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Chondrules alteration study of NWA2086 CV3 meteorite by using μ-IR and SEM/EDS combined analysis and implications for asteroid parent body

Fabrizio Dirri (1), Marco Ferrari (1), Ernesto Palomba (1), Stefania Stefani (1), Andrea Longobardo (1,2), Alessandra Rotundi (1,2)
(1) Institute for Space Astrophysics and Planetology, Via del Fosso del Cavaliere 100, 00133, Rome, Italy (fabrizio.dirri@iaps.inaf.it); (2) Dipartimento di Scienze e Tecnologie, Università di Napoli "Parthenope", CDN, IC4 , 80143, Naples, Italy.

Abstract

The aim of this work is to characterise two different chondrules (from intact chondrule to matrix area) of NWA2086 CV3 type meteorite by using the Infrared μ-spectroscopy (μ-IR) and Scanning Electron Microscope with Energy Dispersive Spectroscopy (SEM/EDS) coupled technique. The Christiansen and Reststrahlen features of the main minerals were identified by using μ-IR (spectral region 7-15μm). The μ-IR results were compared with SEM/EDS analysis able to provide chemical information of meteorite samples and high resolution images of the inclusions morphology. The coupled technique will provide a comprehensive mineralogical characterization of NWA2086 meteorite, giving implications about the CV3 parent body evolution.

1. Introduction

The CV Carbonaceous Chondrite meteorite with many large olivine chondrules and CAIs (Ca-Al-rich inclusions), are among the most studied meteorites founded on Earth [1]. The CV3 were considered primitive and representative of primitive solar nebula [2] and although belong to petrologic type 3, some signatures related to hydration and interaction with water could also be present [3] and should provide information about chemical processes in relatively small planetesimals [4]. In this work, we analysed two portions of NWA2086 meteorite, belonging to the reduced subtype of CV3s, with low shock stage (S = 1) and weathering grade (W = 1). Four types of Chondrules, i.e. 1. plagioclase-rich (PRCs), 2. porphyritic olivine (PO), 3. porphyritic olivine pyroxene (POP), and 4. barred olivine (PO) and three types of CAIs, i.e. 1. spinel-rich, 2. clinopyroxene assemblages plus andradite and perovskite, 3. gehelenite-rich plus perovskite and spinel have been identified by Fintor et al. (2013) by using petrographic and micro-Raman methods.
In this framework, we focused our analysis on mineral characterization of two intact chondrules and matrix area of NWA2086 by coupling the spectral features obtained with μ-IR technique and coupling the results with SEM/EDS chemical data.

2. Method

A preliminary analysis was performed on NWA2086 by using a Stereo Microscope (Leica M205c) equipped with a digital camera in order to select the sample regions characterized by a significant mineralogical heterogeneity. Thus, two chondrules (A, B area; Fig.1) were selected and spectral data acquired with μ-IR Microscope (Bruker Hyperion 3000) and analysed in the spectral range of interest: 7-15 μm.

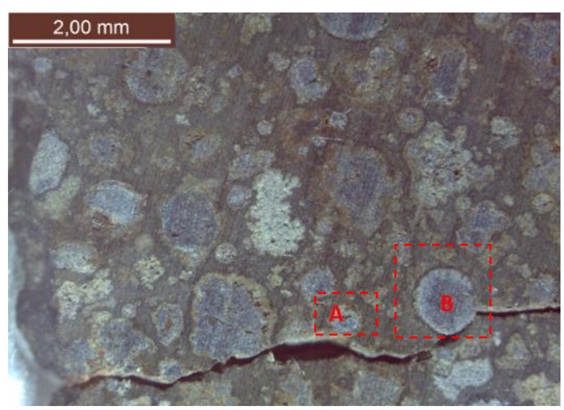

Figure 1. Image of A and B area, analysed with the μ-IR and SEM/EDS techniques.

The A and B regions have been also analysed by using chemical information provided by SEM/EDS technique and compared with the Reststrahlen bands of the main minerals identified and summarized in Table 1.

Table 1. Mineral bands identified by means of μ-IR technique and compared with SEM/EDS data.

NWA2086	**Res. - Christ. features (μm)**	**μ-IR minerals**	**SEM minerals**
A(chondrule)	9.5,10.8, 11.2, 12 - 8.7	Mg-rich oliv. clinopyr., An	Mg-rich olivine
A(matrix)	10.4, 11.3, 12 - 9.3	Fe-rich olivine	Fe-rich olivine
A(chondrule)	9.1, 10.6 - 8.2	an-rich, olivine clinopyroxene	anorthitic plag., clinopyr., oliv., sulphides
B(matrix)	10.4, 11.3, 12 - 9.4	olivine	Fe-rich olivine, poor-phyllosil.

3. Discussion

The matched data of A, B area indicate that:

- the chondrule spectral bands (*"A"* area) can be ascribed to clino-pyroxene and Mg-rich olivine while the matrix spectral bands indicate the presence of Fe-rich olivine. From intact chondrule to matrix area the chemical analysis shows as: 1. MgO decreases; 2. FeO increases (up to 55%); 3. small quantity of Al_2O_3 (<2%); 4. Fe-rich mineral is present in the rim where Mg content decreases and Fe content increases as stated by Kareszturi et al. (2014).

- the chondrule spectral bands (*"B"* area) can be ascribed to clino-pyroxene and plagioclase while the matrix spectral bands indicate the presence of olivine. Chemical data shows as from intact chondrule to matrix area: 1. Al_2O_3 and CaO decreases (35 to 3% and 24 to 4%, respectively); 2. FeO and MgO increases (up to 45% and 22%, respectively) that can be ascribed to Fe-rich olivine largely present in the matrix area.

An example of spectral bands variation from chondrule to matrix of B area is shown in Fig. 2 where mainly composition of An-plagioclase (probably PRCs chondrule) gives way to Fe-rich olivine composition (matrix).

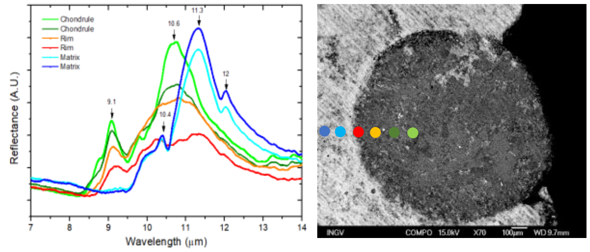

Figure 2. B area: spectral bands from chondrule to matrix (*left*) and location of μ-IR measurements *(right)*.

4. Conclusion and future aims

The chondrules showed a different composition, i.e. clino-pyroxene and Mg-rich olivine ("A"), clino-pyroxene and plagioclase ("B") while the composition of matrix area, i.e. Fe-rich, is mainly ascribed to Fe-rich olivine. In particular, from intact chondrule to matrix the Fe content increases and Mg decreases which suggests, as stated by [6], a chondrule rim composition close to matrix composition (as confirmed by our data), due to fluid interaction during the re-accretion phase of this meteorite. The chondrules rim characterization will be in depth studied in the next future (the comparison of NWA2086 with other CV3 meteorites as well) in order to understand the formation or chemical processes involved in the CV3 parent body evolution.

Aknowledgments

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