NORTHWEST AFRICA 8160 CV3 CHONDRITE FROM THE COLLECTION OF THE EARTH SCIENCE MUSEUM AT THE MOSCOW STATE UNIVERSITY. N. G. Zinovieva[1], K. A. Scripko[2]. [1]Lomonosov Moscow State University, Faculty of Geology, Leninskie Gory, Moscow, 119991, Russia, nzinov@mail.ru, [2]Lomonosov Moscow State University, the Earth Museum, Leninskie Gory, Moscow, 119991, Russia, kscripko@mail.ru.

Introduction: The paper presents data on the petrography, mineralogy, and mineral chemistries of the Northwest Africa 8160 (NWA 8160) CV3 chondrite from the collection of the Earth Science Museum at the Moscow State University. Characteristics of this meteorite are compared with those of the well-known Efremovka CV3 chondrite.

Results and discussion: The Northwest Africa 8160 (NWA 8160) meteorite was found in Morocco in 2013, was classed with CV3 chondrites, weathering grade W2 [1], and was briefly described in [2]. It consists of Mg-rich, Fe-rich chondrules and CAI cemented with fine-grained matrix material.

The magnesian chondrules are mostly porphyritic pyroxene–olivine ones (Fig. 1), with barred olivine chondrules found much more rarely. The compositions of olivine and pyroxene in the magnesian chondrules vary insignificantly, $\boldsymbol{Fa_{1\text{-}2}}$ and $\boldsymbol{Fs_{1\text{-}3}\ Wol_{1\text{-}3}}$, respectively, with pyroxene occurring mostly in the marginal portions of the chondrules, together with clinopyroxene ($\boldsymbol{Fs_3\ Wol_{33}}$).

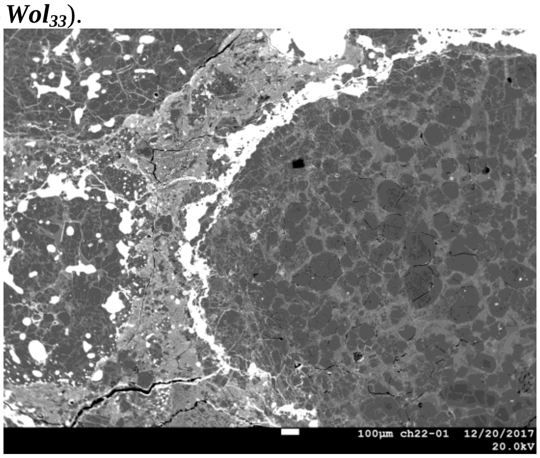

Fig.1. BSE image of magnesian porphyritic olvine–pyroxene chondrules variably enriched in ***Km***

In the Fe-rich porphyritic olivine chondrules (Fig. 2), the composition of large olivine phenocrysts varies from $\boldsymbol{Fa_{21}}$ (cores) to $\boldsymbol{Fa_{34}}$ (margins). The most ferrous olivine ($\boldsymbol{Fa_{42\text{-}46}}$) occurs as small grains cemented with glass (of feldspar-rich composition) with acicular clinopyroxene grains ($\boldsymbol{Fs_{28}\ Wol_{43}}$). Highly ferrous olivine is also found as rims around the magnesian chondrules and grain fragments of magnesian minerals. The fact that the NWA 8160 CV3 chondrite contains chondrules with highly ferrous olivine suggests an early increase in the oxidation potential, although this increase was a little bit less than in the Efremovka CV3 chondrite [3, 4], whose highly ferrous chondrules contain olivine of the composition $\boldsymbol{Fa_{50}}$ [5].

The reducing evolutionary episode of the chondritic material is represented by highly magnesian olivine and olivine–pyroxene material of clastic and chondrule types and by fragments of highly aluminous inclusions, whose content is lower than that of the magnesian material and much lower than in the Efremovka chondrite.

