Petrological peculiarites of carbonaceous chondrite Northwest Africa 12590.

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The meteorite was bought by Sergey Vasiliev from Moroccan meteorite dealer at the St. Marie-aux-Mines mineral show in June 2018, total mass of several pieces is about 1.8 kg. It was investigated and registered as NWA 12590 in 2019 by Fersman Mineralogical Museum. It contained 0.65 wt % carbonaceous matter and about 2.01 ± 0.07 wt % H2O (by CNH elemental analyzer). Modal abundance of metallic Fe,Ni and absence of magnetite allowed to classify it as reduced type of CV3 chondrite (Vigarano-like). Meteorite is composed of chondrules (to 2 mm, average size about 1 mm) set in abundant matrix (about 50 vol%). Large chondrules often have clear pronounced magmatic rims (100-300 μm in width). PO-IA-type prevails among porphyric chondrules. Olivine has relic cores of Fa0.4-9.9 whereas surrounding olivine and olivine in matrix is Fa40-45 (Fig. 1). Some olivine in PO chondrules contains small rectangular melilite inclusions (Fig. 2). Primary magmatic glass is partially crystallized to submicron aggregate. Fluffy CAIs are common and consists of melilite, spinel and Al-diopside. Huge compact CAI in separate polished plate (about 18 mm) has perfect Wark-Lowering rim (Fig. 3). Compact CAI consists of spinel with varying contents of FeO (3-23 wt.%, N=15), perovskite (Ca- 27.5, Ti-33.6, N=2), grossmanite (Fs 0.4, Wo 70.87, Al2O3 = 21.22 wt.%, TiO2 = 14.93 wt. %, N=11), Al-diopside (Fs 0.59, Wo 53.57,
-8.33 wt.%, N=1), Ti-kushiroite (Fs 0.3,
Al2O3 Wo 68.02, Al2O3 = 19.95 wt.%, CaO = 24.35 wt., N=7) in melilite matrix. Tiny drops (up to 2 μm) of hexamolybdenum and other PGE-rich minerals are occurred in these compact CAI.
The chondrules were determined to host
primary magmatic glass, which is partly recrystallized, with the formation of micrometer-sized clinopyroxene crystallites (Fig. 2, right). The metallic component consists of kamacite and taenite. The matrix of the meteorite is fine-grained and its composition is close to ferrous olivine.

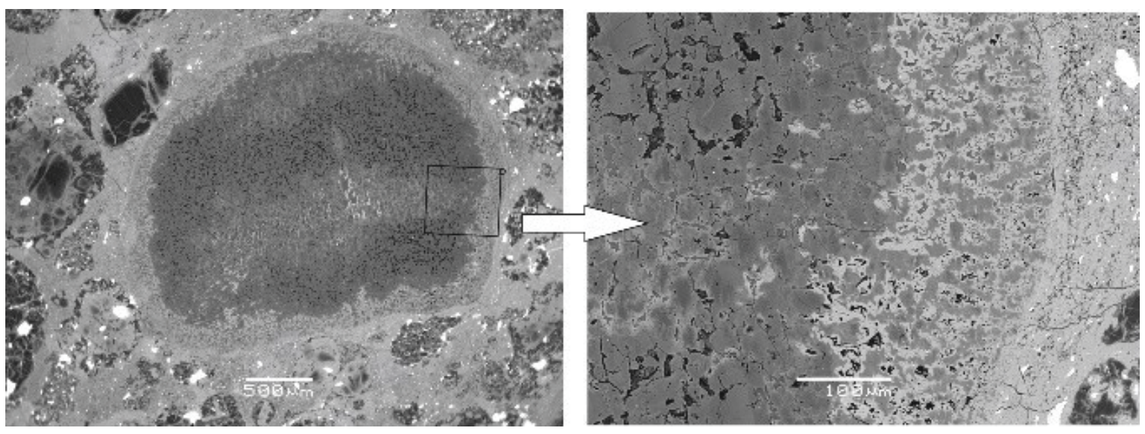


Fig. 1. NWA 12590 carbonaceous chondrite. Pyroxene-olivine chondrule with a rim of ferrous olivine.

