

SIGNATURES OF IRON ENRICHING METASOMATISM IN SIDI ALI OU AZZA METEORITE. I. Gyol-lai¹, Á. Kereszturi², M. Szabó¹, Kereszty Zs.³ ¹EKH CSFK Institute for Geological and Geochemical Research (H-1112 Budapest, Budaörsi 45, gyildi@gmail.com), ²ELKH CSFK Astronomical Institute - H-1121 Budapest, Konkoly Thege Miklós 15-17), ³ International Meteorite Collectors Association (IMCA#6251).

Introduction: The Sidi Ali Ou Azza (nicknamed “Tissint2”) meteorite fell in Morocco, on 28th July 2015. The fall has been observed at the vicinity of Tissint and Sidi Ali Ou Azz by three sonic booms heard, the length of the produced strewnfield was 4 km long. The collectors observed black and brown patchy fusion crust and dark large (5 mm sized) angular clast in meteorite. The classification and first description in Meteoritical Bulletin of this meteorite has been submitted by H. Chennaoui Aoudjehane in 2016. The meteorite has been classified as L4 chondrite, S3 shock stage and W0 weathering rate according to Meteoritical Bulletin [1]. The aim of this work is to overview the iron content changes produced by metasomatic processes in this meteorite.

Methods: The analyzed thin section was prepared by Kereszty Zs. collector, it is a 0.6x1.1 cm sized, well prepared thin section with almost constant thickness. No substantial sample mass was lost during the polishing process, the meteorite was relatively hard. During the analysis three different methods were used and correlated: optical microscope, EPMA, and IR microscope based results.

A polarization microscope NICON Eclipse E600 POL was used with magnifications of 4, 10, 20, and 40 times for textural analysis and basic mineral determination. Elemental composition of certain sections of the sample was determined by 1-2 micrometer spatial resolution with EPMA on the sample covered in vacuum deposited thin amorphous carbon layer, using a JEOL Superprobe 733 electron microprobe with INCA Energy 200 Oxford Instrument Energy Dispersive Spectrometer. The analytical circumstances were 20 keV acceleration voltage, 6 nA beam current and count time of 60 sec for the spot measurement and 5 minutes for linescan analysis. Olivine, albite, plagioclase and wollastonite were standards, we estimated the detection limit for main element identification below 0.5 % based on earlier measurements.

Results: Petrography This chondrite is brecciated, the small chondrules have uncertain rim and recrystallized with the matrix. Only large chondrules above 1.5 mm have well distinguishable rims. The sample consists of 45% matrix (recrystallized with chondrule fragments, megacrysts, and large opaque minerals) and 55% chondrules. The opaque minerals (7% of sample) are kamacite (60%), and troilite (40%). The silicate grains of the sample are 60% olivine (10-200 micron, euhedral shape, green-pink interference color, straight extinction), and 40% pyroxene (columnar form, yellow interference color, straight extinction). The opaque minerals are less altered, alteration occur only in fractures and near to opaque grains resulting FeO infiltration of close minerals, hence weathering rate is W2.

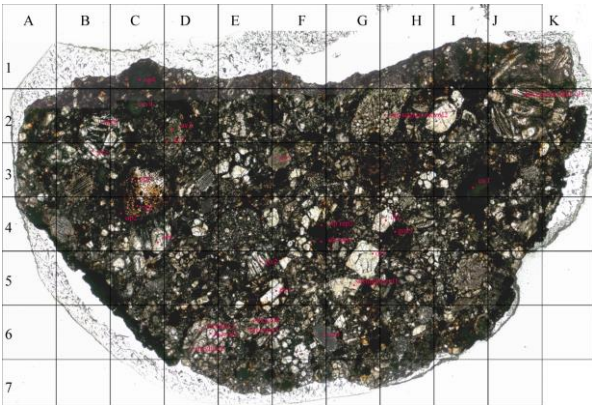


Figure 1 The map of the analyzed Sidi Ali Ou Azza thin section with EMPA measuring points. Only the larger chondrules are characterized by well defined rim, the matrix composed of fine-grained material and brecciated elements.

Alteration and weathering: The opaque minerals are poorly altered in general, alteration occurs only in fractures and near to opaque grains resulting FeO infiltration.

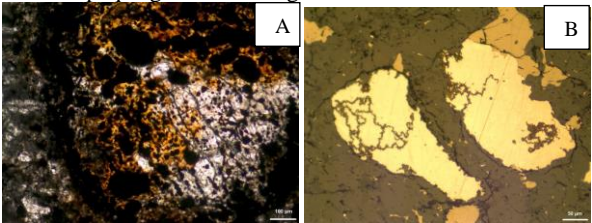


Figure 2. Weathering of opaque minerals: A) Goethite infiltration in the vicinity of opaque minerals (10x resolution). B) weathering of opaque minerals (kamacite and troilite) along the fractures (20x resolution).

