

PETROGRAPHIC AND MICRO-RAMAN ANALYSIS OF CHONDRULES AND (Ca,Al)-RICH INCLUSIONS OF NWA 2086 CV3 TYPE CARBONACEOUS CHONDRITE. K. Fintor¹, H. Walter¹, and Sz. Nagy¹; ¹University of Szeged/ Department of Mineralogy, Geochemistry and Petrology, H-6701 P.O. Box 651, efkrisz@gmail.com, walterhelena88@gmail.com.

Introduction: The CV3 carbonaceous chondrites are among the most investigated meteorite type on the Earth [1]. The object of this study is the NWA 2086 CV3 type carbonaceous chondrite, which is related to 3.3 petrologic types along with the Vigarano, Efremovka and Leoville [2].

Here, we present the petrographical and micro-Raman analysis of chondrules and (Ca,Al)-inclusions (CAI's) of the NWA 2086 CV3 carbonaceous chondrite, as well as the first evidence for attendance of the dmsteinbergite (hexagonal $\text{CaAl}_2\text{Si}_2\text{O}_8$) as refractory mineral in a CV3 chondrite.

Methods: Petrography and the microscopic images of the sample have been carried out by using an Olympus BX41 polarization microscope. Identification of distinct phases in chondrules and CAI's have been made by using a THERMO Scientific DXR Raman Microscope. The following settings were used during the measurements: 532 nm laser line, 10 mW laser power, 25 μm confocal aperture and 100X objective lens. The applied magnification leads to $\sim 1 \mu\text{m}$ optical resolution. The spectra were collected by a Peltier cooled CCD. The gratings were 1800 line/mm resulting $\sim 2 \text{ cm}^{-1}$ spectral resolution. The exposure time was 1 min at each spectrum in auto exposure working mode with S/N:100 signal to noise ratio.

Results:

Chondrules: Four characteristic chondrule types were distinguished in the sample.

Plagioclase rich chondrules (PRCs): The size of these chondrules can reach as high as 5 mm in diameter hence, they represent the largest chondrule type in the sample. Many PRCs show double layered structure an outer rim and an inner core (Fig. 1/a). The two parts are separated by a thin opaque layer. The outer rim shows porphyritic equigranular texture and consists of olivine and clinopyroxene phenocrysts. The inner core exhibits lath-shaped anorthitic plagioclase, tabular or lath-shaped clinopyroxene, olivine phenocrysts, interstitial enstatite, mackinawite (Fe-Ni sulphide), Fe-Ni nodules and crystalline mesostasis (Fig. 1/b). The mesostasis contains anhedral anorthitic plagioclase and clinopyroxene crystals. At some places the plagioclase and the clinopyroxene crystals form acicular radially intergrown texture.

Porphyritic Olivine chondrules (PO): Most of them are rarely reach a few mm sizes in diameter. These chondrules have been made by almost entirely forsteritic-

ic olivine phenocrysts, and subordinate amount of Fe-Ni nodules and mesostasis. At some olivine crystals contain small euhedral spinel inclusions.

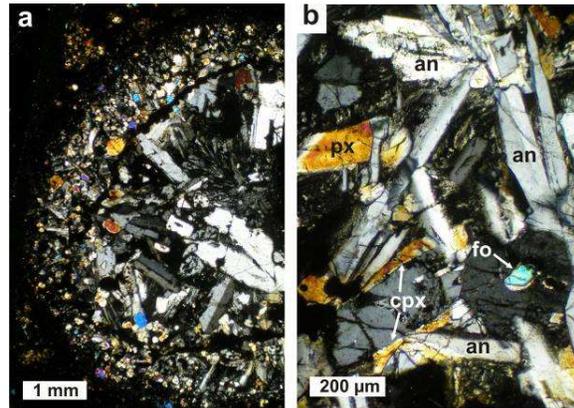


Figure 1. Plagioclase rich chondrule (PRC): a) PRC exhibits a granular texture outer rim and a porphyritic texture inner core; b) lath shaped anorthitic plagioclase crystals in the inner core of PRCs, abbreviations: an: anorthite, px: pyroxene; cpx: clinopyroxene, fo: forsteritic olivine.

Porphyritic Olivine Pyroxene chondrules (POP): The textural and mineralogical features are very similar to PO types with some exceptions. Olivine phenocrysts and lath-shaped clinopyroxenes are the major mineral phases, with Fe-Ni nodules and higher amount of mesostasis.

Barred Olivine chondrules (BO): This type is containing olivine with glassy mesostasis and Fe-Ni nodules.

(Ca-Al) rich inclusions: Three different type of CAI's can be distinguished in the sample.

Spinel rich type CAI's made by very small size (few 10 μm) grains. In this type anhedral spinel agglomerates are the major constituents. Tiny (3-5 μm) circular perovskite inclusions can be found in the inner part of this agglomerates. The spinel agglomerates are embedded in fine grained clinopyroxene assemblage exhibiting hedenbergite-diopside composition. Micropores are occurring frequently in the clinopyroxene assemblage. Subordinately, forsteritic grains with sub-micron size ilmenite are also occurring in this type. Sodalite and nepheline as secondary minerals are also occurring rarely in the clinopyroxene assemblages.

