PETROLOGY AND GEOCHEMISTRY OF TYPE II PORPHYRITIC OLIVINE CHONDRULES IN THE NORTHWEST AFRICA (NWA) 12692 LL3.00 CHONDRITE METEORITE. D. Rezes[1,2], [1]Department of Petrology and Geochemistry, Institute of Geography and Earth Sciences, ELTE Eötvös Loránd University, H-1117, Pázmány Péter stny. 1/C, Budapest, Hungary, [2]Konkoly Observatory, Konkoly Thege Miklós Astronomical Institute, CSFK Research Centre for Astronomy and Earth Sciences, ELKH Eötvös Loránd Research Network, H-1121, Konkoly Thege Miklós út 15-17, Budapest, Hungary. Email: kisrezidani@gmail.com

Introduction: The Northwest Africa (NWA) 12692 meteorite was classified in 2019 as an LL3.00 ordinary chondrite. The 16 identical stones of this meteorite with a total mass of 373 g were found in 2012 by nomads in Mali [1]. The Meteoritical Bulletin Database contains just four examples of this rare ordinary chondrite type (i.e., LL3.00). The petrologic type 3.00 of chondrites indicates such ancient materials that were unaffected by metamorphic processes on the parent asteroids and thus they provide valuable information about nebular processes [2], however even one of the least equilibrated ordinary chondrites (e.g., Semarkona [3]) show trace evidences of aqueous alteration [4]. This research provides the first insight into this scientifically important Saharan unequilibrated ordinary chondrite.

Sample and Methods: The analyzed sample was a carbon-coated thick section (~200 μm thickness) of NWA 12692. Six type II (Fe-rich) porphyritic olivine chondrules were selected for the measurements. The section was analyzed by JEOL JSM-IT700HR Scanning Electron Microscope (SEM) with Aztec X-ACT Premium SDD Spectrometer at CSFK GKI. The instrument operated at 20 keV accelerating voltage with a 3nA beam current. The diameter of the focused beam was 1 μm. The acquisition time was 40 s for point analyses and 20 min for elemental mapping. The backscattered electron (BSE) images were obtained with Amray 1830 Scanning Electron Microscope (SEM) with EDAX PV9800 Energy Dispersive Spectrometer (EDS) at ELTE KGT. The instrument operated at 20 keV accelerating voltage with a 5 nA beam current.

Results: The sizes of the examined type II porphyritic olivine chondrules vary widely, the smallest is 500×780 μm (chondrule G3-1), while the largest is 1260×1370 μm (chondrule E3-1). They are mainly rounded, and contain euhedral olivine crystals with a grain size up to 650 μm (Fig. 1). The mesostases of the chondrules are made up of glass with a large number of pyroxene crystallites. Furthermore, the chondrules contain minor amount of chromite, troilite and FeNi metal.

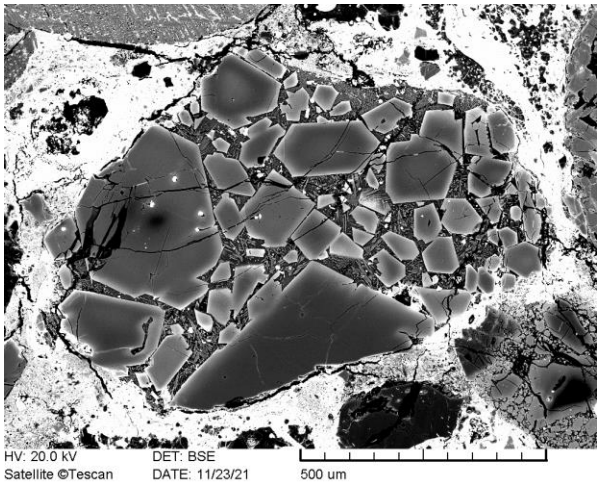

Figure 1. BSE image of chondrule H1-1. The chondrule contains euhedral, strongly zoned olivine crystals in glassy mesostasis with abundant pyroxene crystallites and minor amount of chromite, troilite and FeNi metal.

The olivine crystals in the examined chondrules are rich in FeO with an average Fa value of 18.6±7.8 mol%. The olivines are strongly zoned (Fig. 2) with Fa values from 8.4 mol% to 48.0 mol% (Fig. 3). Several olivine crystals show skeletal growth and contain rounded depressions (Fig. 4), which are characteristic features of the so-called hopper morphology [5].

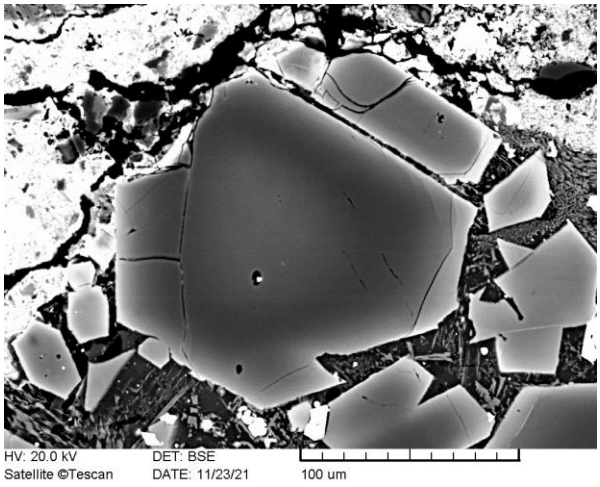

Figure 2. BSE image of an olivine crystal inside chondrule H1-1. The olivines show strong zonation.

