News on the Machtenstein H5 ordinary chondrite. V.H. Hoffmann[1,2], R. Hochleitner[3], M. Kaliwoda[3], A. Günther[1], E. Schmidbauer[1], T. Mikouchi[4], D. Heinlein[5]. [1]Fac. Geosciences, Dep. Geo- and Environmental Sciences, Univ. München; [2]Dep. Geosciences, Univ. Tübingen, Germany; [3]Mineralogical State Collection, München, Germany; [4]Dep. Earth & Planetary Science, The Univ. of Tokyo, Japan; [5]Augsburg, Germany.

Introduction

First results on our investigations on the new Bavarian meteorite Machtenstein have been reported by [1,2]. In this contribution we will briefly summarize the earlier results. Our main focus is on the magnetic signature of the H5 ordinary chondrite.

The stone was found by a landowner during farming in his field around 1956 near Machtenstein, South Bavaria. Because of its unusual appearance, the stone was kept by the finder until it was rediscovered and recognized as a meteorite in 2014 [1]. The total mass of the meteorite is 1422 g, type specimen mass is 21.7 g. Type specimen and 1 polished thin section, 1 polished thick section and one EMP sample are deposited in the Mineralogical State Collection Munich (MSCM) The ownership of the main mass is open at the moment.

Petrography and mineralogy

The total mass of the Machtenstein meteorite is 1422 gr, fusion crust is widely absent due to terrestrial weathering (figure 2). Dominant mineral phases are orthopyroxene ($Fs_{16.5}Wo_{0.01}$), troilite, feldspar, olivine ($Fa_{18.7}$) and metal (kamacite / taenite with 7.0±0.23 wt% Ni and 0.46±0.1 wt% Co) [1], see figures 1, 3 and 4.

The size of the chondrules was found to be around 0.2 to 1 mm, the recrystallized matrix is mostly hypidiomorphic with grains of 0.01 to 0.5 mm in size. Dominant matrix minerals are olivine and pyroxene, feldspar grains up to 50 µm, and metal (kamacite and taenite up to 50 wt% Ni, Co in kamacite 0.46±0.1). Metal (esp. kamacite) is generally altered to goethite/limonite (up to 70%). Massive veining of iron oxides in cracks is visible, and most parts of the stone are heavily weathered.

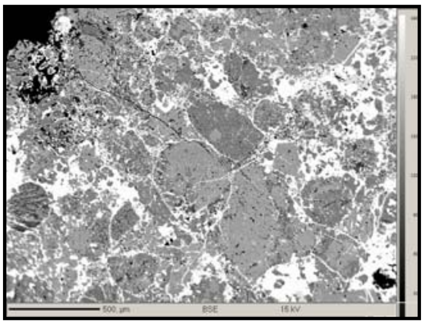


Fig. 1: Overview of Machtenstein matrix by SEM backscatter imaging showing olivine, pyroxene, opaques and several chondrules of different types.

Shock stage was found to be in the range of S2 with uneven darkening of olivines. Weathering grade is close to W 3.

Fig. 2: Main mass of Machtenstein and interior view after cutting off the type mass (front).

(a)

(b)

