A NEW TYPE OF CARBONACEOUS CHONDRITE MATTER FROM THE EREVAN HOWARDITE; M. A. Nazarov, Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow 117975, Russia; F. Brandstätter and G. Kurat, Naturhistorisches Museum, Postfach 417, A-1014, Vienna, Austria

Numerous carbonaceous chondrite clasts which have characteristics of CM and CI chondrites have been documented in the Erevan howardite [1,2]. Here we describe a unique carbonaceous chondritic clast that is quite different from known carbonaceous chondrites with the matrix being strongly depleted in volatile and siderophile elements. Similar to CM chondrites this clast contains Mg-rich olivine and pyroxene grains with a very low Fe/Mn ratio. However, the clast contains also Fe- and Ni- rich olivines and reveals, therefore, some similarity with the newly defined CK chondrite group [3]. Mineral chemistry of the xenolith records increasingly oxidizing alteration conditions prior to the incorporation into the Erevan host. Similar to other carbonaceous clasts in the howardite, this clast does not show shock-induced deformations, which should result from accretion of the carbonaceous matter to the surface of the HED parent body.

Results. The xenolith has a maximum size of 300 μm and a brecciated, veined texture (Fig.1). It consists of rounded or clast-like angular aggregates (20-100 μm) and mineral grains cemented by a fine-grained matrix. These aggregates have a bulk composition which is generally intermediate between that of enstatite and serpentine, and shows a significant enrichment in Ca and Al (Table). They are characterized also by a high Cr content and a low Fe/Mn ratio. Some traces of Ni are also present. The largest aggregates have a banded texture (Fig.2). The bands are composed of forsterite (Fo 97), orthopyroxene (En 97), and, perhaps, serpentine. There are also thin bands or chains of inclusions of Ca-Al rich pyroxene (Table) and feldspar. Some aggregates do not show clear separation of mineral phases and EMPA gives a low total indicating the possible presence of serpentine. The mineral grains are mainly enstatite and forsterite which are similar in composition to the phases in other aggregates. Fe-rich olivine (Fo 64) and orthopyroxene (Wo 6; En 76, *mg´* 0.81) rounded grains of 5-20 μm size were found to be closely associated with Mg-rich grains and aggregates in the matix. The characteristic feature of the Fe-rich olivine is a high Ni content that is close to that in the CK chondrite olivines [4,5]. The fine-grained matrix contains similar rounded objects and olivine and pyroxene grains of a smaller size. The matrix is enriched in minute grains of Ni-rich sulfide (probably pyrrotite or pentlandite) which are too small for a precise analysis. We found also in the matrix one grain of Ni-bearing metal and one grain of a silica phase. The latter is of 5 μm in size and quickly decomposes under the electron beam and, hence, could be an opal-like material. The chemical composition of the matrix differs significantly from that of carbonaceous chondrite matrices. It is poorer in Fe, Ni, and S, and richer in Si, Al, Mg, and Ca. The composition of the matrix is very close to that of a metal-free, sulfur-poor fraction of H chondrites, except for a lower Na content. When compared to the composition of aggregates, the matrix shows an enrichment in Fe, S, Ni and Na (Table).

Discussion. Obviously the clast has unique characteristics and cannot be firmly classified. The presence of Ni-rich olivine and a low bulk Ni content are the features of CK chondrites. However, no magnetite, which is typical for CK chondrites was recognized in the Erevan clast. Moreover, the CK chondrites are equilibrated and contain olivine of about Fo 70 [4,5], whereas the xenolith is not equilibrated and contains mainly Mg-rich olivine (Fo 97) grains and aggregates which resemble the non-hydrous aggregates from CM chondrites. The assemblages give evidence for increasingly oxidizing alteration conditions in the solar nebula. In fact, the aggregates and high-temperature grains appear to be primary objects which were not totally melted and show insignificant secondary alteration. The low Fe/Mn ratio and the low Fe content of the aggregates and grains point to an origin under reducing nebular conditions. The conditions became oxidizing just before and during matrix formation and prevailed for some time after the aggregate was formed. There is no evidence for the formation of the Ni-rich olivine by oxidation of metal grains within the xenolith. The low bulk Fe content of the rock suggests that metal was not yet condensed or has been removed from the xenolith source area. Therefore, the Ni-rich olivine should have been precipitated directly from the oxidizing nebular environment. The matrix was probably formed by a simple mixing of a fine-grained and partly altered Mg-rich material with Fe-bearing silicates and Fe, Ni-sulfides, and may be in some relation to H-chondrites. The occurrence of the silica grain is of significant interest. Silica phases have never been found in carbonaceous chondrites. Rare silica grains identified in ordinary chondrites are related to fractional crystallization of chondrule melts accompanied by evaporation processes [6]. The presence of silica in the Erevan clast indicates that some silica phases could be of nebular origin. Silica grains were also tentatively recognized among the Halley comet dust particles [7], a fact, which supports a possible nebular origin of silica !