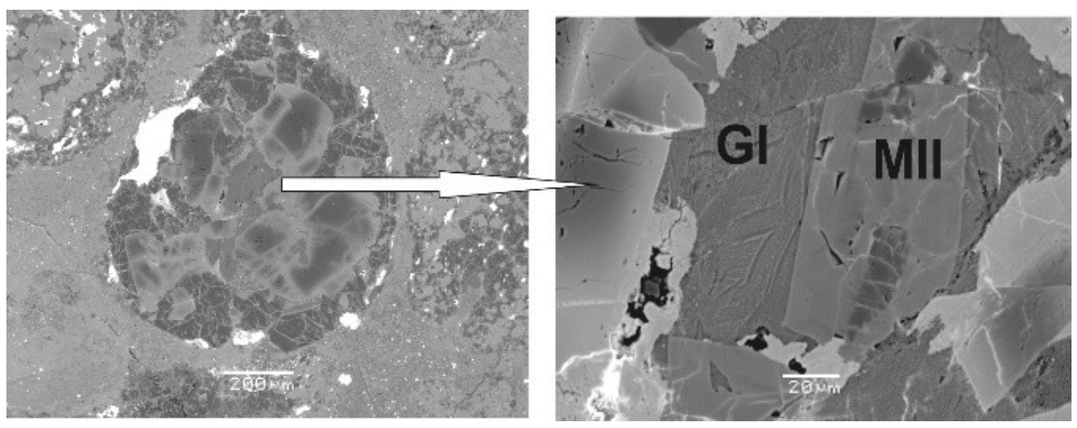


Fig. 2. Pyroxene–olivine chondrule containing glass and melilite in its core.

The Wark-Lowering rim shown in Fig. 3 consists of the following mineral layers (listed in order from the inner part of the rim to its outer part): spinel, kushiroite, melilite, and ferrous olivine, which is similar to the matrix olivine.
Melilite in the CAI inclusion (MgO = 15.6 wt %) differs from this mineral in the chondrules (MgO = 10.5–12.2 wt %) in containing more MgO and less Al2O3 (8.3 wt % in CAI and 22.4–23.5 wt % in melilite in the chondrules) and Fe (0.4 wt % in CAI and 1.1–1.9 wt % in chondrules), and in the absence of TiO2 and NiO admixtures (melilite in the chondrules contains 1.9 and 0.1 wt % of these components, respectively).
In the protoplanetary nebula, CAIs interacted with nebular gas and suffered multiple heating episodes, which led to their partial or complete melting and evaporation (Ivanova 2016), and these exactly processes were responsible for the origin of the Wark- Lowering rims. The time when the rims and CAIs were formed may differ by ~2 Ma (Mane et al. 2016).
Another noteworthy feature of the NWA 12590 carbonaceous chondrite is that it contains very few (if any) dark inclusions, which are typical of the Efremovka meteorite (which is also a CV3 chondrite of reduced type (Vigarano-like)).

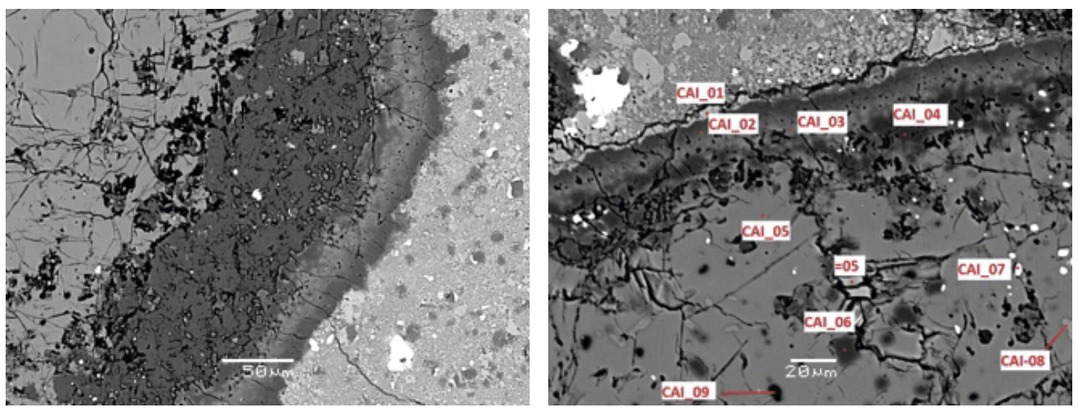
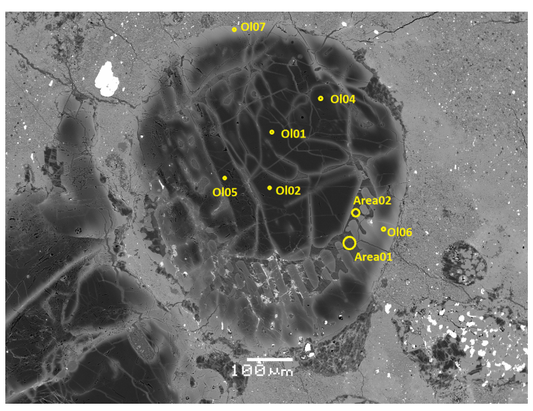


Fig. 3. Wark-Lowering rim around CAI in the NWA 12590 carbonaceous chondrite. In the diagram: CAI-01 is ferrous olivine, CAI-02 is melilite, CAI-03 is kushiroite, CAI-04 is spinel, CAI-05 is kushiroite, CAI-06 is spinel, CAI-07 is perovskite, CAI-08 is grossmanite, and CAI-09 is spinel.

