SHOCK EFFECTS AND PETROLOGICAL FEATURES OF THE OHABA CHONDRITE

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ABSTRACT

The Ohaba meteorite, which fell on October 11, 1857, in Transylvania (Alba District, Romania) has been classified in this study as an H5 chondrite based on the petrologic features and the chemical composition of olivine and pyroxene. By studying the shock effects in silicates and metallic phases we estimate the shock degree of this meteorite as S-3.

INTRODUCTION

The Ohaba meteorite fell in October 11, 1857, in Transylvania (Alba District, Romania). After appearance of a fireball, followed by detonations, a stone of 16.25 kg was found by a priest [1,2,5,7,9]. The fragments recovered are kept in 16 museums from 11 countries. The Museum of Natural History from Vienna is the repository of the main mass (15.73 kg). The samples of the Ohaba chondrite are kept in 16 foreign museums from 11 countries.
The meteorite was previously classified as an H5 veined ordinary chondrite, based on olivine composition – Fa_{20}, as in [4].

SAMPLES AND ANALYTICAL METHODS

Two polished thin sections representing the Ohaba chondrite were studied under the microscope in both transmitted and reflected light. In order to determine the shock degree of this chondrite the mineral grains were examined with 20x- or 40x- objectives as in [10] and with the electron microprobe. Quantitative chemical analyses of the constituent minerals were obtained on the carbon-coated, polished thin sections by using a JEOL JSM-6400 scanning electron microscope at the Museum of Natural History from Vienna. The instrument was operated at an accelerated voltage of 15 kV, a 38.5 nA beam current and 39 mm working distance. About 30 points of both olivine and orthopyroxene were measured on each thin section.

PETROLOGIC TYPE OF THE KAKOWA METEORITE

The microscopic study in thin sections revealed the presence of the following types of chondrules in the Ohaba chondrite: readily distinguished PO – porphyritic olivine (Fig. 1), RP – radial pyroxene, BO – barred olivine (sometimes polysomatic; Fig. 2) and GOP – granular olivine-pyroxene chondrules, ranging in size from 300 µm to up 1200 µm. The matrix is recrystallized, the feldspar ($An_{15}Or_3$) occurs in grains smaller than 50 µm and the igneous glass is absent. Pyroxenes are mainly orthopyroxenes but less than 10% of the grains are clinopyroxenes with Wo_{37} (mole percentage), which is similar to diopside composition. Other minerals identified in polished thin sections are kamacite (Fig.3), troilite, taenite, plessite, chromite and magnetite.

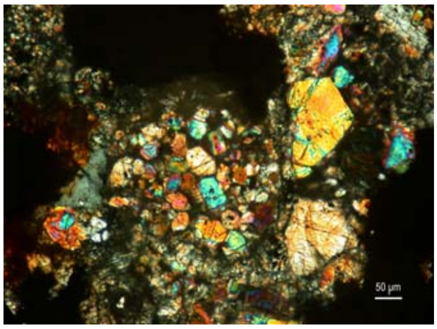

Fig. 1. Readily distinguished PO chondrule, 2N

Based on petrographic data, the Ohaba chondrite is classified as petrologic type 5, consistent with the data printed in [1]. Reference [6] reported a density of 3.38 g/cm^3 for Ohaba which is close to the bulk density found by [11] for the H group: 3.44 $\pm$ 0.19 g/cm^3.

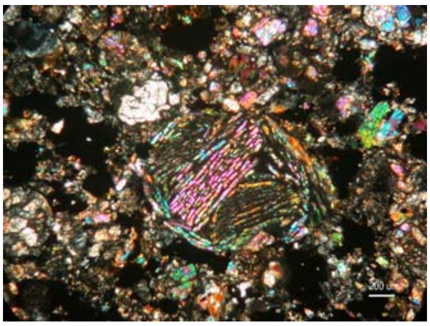

Fig. 2. Readily distinguished BO chondrule, 2N

Analysis of 15 olivine grains from two thin sections shows a variation in composition from Fa_{14} to Fa_{15}

mole% fayalite (avg. Fa_{15}; PMD 2.2%). Twelve orthopyroxene grains from thin sections show a range in composition from Fs_{13} to Fs_{16} mole % ferrosilite (avg. Fs_{14}; PMD 6.06%).

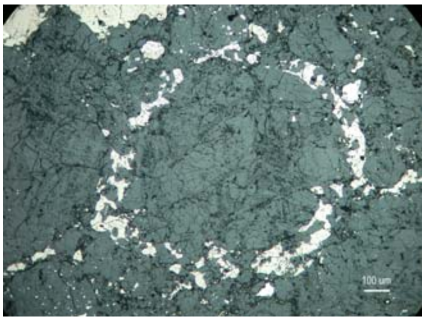
Fig. 3. Rim of kamacite bordering a BO chondrule (RL), 1N

Taking into account the iron-content of olivine plotted against iron-content of orthopyroxene [3], Ohaba meteorite may be considered as an ordinary chondrite – H_5, belonging to the primitive meteorites class (Fig. 4), consistent as well with the data published by [1].

