified as a C 2 ungrouped carbonaceous chondrite [5]. Only four witnessed falls of this type are known, Tagish Lake is the most well known of these (fall 2000, [6]).

More details on all these recent meteorite falls are found in [7].

Samples and methods

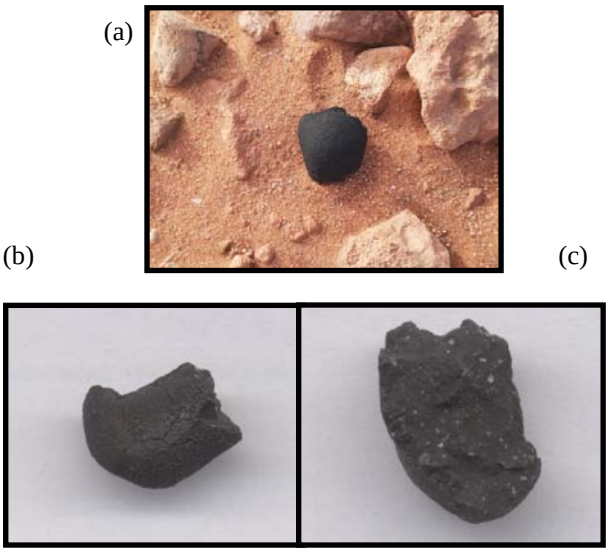
Several unprepared fragments and one individual of Tarda were used for our studies, and additionally one small unprepared fragment of Kolang.

We used LASER Micro Raman Spectroscopy (Horiba XploRa Raman System, MSM/SNSB) for our studies 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 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.

(a) (b)

Fig. 1: Kolang meteorite, (a) 100 gr mass (2 fragments) and (b) 2100 gr main mass. [7]



(a) (b) (c)

Fig. 2: (a) Field view of a fully crusted Tarda individual [7]. (b) Exterior (fusion crust) and (c) interior view of the 0.81 gr individual under study in our project. A number of chondrules and chondrules fragments, as well as olivine/forsterite and carbonate particles can be recognized in the blackish, carbon rich matrix.

Results

Tarda and Kolang carbonaceous chondrites are dominated by a very fine grained matrix with a variety of carbon components.

The following phases could be identified in Tarda**:**

- Carbon – components, various

- Carbonate (Ca, Mg)
- Apatite
- Forsterite (individual particles)
- Phyllosilicates
- Iron – sulfides (Troilite, Pyrrhotite)
- Iron – oxides (magnetite)

A clear identification of components of the tochilinite-cronstedtite group (TCG) requires more sophisticated Raman experiments due to frequent and quick alteration effects already during the measurements.

Frequently clusters of tiny - micron sized – magnetite and/or troilite particles have been found.

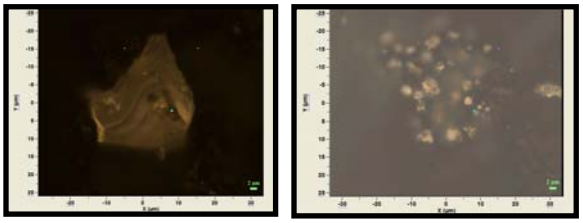
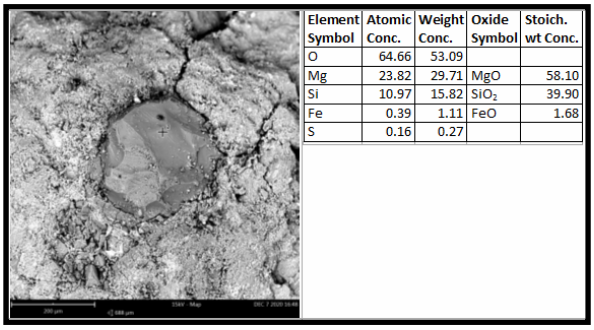


Fig. 3: Tarda (a) Typical large olivine-group particle which was identified as nearly pure forsterite. (b) A cluster of micro – sized iron sulfide / oxide particles (troilite / magnetite?).



Element Symbol	Atomic Conc.	Weight Conc.	Oxide Symbol	Stoich. wt Conc.
O	64.66	53.09		
Mg	23.82	29.71	MgO	58.10
Si	10.97	15.82	SiO_2	39.90
Fe	0.39	1.11	FeO	1.68
S	0.16	0.27		

Fig. 4, Tarda: A similar olivine particle (left side) as seen in fig. 3a was analyzed by SEM/EDX, the composition of a Mg-rich end member forsterite could be confirmed (see also fig. 5).

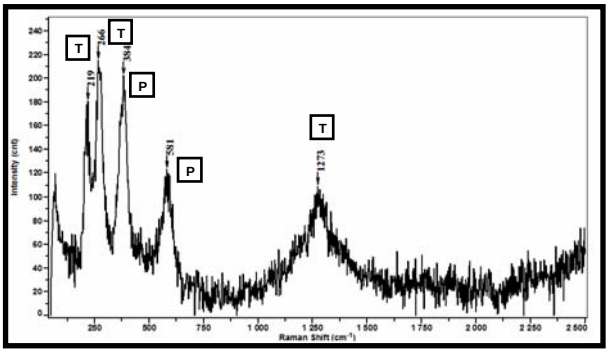


Fig. 5 Tarda: Typical Raman spectrum of a troilite (T) - pyrrhotite (P) intergrowth.

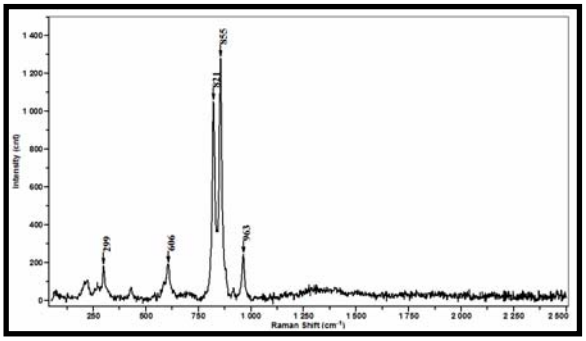


Fig. 6 Tarda: Raman spectrum of the olivine particle in fig. 3a points to the nearly pure Mg-rich end member forsterite (see also fig. 4).

The results of our Raman spectroscopy experiments on Kolang have to be seen as very preliminary as we had only one small fragment for our project presently. Generally, performing successful LASER Raman experiments on the three investigated carbonaceous chondrites (Flensburg [3], Tarda and Kolang) requires the design of a highly sophisticated setup to avoid or minimize alteration effects even during the measurements on one the hand and 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.

Mineral phase composition Kolang:

- Carbon phases, various
- Tochilinite-cronstedtite phases
- Phyllosilicates
- Iron – sulfides (troilite)

An update of the compilation of the Magnetic Susceptibility data is part of this project (as for Flensburg [3]. Further details will be shown on our online poster.

References:

[1] Hayabusa 2 mission to asteroid Ryugu (finished 12/2020), JAXA: https://www.hayabusa2.jaxa.jp/en/
[2] Osiris Rex mission to asteroid Bennu, NASA: https://www.nasa.gov/osiris-rex
[3] Hoffmann V., et al., 2021. Flensburg meteorite, 52nd LPSC 2021, this issue.
[4] Meteor. Bull. Database 2020: Kolang CM 1/2 (12/2020).
[5] Meteor. Bull. Database 2020: Tarda C2 – ungrouped (12/2020)
[6] Meteor. Bull. Database 2020: Type - C2 – ungrouped meteorites (12/2020).
[7] https://www.karmaka.de (12/2020)