Planetary and Space Science 104 (2014) 200–210

Contents lists available at ScienceDirect

Planetary and Space Science

journal homepage: www.elsevier.com/locate/pss

Analysis of ripple or flow-like features in NWA 3118 CV3 meteorite

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ARTICLE INFO

Article history:
Received 22 April 2014
Received in revised form
2 September 2014
Accepted 5 September 2014
Available online 28 September 2014

Keywords:
Meteorite
Chondrite
CV3
Matrix

ABSTRACT

Analysing NWA 3118 CV3 chondrite with optical microscopy and electron microprobe methods, mostly intact chondrules were present, and fragmentation happened before the chondrules settled down at their current location. During or after the consolidation metasomatism changed Mg to Fe in olivines around the scale of 100 μm toward the chondrules' interior. Specific elongated dark, often rim-like features with length above 0.3 mm were identified in the matrix. While in most cases these features looked like as a rim around chondrules, at several cases they appeared without chondrules. Their mineral size was very small, and elemental composition did not show obvious difference from that of the matrix, although they have moderately elevated S at some locations. They were mostly composed of olivine, although it is very difficult to determine the exact mineral phase because of the small grain size. They contained elongated, chain-like larger crystals, occasionally arranged along curved arches, suggesting some specific oriented crystal growth and also some small-scale mechanical movement might contribute in their formation. Our observations suggest that some features earlier termed as chondrule rims in CV meteorites might also form without chondrules or not directly around them. Their origin irrespective of chondrules and may represent a knowledge gap in the understanding of processes inside CV parent bodies.

1. Introduction

In this work a CV3 chondrite named NWA 3118 is analyzed that has curved and elongated dark stripes in its matrix. The aim was to identify basic properties of these features in order to elucidate could they be formed by movement of the matrix material during a partially molten phase or what type of origin may be relevant. NWA 3118 is a moderately or poorly analyzed oxidized CV3 meteorite that was bought in a market in Morocco. The original mass was 5.9 kg, and the unique ripple-like structure was already mentioned in its first description in Meteoritical Bulletin Database. Its chondrules are usually <2 mm in diameter, but few of them may be as large as 8 mm. Various CAI grains also present in the meteorite (Ivanova et al., 2010b, 2011a, 2011b), where heterogeneity in bulk composition (Ivanova et al., 2013) and enrichment in Zr, Sc, Y (Ivanova et al., 2010a) were found. Earlier works also analyzed its carbon content using Raman microscopy (Ghimire et al., 2012).

Alteration related observations of chondrules and matrix are important for CV and CK chondrites, as these two different groups might have the same parent body. These meteorite groups represent primitive material (McSween, 1979), they also show low levels of aqueous alteration, providing insight into the processes in relatively small planetesimals (Gyollai et al., 2011). The group named together CV–CK clan (Weisberg et al., 2006, Davidson et al. (2012)) displaying affinity in oxygen isotopes, large chondrules and refractory inclusions (Greenwood et al., 2010). The possible continuum between CV and CK chondrites might be related to a common parent body possibly Eos family, Hardersen et al., 2011; Mothe-Diniz et al., 2008).

2. Methods

During the analysis we used morphological, mineralogical and chemical compositional observations of a thin section of NWA-3118 meteorite. The sample was a 9 by 14 mm sized, nicely polished thin section where substantial break off chips did not happen, and was ideal for detailed research. For textural analysis polarization microscope NIKON Eclipse E600 POL was used. Elemental composition of certain sections and profiles of the sample was measured with 1–2 μm spatial resolution under thin amorphous carbon cover layer deposited in vacuum, using a JEOL Superprobe 733 electron microprobe with INCA Energy 200 Oxford Instrument Energy Dispersive

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http://dx.doi.org/10.1016/j.pss.2014.09.011
0032-0633/

Spectrometer. The analytical circumstances were 20 kV acceleration voltage, 6 nA beam current and count time of 60 s for the spot measurement and 5 min for linescan analysis. SE pictures and EDX measurements were made by AMRAY 1830 scanning electron microscope equipped with EDAX PV9800 energy dispersive spectrometer. During the compositional analysis olivine, augite and plagioclase standards were used.

3. Results

The meteorite section is composed of 25% matrix and 75% chondrules (Fig. 1). The chondrules are homogeneously distributed, they are not in physical contact along their edges with each other. No oriented pattern is visible in the sample, although there are small-scale ripple or flow-like features that will be discussed later. Inside the chondrules large phenocrystals are often present, while the matrix is very fine grained and difficult to analyze.

Regarding the bulk composition, the whole meteorite is oxidized, ferrous. The matrix is reddish brown, with small elongated olivine rods and clusters of pyroxene crystals of 5–20 μm diameter. Most chondrules are round shaped, their size is between 2.8 and 0.4 mm. The main component is olivine 80 wt% and the rest 20 wt % is composed of plagioclase, pyroxene and opaque minerals. For the whole meteorite three particle size groups could be identified: (1) big ones (200–1000 μm) with regularly shaped, (2) middle size particles often irregularly shaped (40–100 μm) and (3) small size particles also often irregularly shaped (10–30 μm). Chondrules with regular shape are present in the (1) and the with irregular shape in (2) and (3) groups. The edges of the chondrules are fine grained and show the same particle size as the matrix, they have yellow and reddish brown colour. Between the chondrules' edge and the matrix a dark band with diffuse outline can be seen, discussed below as ripple or flow-like structures.