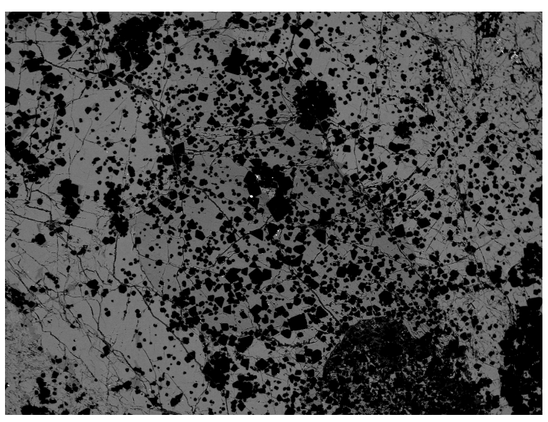
References:

Ivanova M. A. CAIs in carbonaceous chondrites are the oldest material in the solar system.// Geochemistry, 2016, No 5, c. 409– 426 (in Russian).
Mane P., Bose M, Defouilloy C., Kita N. T. MacPherson G. J. and Wadhwa M. Formation timescales of Wark – Lovering rims around calcium- aluminum rich inclusions// 47th Lunar and Planetary Science Conference (2016). 2560.pdf



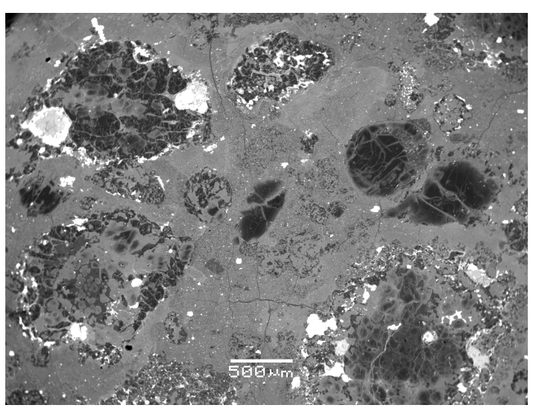
Olivine chondrule with different concentrations of iron and barred olivin in carbonaceous chondrite NWA 12590.

One of metal grains in grossmanite. Phases : a)Mo b)(Ni,Fe,Ir,Pt) c)(Os,Ir,Mo,Ru) d)(Ni,Nb)



In central part CAI from meteorite NWA 12590 between melilite (light grey) relatively equilibrium crystal of grossmanite (grey) ambundant of perovskite (dark crystals) and submicron metal grains which consist of many phases.

The differences between reduced type of CV3 chondrite (Vigarano-like): carbonaceous chondrite NWA 12590 and Efremovka.



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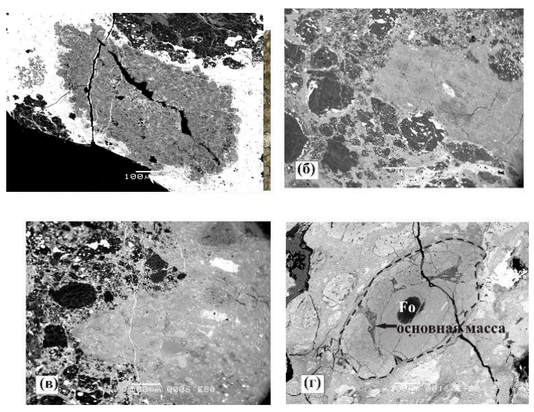

Dark inclusions (olivine chondrites) in the chondrites Efremovka (b–d): (a) dark inclusion NWa 3118 (CV3) (url: http://www.meteorites.com.au/odds&ends/DarkInclusions.html) characterized by the smaller size of chondrules in comparison with the host carbonaceous chondrite; CAIs (light) occur in the dark inclusion, as well as in the host chondrite; arrow indicates the surrounding rim composed of hedenbergite, wollastonite, and andradite, scale bar 1000 μm; (b) dark inclusion E53 from the meteorite Efremovka represented by iron rich chondrules in an iron rich matrix; "pressed" chondrules of the host meteorite are observed in the marginal parts of the inclusion, which provides evidence for a plastic state of the inclusion at the moment of its capture by the host meteorite, scale bar 1000 μm; (c) dark inclusion E80 (1) from the meteorite Efremovka characterized by angular boundaries, which provides evidence for its appearance in the host meteorite as an already cooled fragment, scale bar 500 μm; (d) chondrule from dark inclusion E80 (1) from the meteorite Efremovka replaced by iron rich olivine with a
forsterite (Fo) relic in the center; relict areas of crystallized groundmass with microlites of olivine and alumodiopside in intersti tials are observed.