Thus, in addition to CM and CI clasts the HED parent body sampled also some unknown type of carbonaceous material formed under increasingly oxidizing conditions. Surprisingly, all of the clasts do not show any trace of shock-induced deformations which should have formed during accretion. This suggests a gentle mode of the accretion of the carbonaceous material. However, the howardites and the polymict eucrites as well as the Erevan howardite contain abundant fragments of impact melts suggesting a high-speed accretion of a certain meteorite component to the parent body. The presence of Ni-rich remelted metal grains in the melts suggests the high-speed projectiles to be of an iron or ordinary chondrite composition. Thus, it can be assumed that different types of meteorites had different velocities relatively to the HED parent body.

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Table. Representative analyses of components of the xenolith.

	Aggregates	Ol	Fe-ol	Opx	Fe-opx	Al-cpx	Matrix
SiO_2	51.1	41.0	36.6	57.3	54.7	50.00	43.7
TiO_2	0.21	0.01	0.00	0.09	0.09	1.08	0.17
Al_2O_3	4.30	0.04	0.03	0.53	0.53	8.40	3.60
Cr_2O_3	0.80	0.67	0.10	0.54	1.18	1.73	0.69
FeO	3.70	2.88	32.2	1.82	11.7	1.21	12.10
MnO	0.30	0.36	0.45	0.21	0.48	0.25	0.25
MgO	37.1	53.4	32.0	7.8	7.5	8.7	1.40
CaO	3.50	0.21	0.15	0.33	2.80	19.3	2.91
Na_2O	0.05	0.00	0.00	0.00	0.08	0.03	0.23
K_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.07	0.00	0.40	0.00	0.00	0.01	0.59
Total	101.13	98.57	101.93	98.62	99.06	100.71	98.86*

*Including 3.22 wt.% of SO_3.

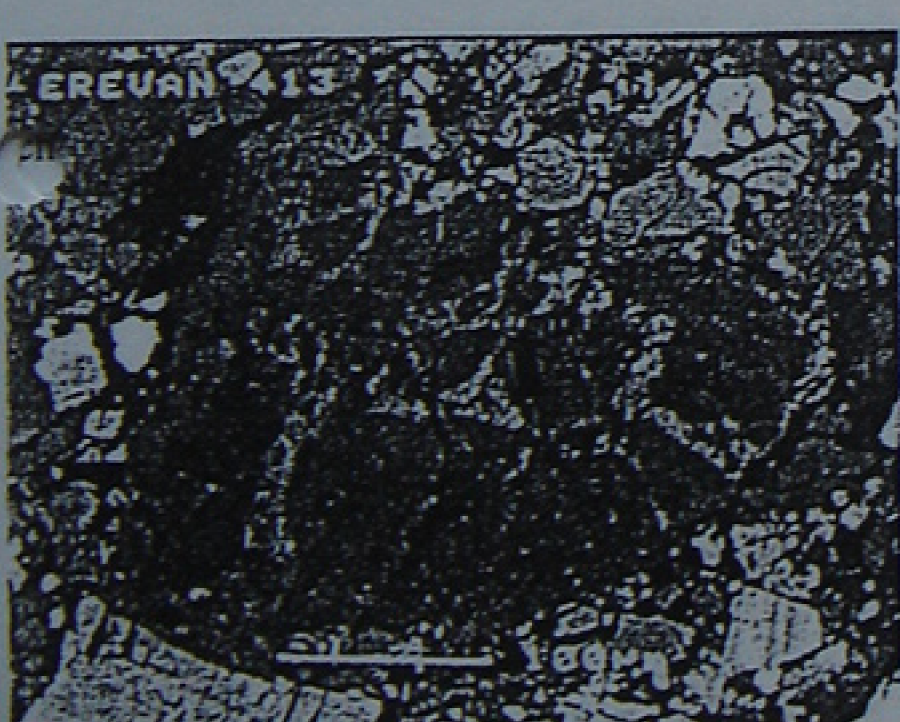

Fig.1: Brecciated xenolith from the Erevan howardite with veined texture consisting of rounded to angular aggregates.

Fig.2: Magnesium x-ray scan exhibiting the banded texture of the larger aggregates within the Erevan xenolith.