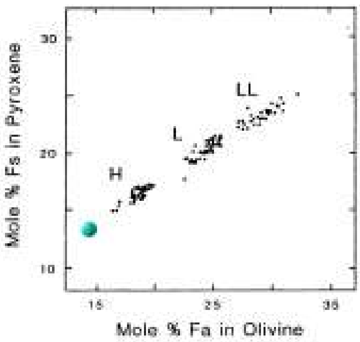

Fig. 4 - Iron-content of olivine plotted against iron-content of orthopyroxene as in [3]

SHOCK EFFECTS

The shock effects in ordinary chondrites vary with increasing shock intensity such that a progression of characteristic stages of shock metamorphism can be recognized and arranged on a relative scale of increasing degree of deformation and alteration of the constituent mineral phases. Therefore, a particular ordinary chondrite sample can be assigned to a specific "shock stage" or to a "shock facies" [10]. The shock effects in chondritic silicates for which an accurate shock pressure calibration is available include the following major deformation and transformation phenomena in olivine, oligoclase, and pyroxene observable in the petrographic microscope:

1) Mechanical deformations - a) undulatory extinction in olivine, pyroxene and plagioclase; b) planar fractures and planar deformation features in olivine and planar deformation features in plagioclase; c) mechanical twinning in pyroxene and d) mosaicism in olivine, pyroxene and plagioclase.

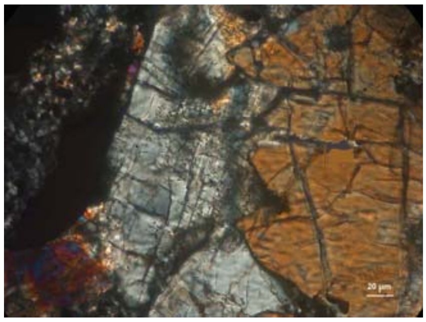
Fig. 5. Planar fractures and undulatory extinction in olivine, 2N

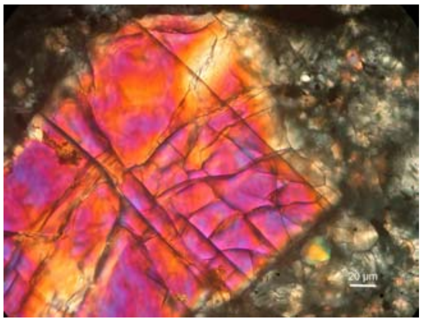
Fig. 6. Olivine with one set of parallel planar fractures, 2N

2) Phase transformations - a) transformation of plagioclase into diaplectic glass (maskelynite); b) melting of plagioclase and formation of (normal) glass; c) solid state recrystallization of olivine; d) melting of olivine and formation of fine-grained polycrystalline olivine and e) transformation of olivine and pyroxene into ringwoodite and majorite, respectively, and / or dissociation of olivine into several crystalline or glassy phases.

Reference [8] stated that in addition to shock events in olivine, plagioclase, orthopyroxene and Ca-pyroxene, petrographic shock indicators in equilibrated ordinary chondrites (OC) include chromite veinlets, chromite-plagioclase assemblages, polycrystalline troilite, metallic Cu, irregularly shaped troilite grains within metallic Fe-Ni, rapidly solidified metal-sulfide intergrowths, melting of metal (and troilite), martensite and various types of plessite, metal-sulfide veins, large metal and/or sulfide nodules, silicate melt veins, silicate darkening, low-Ca clinopyroxene, silicate melt pockets, and large regions of silicate melt. The presence of some of these indicators in every petrologic type-4 to –6 ordinary chondrite demonstrates that collisional events caused all equilibrated OC to reach shock stages S3-S6.

From the above features, in the Ohaba chondrite we observed olivine with undulatory extinction, irregular fractures (Fig. 5) and planar fractures (Fig. 6), plagioclase with undulatory extinction and metal-sulfide melt drops along planar fractures in olivine (Fig. 7). The shock degree of this chondrite may be estimated as S-3 (weakly shocked).

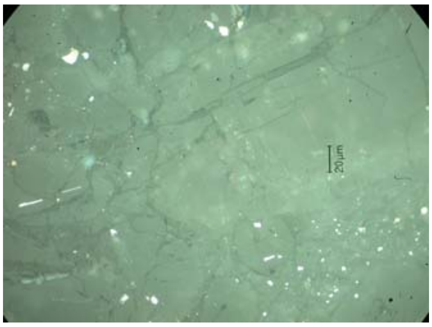

Fig. 7. Metal-sulfide melt drops and troilite along planar fractures in olivine (RL), 1N

CONCLUSIONS

The results of this study are summarized as follows:
1. Based on electron probe microanalyses and optical microscope study, the Ohaba meteorite is a typical H5 chondrite. The result is consistent with the classification of this chondrite made by [4].
2. The degree of shock metamorphism reached by Ohaba meteorite during it's evolution in space is S-3 (weakly shocked).

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