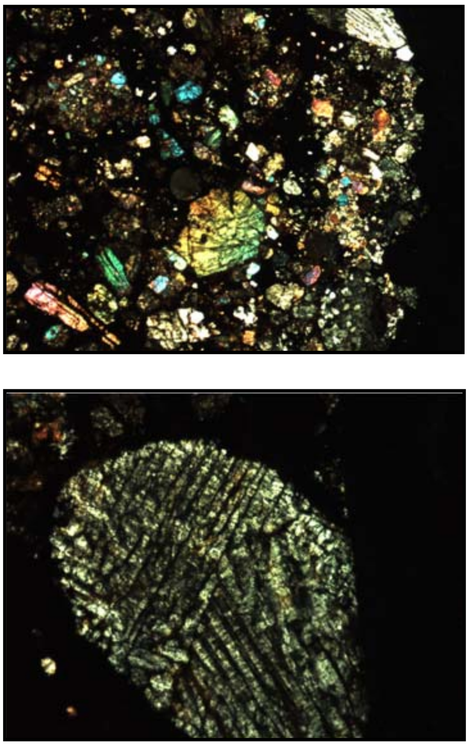
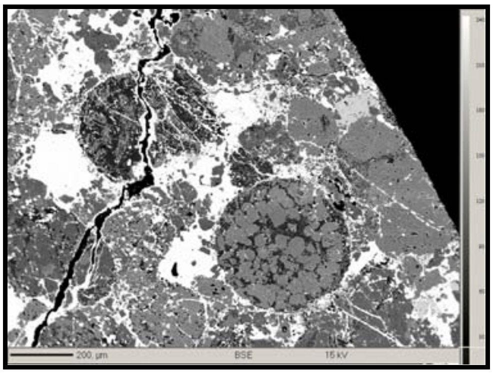
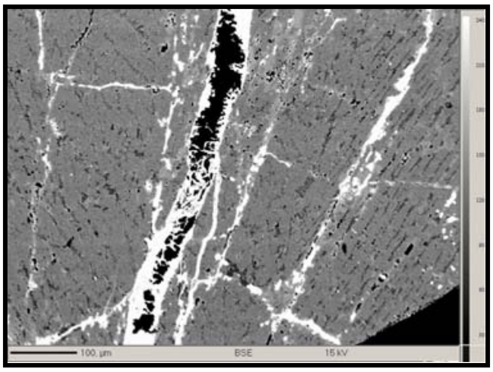


Fig. 3: Detailed views in polarized light: (a) matrix characteristics, and (b) a typical pyroxene chondrule. Magn. 100x.



(a)



(b)

Fig. 4: SEM backscatter images showing typical matrix features such as strong terrestrial weathering effects (eg cracks) in the Machtenstein meteorite (in a and b), and the presence of iron oxy-hydroxides (white colour).

Raman Spectroscopy

Optical microscopy, SEM and LASER Micro Raman Spectroscopy revealed the presence of the following phases (T: terrestrial alteration):

- Olivine
- Pyroxene (OPX and CPX)
- Iron – Nickel metal (Kamacite, Taenite)
- Troilite
- Plagioclase (low-intermediate shock)
- Chromite
- Graphite
- Apatite
- Merrilite – Whitlockite
- Magnetite T
- Various Fe-oxides / hydroxides T
- Calcite T

Magnetic signature

Magnetic susceptibility was investigated by SM100 (ZH Instruments). The following values have been obtained on different sets of samples, details will be found on our poster. Values are given in decimal log of mass specific MS in 10^{-9} m^3/kg, as used in MS databases such as published in [3, 4]:

Magnetic susceptibility in 10^{-9} m^3/kg MS from databases (referenced in [3,4]		
Sample	Type	Log MS
Machtenstein 1	Part slice (ext / int) 0.11 gr	4.91 +/- 0.01
Machtenstein 2	Fragments (int) 0.03 gr	5.12 +/- 0.01
Machtenstein 3	Slice (ext / int) 11.45 gr	5.02 +/- 0.02
H 5 H	Falls only All H falls	5.32 +/- 0.10 [3] 5.32 +/- 0.01 [3]
H	All H finds	5.05 +/- 0.11]4]
H	All H finds: non-antarctic	4.89 +/- 0.31 [3]

Machtenstein MS values fit quite well with the average MS values for all H ordinary chondrite finds (interior fragments) and all non-antarctic H (OC) finds (exterior parts of the stone included).

The magnetic signature of the Machtenstein meteorite is dominated by magnetite-like phases (Curie-temperatures typical for magnetite). Only minor contributions result from Fe-Ni metal phases such as Kamacite and/or Taenite. This confirms that the stone is characterized by heavy terrestrial alteration; magnetite-like phases are not of primary origin but are only formed under terrestrial atmospheric conditions.

Moessbauer Spectroscopy was performed on different sets of samples in order to investigate in detail the magnetic phases and their individual contributions. Generally, the spectra are highly complex on Machtenstein material as it is the case for many meteorites. Strong terrestrial alteration effects and a high number of contributing phases prevent a precise evaluation and interpretation. More details, advantages and drawbacks of performing Moessbauer experiments on extra-terrestrial materials will be discussed in our poster.

References

[1] Machtenstein, in: Meteoritical Bulletin 8/2015
[2] Hochleitner R. et al., LPSC 2015, #1471.
[3] Rochette P. et al., 2003. MAPS 38/2, pp251.
[4] Macke R. 2012. PhD Thesis.

Acknowledgements

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