Geochemistry

Table 1: variation in mineral endmember composition

	endmember	min	max	average	deviat.
olivine	Te	0,0	1,0	0,0	0,1
	Fo	45,6	85,1	62,8	6,8
	Fa	14,9	54,4	36,6	6,7
	Ca-Ol	0,0	11,3	0,6	2,2
pyroxene	Wo	0,0	47,4	17,1	19,1
	En	36,1	75,6	56,9	12,1
	Fs	13,1	36,7	26,1	8,0
	Aegerine	0,0	0,0	0,0	0,0
	Jadeite	0,0	65,7	40,3	19,9
	Diopside	34,3	100,0	61,8	21,5
feldspar	An	11,6	18,9	15,6	3,2
	Ab	75,9	84,3	80,2	3,8
	Or	0,0	9,3	4,2	3,3

Chondrules The chondrules are averagely 970 micronsized, ranging between 0.5 mm and 3 mm. The ratio of opaque minerals in sample is 7%, which could be divided to two group: smaller than 10 micron, occur among fine-grained particles of matrix and at chondrule rims; the second group is composed of large grains about 100-150 micron, which occur as components among the chondrules and inside several large chondrules. The weathering product is goethite (alteration from opaque minerals, like troilite and chromite), showing reddish-brown color in transmitted light. The chondrules have mostly porphyritic texture, which can be divided forward to microporphyritic (grain size with 10-30 microns, porphyre minerals are olivines), macroporphyritic with grain size 50-120 micrometers. In several case glassy chondrules were observed, where the 1.5 mm in sized object well preserved, the other 4 objects - 0.5 mm sized - glassy chondrules have been recrystallized.

Shock metamorphism: most of sample characterized by fracturing brecciation, which is relevant to S2 shock stage. But several pyroxene have dense twin lamellation (less than 5 micron thick lamellae), which could be contain dislocation, the shock induced twins in pyroxene are characteristic for S4 shock stage according to Ashworth [2]. Several olivine grain show mosaicism (S4), one grain with strong mosaicism show kink bend or deformation microstructure lamellae, indicating S5.

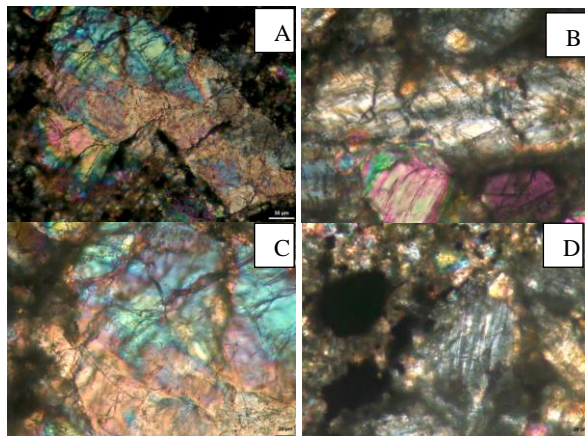


Fig. 2 shock metamorphic features A: strongly shocked olivine (20x resolution). B: pyroxene with mechanical twins (40x resolution). C: kink bends – shock deformation microstructure in the strongly shocked olivine, D: dense shock twin lamellae as deformation microstructure - putative dislocation (40x resolution).

IR spectroscopy: The principal bands of olivine is near 850 and 1000 cm^{-1} of Si-O asymmetric stretching vibration ν_3 mode of SiO_4 [2]. In our spectra, this band was split to bands between 949-970 cm^{-1} and near 900 cm^{-1} , in some cases occur band near 1030 cm^{-1} . With increasing iron content and presence of OH layer, the band 950-970 is shifted to 950 cm^{-1} . The band 850 appears at 862-873 cm^{-1} , the band near 870 is more characteristic for hydrated olivines. The band at 825 cm^{-1} corresponds to ν_1 stretching mode of olivine. This band varies between 825-838 cm^{-1} , which is at lower wavenumber in case of hydrated olivines and near opaque minerals. The bands between 610-460 cm^{-1} are splitting of degenerate ν_4

antisymmetric bending vibration, varies with Fe-Mg composition [2].

Discussion According to our measuring data, the meteorite is an ordinary chondrite but in spite of the official classification in Met. Bull. [1], the parameters do not confirm the L4 in all cases. As the 3.5 % of the sample is kamacite (pure iron) this can be well confirmed in L group where the metal content in meteorite should be 4%. [4] The presence of chromite, Na-feldspar and phosphate are characteristic for both of L, and LL groups following Weisberg et al [3] classification. But the average chondrule size with 0.97 mm in our meteorite fits to LL group (0.9 mm according to Weisberg et al. [3]. The higher, 36.7 average Fa% content, and high matrix content of 45% in our sample indicate a compositional characteristic of Rumuruti-type chondrite (the Rumuruti chondrites have 36% matrix and 38% average Fa content according to Weisberg et al. [4]).

The elevated FeO ratio in olivines and pyroxenes concentrated in the vicinity of opaque minerals (kamacite –F3, E5, kamacite+troilite, chromite: D6, F5). The highest concentration is near troilite microchondrules in F5 area – olivine is almost pure fayalite here. The pyroxenes have also higher Fe content in this area (Fs 13-37%) Fe/Mg diffusion is limited to a few μm (Weinbruch et al [5]). Fe-rich isolated olivine grains (modal abundance (Fa 14-52 vol.%) are near opaque minerals. Some Fe-rich (Fa 25-31 vol.%) olivines (have tiny Cr_2O_3 content: 0.45-1.29 vol%). The chromite rich areas varies in diameters between 5 and 20 μm , and occur at the boundary and crack of chondrules together with kamacite and troilite and chlorapatite. According to Lauretta and Buseck [6] the metal grains corroded by reaction with gas phase of solar nebulae, produced Fe-rich phases around the chondrule rim- accreting microchondrules and mineral fragments to chondrule surface. The diffusion of iron between olivine-chromite pairs yields temperatures between 800 and 1000 K (Weinbruch et al. [5]), and Fe metasomatism was observed in the vicinity 20-100 μm of opaque grains depending on their size and presence of cracks. The Fe-metasomatism could have been caused by accretion or by aqueous alteration on parent body [7].

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