Type 2: CAI's are also containing fine mineral grains however spinel is occurring much lesser amount than in the spinel rich type. In these inclusions clinopyroxene assemblages are the main constituents. Andra-

dite garnet can be found as identical grains or in a center of diopside-hedenbergite aggregates. Perovskite are also occurring as small (3-5 μm) inclusions in diopside/augite assemblages. Forsterite grains with diopside rim are also occurring subordinately.

The third type CAI's are made by large (>100 μm) anhedral to tabular shaped crystals and fine grained crystal aggregates are occurring interstitially among larger crystals. The large grains are gehlenites which contain small (~10 μm) spinel and perovskite (4-5 μm) grains and they are embedded poikilitic in gehlenite. The fine grained aggregates contain high temperature phases as well as anorthite and diopside-hedenbergite and low temperature secondary phase together with grossular garnet.

Among the clinopyroxene-grossular and spinel-gehlenite assemblage can be observed the dmsteinbergite by Raman spectroscopy which is a hexagonal form of $\text{CaAl}_2\text{Si}_2\text{O}_8$. (Fig. 2/a, b).

Discussion:

In the investigated sample the PRCs are the more characteristic chondrules. They show similar mineralogical composition and textural features than can be observed in reduced CV chondrites such as Efremovka, Leoville or Vigarano [3]. In Efremovka many PRCs are surrounded by porphyritic forsterite-clinopyroxene rim as well as in the sample studied here [3].

The melilite rich CAI-s are supposed to be intermediate between type A and B inclusions based on their petrographic features [4]. CAI's which containing spinel rich aggregates show similarities to spinel rich fine grained inclusion type [4]. Spinel rich objects are also occurring in other CV3 chondrites such as Allende, Mokoia, or Kaba [5]. Nevertheless spinel rich CAI's in the studied sample show wormy appearance. Spheric type ones which occur frequently in Kaba Allende and Mokoia [5] have not been observed in NWA 2086 up to now.

The refractory mineral dmsteinbergite (hexagonal $\text{CaAl}_2\text{Si}_2\text{O}_8$) has not yet been detected in meteorite before. This mineral along with its polytype svyatoslavite (monoclinic $\text{CaAl}_2\text{Si}_2\text{O}_8$) is only described from the Earth or as a synthetic phase. They were identified firstly from a southern Ural coal basin [6] and later from North Italian Alps [7]. In the nature, the dmsteinbergite can be found in high temperature and hydrothermal environment also [7]. In NWA 2086 the high temperature origin are favourable due to the absence of any low temperature hydrous phases as zeolites. This mineral nucleates and grows prior to the appearance of stable anorthite when the melt is supercooled by rapid cooling below 1200 $^{\circ}\text{C}$, and has a melting point of 1400 ± 15 $^{\circ}\text{C}$ [8]. Based on these ob-

servations and earlier works, it appears that the presence of this mineral could be an indicator of high temperature conditions and extremely rapid quenching.

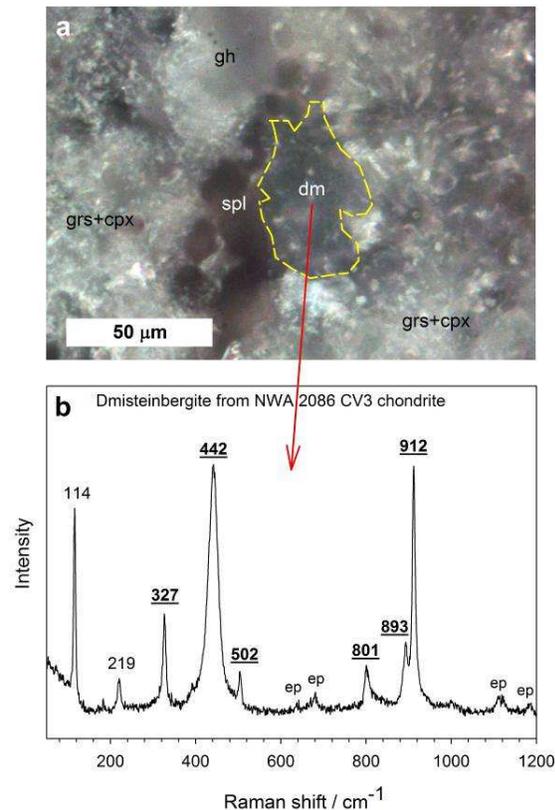


Figure 2. a) anhedral dmsteinbergite among sp+cpx+grs assemblage abbreviations: grs=grossular, cpx=clinopyroxene, spl=spinel, gh=gehlenite, dm=dmsteinbergite; b) Raman spectra of the crystal from picture 'a', ep. refer to epoxy.

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