

Analysis of a spinel grain in Northwest Africa (NWA) 12391 ordinary chondrite meteorite

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Abstract

The Northwest Africa (NWA) 12391 is an ordinary chondrite meteorite with L5 S3 W3 classification. The average chondrule size is 702 μm . The Fa-content of olivine is $22,51\pm 0,73$ mol%, while the Fs- and Wo-contents of pyroxene are $18,98\pm 0,84$ mol% and $1,48\pm 0,25$ mol% consecutively. The Ab-content of feldspar is 82.76 ± 4.96 mol%. There is an unusually large (~ 200 μm diameter) spinel grain in a chondrule. Thermal calculations showed $775\pm 50^\circ\text{C}$ on that grain.

1. Introduction

NWA 12391 is a normal chondrite meteorite. Despite there is a large number of such meteorites, L chondrites are worth for detailed research [1,2,3], as their analysis could clarify potential melting events [4,5] various weak alterations [6] or shock impact history [7,8,9,10,11] of the parent bodies [12,13]. Analysis of normal chondrites also could support the better targeting of asteroid missions [14, 15].

2. Sample and Methods

The meteorite was analysed by OPTIPHOT2-POL optical polarization microscope, INCA Energy 200 Oxford Instrument Energy-dispersive Spectrometer + JEOL Super-probe 733 electron microprobe. The infrared spectroscopic analysis was performed by Bruker Vertex FTIR plus 70 Hyperion 2000 microscope equipped with ATR objective, and for the micro XRD analysis a Rigaku D/max rapid instrument was used. The analysed sample is a 51,4 gram piece of the NWA 12391 meteorite originally sized $5,5\times 3,5\times 2,5$ cm, without fusion crust and a ~ 45 μm thick thin section was produced.

3. Results and Discussion

One type of lithology can be observed in the sample, the edges of the chondrules are not sharp, the chondrule-matrix ratio is $\sim 70\%$. Black melt veins were present in the meteorite (Figure 1). The diffuse chondrule edges indicating partial melting events and already started homogenization.

The matrix is recrystallized, with many faults crossing the sample including melt veins form shock melting. The average chondrule size is around 702 μm , with most of them are between 341 and 441 μm , while the maximal diameter is 2046 μm . The shock veins were opaque with 1 Nicol analysis, their width were below 200 μm , followed straight lines in most cases. Several cracks were filled with brownish desert dust, intruded after fall into the meteorite. The calcite com-posed veins host random located quartz grains, and there are opaque phases along the border between the veins and the matrix material.



1. Figure Characteristic part of the texture of the NWA 12391 with 1N.

Composition: The olivine grains showed $22.51\pm 0,73$ mol% Fa-content (N=18), while the low-Ca pyroxenes showed average 18.98 ± 0.84 mol% Fs-content and 1.48 ± 0.25 mol% Wo-content (N=10). Feldspars presented on the average 82.76 ± 4.96 mol% (N=6) Ab-content, while their Cr-content were 0.003 ± 0.004 , and K-content 0.032 ± 0.009 .

A large, ~ 200 μm sized, euhedral, hexagonal, rectangular shaped spinel grain with dark red colour and finely fractured surface was observed in one chondrule. The grain is surrounded by fine grained feldspar and one plagioclase grain is located inside the spinel. The host chondrule is surrounded by opaque rings. On BSE images the chondrule shows

many fractures and veins. Beside the spinel, Cl-apatite, whitlockite, and around the chondrule edge chromite and FeNi could be present in small amount.

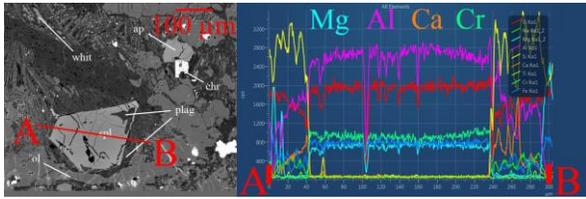


Figure 2. Microprobe profiles showing elemental compositional changes along the spinel grain.

Compositional variations along profiles crossing the spinel (Figure 2), Mg- and Al-content showed decreasing abundance toward the edge, Cr-content did not show a strong trend. Along the border of the feldspar and spinel the Al- and Ca-content increase. The Ab-content of feldspar embedded inside the spinel was 45.98 ± 14.62 mol%, while the Cr-content was 0.024 ± 0.015 and K was below detection limit.

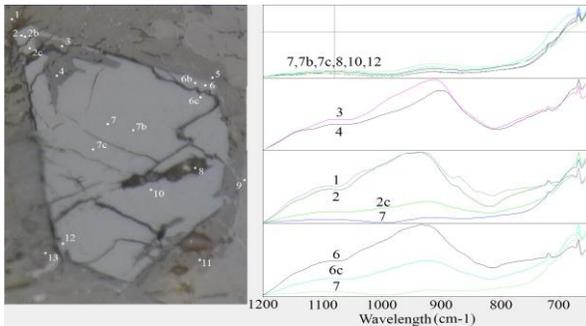


Figure 3. Example analyzed FTIR spectra of the spinel and surrounding phases.

Profiles of FTIR spectra (Fig. 3) showed that from the feldspar toward the interior of the spinel the absorbance of feldspar was decreased, while the peak of spinel increased. The μ XRD results showed the existence of andesine, spinel, olivine and magnetite minerals.

Thermal calculations: According to [16] olivine/Cr-spinel thermometer equation the Cr-spinel indicates $775 \pm 50^\circ\text{C}$ temperature thermal metamorphism (Figure 4). Comparing the result to other author's spinel calculations, the measured Cr_2O_3 and FeO-content, correspond to the values determined by the Acfer 307 chondrite. But the MgO and Al_2O_3 values seem to be higher in the analysed sample. The Fe# values is lower than those of the above mentioned Acfer 307 meteorite.

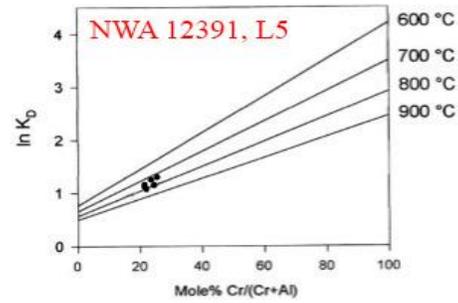


Figure 4. Isotherm diagram for Cr-spinel.

4. Conclusions

NWA 12391 is a moderately equilibrated L type thermal metamorphosed meteorite. The processes equilibrated the Fe-Mg heterogeneity between the olivine and pyroxene grains. The borders of chondrules became to blurred (5. petrographic type). The meteorite showed moderate signs of shock metamorphism (S3), and substantial weathering after fall (W3). The large spinel showed thermal interaction with the feldspar in contact, and the elemental ratios of $775 \pm 50^\circ\text{C}$ temperature metamorphism in agreement with other L5 chondrites.

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