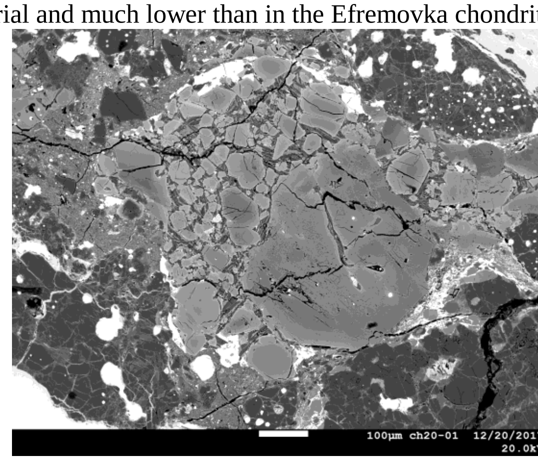

Fig.2. BSE image of Fe-rich porphyritic olivine chondrule

The NWA 8160 CV3 chondrite contains two types of aluminous inclusions: (i) a Ti- and Al-rich hibonite–perovskite–spinel–melilite inclusion (Inc. 01, Fig. 3, 4, Table 1, 2) and (ii) a Ti-poor spinel–melilite–pyroxene one (Inc. 2).

The Ti-rich aluminous inclusion is irregularly shaped, its size is 550 × 1000 μm, and it is zoned. Its outermost zone is strongly resorbed. At contact of this zone with the fine-grained matrix material, a rim develops that consists of practically Ti- and Al-free clinopyroxene. Farther inward, this zone gives way to a zone of resorbed spinel, which is partly replaced by clinopyroxene and melilite in association with hibonite (Figs. 3, 4), and then to intricate symplectitic aggregates of spinel, anorthite, and clinopyroxene. The central, less altered, portion of the inclusion, is made up of an assemblage of spinel (Table 1), melilite (of gehlenite composition, Table 2), and perovskite with or without Al- and Ti-rich clinopyroxene. The Ti concentration of the clinopyroxene is at a maximum in its rims around perovskite grains. The composition of the mineral (Table 2) corresponds to grossmanite, which was documented in the Allende CV3 chondrite [6].

The Ti-poor spinel–melilite–pyroxene inclusion (Inc. 2) is dominated by melilite and clinopyroxene of fassaite composition. Spinel grains are constrained to the central portion of the inclusion and are extensively replaced by melilite, which develops as rims around the spinel grains.

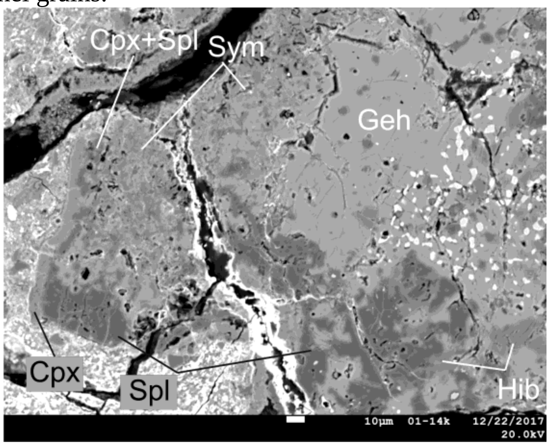

Fig.3. BSE image of Al- and Ti-rich CAI (Inc. 1), whose central portion is made up of melilite, spinel, Ti-rich pyroxene, and perovskite. A reaction rim along the contact between the inclusion and matrix consists (in succession from the matrix toward the central part of the inclusion) of a monomineralic clinopyroxene zone, which gives way to a clinopyroxene-spinel zone and then to an intricate symplectitic (Sym) aggregate of spinel, anorthite, and clinopyroxene