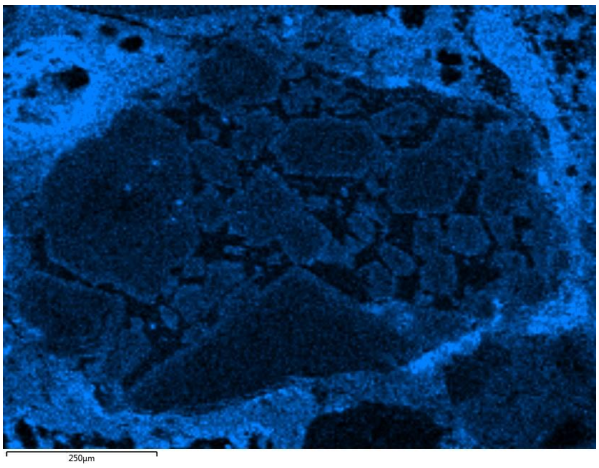

Figure 3. Fe-Kα X-ray map of chondrule H1-1. The olivine crystals show strong fluctuation in iron content. The cores and rims are mainly Fa-rich, while intermediate regions are forsteritic.

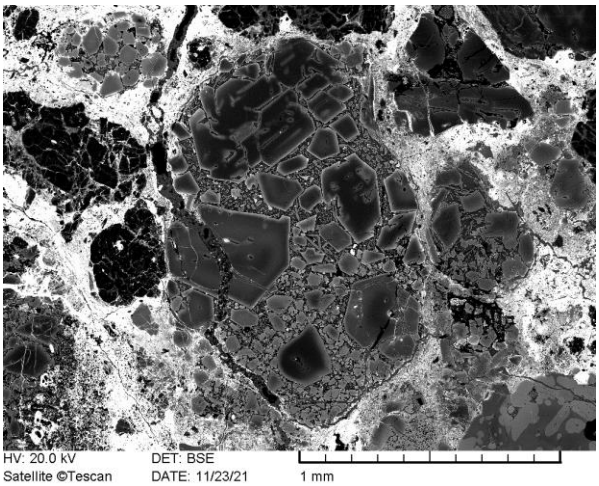

Figure 4. BSE image of chondrule E3-1. The large olivine phenocrysts show skeletal growth and round indentations (i.e., hopper morphology).

The average composition of the chondrule mesostases is SiO_2=68.05±2.30, TiO_2=0.49±0.08, Al_2O_3=13.08±1.12, Cr_2O_3=0.08±0.08, FeO=7.72±1.95, MnO=0.29±0.10, MgO=1.21±0.69, CaO=2.04±1.55, Na_2O=4.99±0.52, K_2O=1.23±0.14, P_2O_5=0.80±0.71 (n=35; all in wt%). The mesostases are relatively rich in volatile elements (i.e., Na, P and Mn). In chondrule D2-1, pyroxene crystallites were large enough to take measurements on them (~10×60 µm). All of the measured pyroxene laths are Mg-rich augites with an average composition of SiO_2=53.45±0.26, TiO_2=0.12±0.21, Al_2O_3=1.10±0.10, Cr_2O_3=1.68±0.24, FeO=10.19±0.19, MnO=0.56±0.02, MgO=16.45±0.81, CaO=16.02±1.31, Na_2O=0.44±0.38 (n=3; all in wt%).

Discussion: The coarse-grained ferroan olivines in NWA 12692 show lesser mean Cr_2O_3-content with a higher standard deviation (0.43±0.16 wt%) than that of Semarkona olivines (0.50±0.10 wt%; [2]), however olivines of NWA 12692 are more fayalitic (18.6±7.8 mol% Fa) than Semarkona olivines (13.3±6.7 mol% Fa; [2]). Furthermore, NWA 12692 olivines are moderately richer in P. The hopper morphology of several olivine crystals recorded the moderately rapid cooling of chondrule melt from which olivine crystals were grown [5].

The chondrule glass in NWA 12692 contains higher concentrations of FeO (7.72±1.95 wt%), MnO (0.29±0.10 wt%) and P_2O_5 (0.80±0.71 wt%) than those of Na- and K-rich mesostases of Semarkona chondrules [2]. Semarkona chondrules contain pyroxene crystallites with pigeonite and augite compositions [6], however our limited number of measurements indicated only the presence of Mg-rich augite crystallites in the mesostases of type II porphyritic olivine chondrules in NWA 12692.

Conclusion: Based on the observations, NWA 12692 contains very primitive chondrules that can help to identify early solar nebular formation processes. Moreover, NWA 12692 is a great example beside Semarkona to measure primordial values, estimate related processes [7] and exploit new infrared technology [8] on these rare extraterrestrial materials.

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