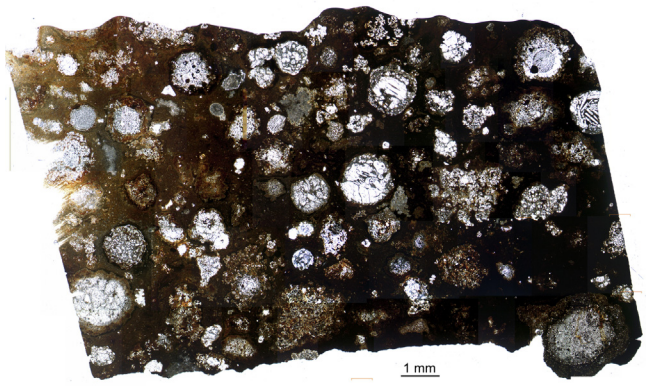

Fig. 1. Overview of the analyzed thin section of the meteorite NWA3118.

3.1. Petrology of NWA-3118 CV3 chondrite

The main mineral components of the meteorite are olivine, pyroxene, plagioclase and opaques (see some examples in Fig. 2):

- Olivine (85 wt%): main mineral type of the meteorite, mostly isometric and table shaped, has spinifex feature, larger ones are 200–1000 μm and smaller are 20–100 μm in diameter. Occasionally fluid inclusions could be observed inside them.

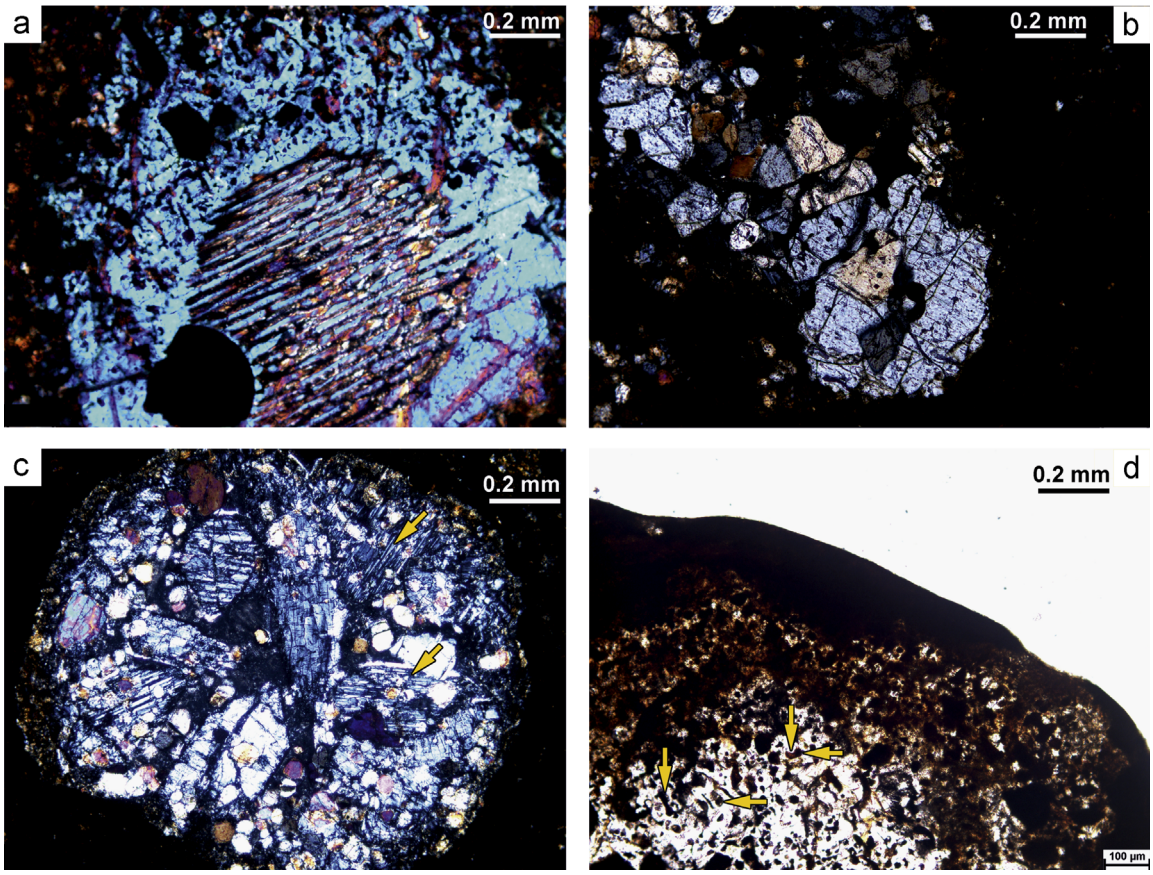

Fig. 2. Example for characteristic minerals in the sample with crossed nicols. (A) exsolution inside olivine chondrule (no. 19) with a large round opaque grain at the bottom left, (B) a large 200 μm sized (lower right, somewhat fragmented) pyroxene crystal in the no. 75 chondrule, (C) twinned plagioclase crystals with embedded olivine grains in chondrule no. 79 (top right, right arrows), (D) elongated, teardrop shaped (arrows) opaque grains at the edge of chondrule no. 19 with 1N.