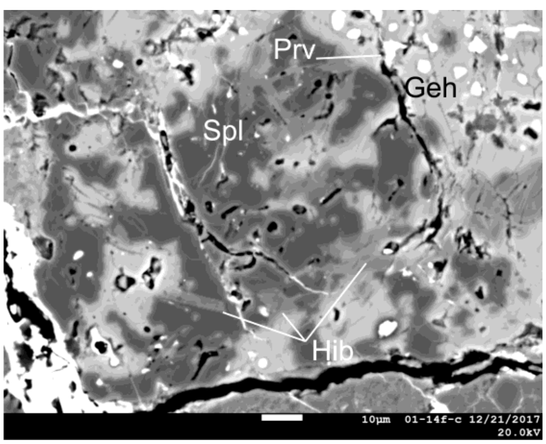

Fig.4. BSE image of fragment of an Al- and Ti-rich CAI (Inc. 1) shown in Fig. 3. The primary spinel is replaced by elongate euhedral tabular crystals of hibonite and melilite

The marginal portions of both of the aluminous segregations are disintegrated and actively reworked by the matrix material, up to the origin of "nebulous" relict domains. At contacts with the matrix, the Al and Ti concentrations of the clinopyroxene decrease, as also does the anorthite content, and this results in almost monomineralic clinopyroxene rims, as is typical of most of the aluminous segregations. Similar to the Efremovka chondrite, the development of pyroxene rims along contacts between the inclusions and matrix is associated with the transition from fassaite to diopside and a decrease in the TiO_2 and Al_2O_3 concentrations. The material contains all transitional pyroxene varieties from Ti- clinopyroxene (grossmanite) with very high concentrations of TiO_2 (20–2%) and Al_2O_3 (22–14%) to diopside, which is devoid of TiO_2 and very poor in Al_2O_3 (0–5%). Single fragments of the variably resorbed zones are found in the matrix material of the meteorites.

Table 1.

Inc. 01	Hibonite			Spinel		
	Av. 3	SD	F.u. O=19	Av. 3	SD	F.u. O=3
MgO	2.52	0.17	0.43	28.07	0.14	0.98
Al_2O_3	82.85	1.37	11.05	72.02	1.38	2.00
SiO_2	0.69	0.35	0.08	0.04	0.03	0.00
CaO	8.86	0.30	1.07	0.21	0.10	0.01
TiO_2	4.24	0.41	0.36	0.19	0.03	0.00
FeO	0.48	0.17	0.05	0.25	0.13	0.00
Total	99.66	1.31	13.04	100.80	1.30	3.00

Table 2.

Inc. 01	Melilite (Gehlenite)			Ti- clinopyroxene		
	Av. 3	SD	F.u. O=7	Av. 3	SD	F.u. O=6
MgO	0.67	0.07	0.05	6.40	0.59	0.35
Al_2O_3	35.85	0.02	1.91	22.27	0.77	0.98
SiO_2	23.42	0.40	1.06	31.33	3.19	1.16
CaO	40.61	0.40	1.96	24.75	0.05	0.99
TiO_2	0.11	0.07	0.00	15.25	2.71	0.43
Cr_2O_3	-	-	-	0.04	0.00	0.00
MnO	-	-	-	0.01	0.01	0.00
FeO	0.14	0.03	0.01	0.53	0.02	0.020
Total	100.81	0.08	4.99	100.58	0.33	3.92

Comparison of the petrology, mineralogy, and mineral chemistries of the two carbonaceous chondrites, NWA 8160 and Efremovka, shows that their chondritic material evolved during two episodes: (i) a reducing episode, when aluminous inclusions and early magnesian chondrules were produced, and (ii) an oxidizing one, when the aluminous inclusions and early magnesian chondrules were modified via interaction with the matrix material.

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References: [1] Ruzicka A. et al. **(**2015) Northwest Africa 8160. *The Meteoritical Bulletin 102*, 248p. (*https://www.lpi.usra.edu/meteor/docs/mb102.pdf*). [2] Skripko K. A. et al. (2017) *Zhizn' Zemli (The life of the Earth 39 (1)*, 39-46. [3] Marakushev A. A. et al. (2003) *Cosmic Petrology*, Moscow, Nauka, 387p. [4] Marakushev A. A. et al. (2010) *Petrology*, *18, 7*, 677-720. [5] Marakushev A. A. et al. (2010) *Dokl. Earth Sciences, 434, 2,* 1354-1358. [6] Ma C., Rossman G. R. (2009) *American Mineralogist 94, 10,* 1491–1494.