NWA 6356: UNEQUILIBRATED POLYMICT UREILITE. C. A. Lorenz[1], N. N. Kononkova[1], H. Stehlik[2], I. A. Franchi[3] and R. Greenwood[3] [1]Vernadsky institute of geochemistry and analytical chemistry RAS, 119991, Kosygin St. 19, Moscow, Russia, c-lorenz@yandex.ru, [2]Hagedornweg 2/12, 1220 Wien Austria, hstehlik@aon.at, [3]Open University, Walton Hall, Milton Keynes MK7 6AA, Bucks, U. K.

Introduction: The polymict ureilites are suggested to be a regolith of ureilite parent body (UPB) [1]. Polymict ureilite NWA 6356 is unequilibrated clastic matrix breccia, consisting of rock fragments, breccias, melts, carbonaceous chondrite clasts (CCs) and chondrules. Four sections of the meteorite with total area of 3.6 cm^2 were studied with optical microscopy and EPMA. Oxygen isotopic composition of NWA 6356 was determined by laser fluorination. Unusual features of the breccia are: 1) sulphur reduction of olivine; 2) occurrence of two highly reduced forsterite lithologies; 3) presence of several textural types of graphite; 4) occurrence of medium-grained gabbroic rocks; 5) presence of xenolithes in microlithic feldspatic clasts; 6) presence of the best preserved CC fragment.

Results: NWA 6356 is a coarse-grained polymict breccia, consisting of angular fragments of olivine (Ol) and minor pyroxene (Px), up to 5 mm of size. Graphite is a minor phase, plagioclase (Pl), chromite, troilite, Ca-phosphate, FeNi metal, diamond, Fe-silicides and silica are rare. The Ol is Fo_{78} (Fe/Mn=42; 0.61 wt% Cr_2O_3; 0.32 wt% CaO) and rarely contains round inclusions of Px ($En_{78.2}Wo_{3.4}$; Fe/Mn=32.5 at; Cr_2O_3 0.81 wt %), FeNi-metal and sulfides. The Ol is getting more MgO-rich (up to Fo_{95}, Fe/Mn=10) towards graphite inclusions. This zoning is interrupted by the clast margins. The most MgO-rich areas of Ol grains contains many tiny FeNi-metal inclusions.

Thin veins of troilite (0.8 Ni, 0.3 Cr, wt%), running through the Ol, are accompanied by replacement of surrounded Ol by fine-grained aggregate of troilite and Px ($En_{92.3}Wo_{1.2}$, Fe/Mn=11.5). The Ol varies in composition from Fo_{78} (Fe/Mn=40) to Fo_{86} (Fe/Mn=34) towards the areas of Ol replacement, interrupted by the margins of Ol clasts.

Minor and accessory minerals. Two populations of olivine, different from dominant lithology were found. The population I includes large grains of Fo_{91-96} (Fe/Mn=9-16), that are free of fractures and any traces of secondary alterations. The population II includes grains of forsterite Fo_{99} with network of feldspatic veins ($An_{73}Ab_{17}Or_{10}$). This Ol also has no reduction features and contains microelements in concentrations close to detection limits of EPMA.

Large Px clasts have average composition $En_{77}Wo_4$ (Fe/Mn=30) varying in a narrow range. Px contains fine lamellae of Ca-pyroxene. Troilite, associated with interstitial carbon, contains 1.9 wt% of Cr. Troilite in reducing veins contains less Cr – 0.3 wt%. FeNi-metal contains 3.4 Si, 0.25 Cr, 2.5 Ni (wt%). Thin FeNi-metal veins crossing the large OL clasts are Si,Cr- poor. Chromite, occurs in the matrix, and has composition in ranges: Fe/(Fe+Mg) 0.66-0.77; Cr/(Cr+Al) 0.78-0.88. Silicides have a wide range of compositions. Silica contains of 0.55 FeO and 0.14 Al_2O_3 (wt%).

Graphite in NWA 6356 occurs in veins within Ol, irregular aggregates in the breccia matrix, which probably are fragments of veins. One fragment of olivine rocks contains abundant thick vermicular veins of graphite. The prismatic crystals of graphite occur in Ol and in the matrix. Isometric grains, of diamond, 0.5-50 μm in size, occurs in graphite aggregates. No any evidences of reduction of the matrix silicates were observed at the contacts with carbon.

Feldspar-pyroxene rocks. Minor populations of crystalline (CFP) and microlithic (MFP) feldspar-pyroxene rocks were found in the breccia. CFP clasts consist of 200-400 μm grains of PX $En_{75}Wo_9$ (Fe/Mn=25, 1 wt% Cr_2O_3) and partly isotropic PL ($An_{84}Ab_{16}$-$An_{92}Ab_8$).

The MFPs are presented by three groups. MFPs of group I are composed of tiny co-oriented skeletal crystals in glassy mesostasis. These rocks are varying in composition from PX ($En_{52}Wo_{40}$ (MG#87.5; Fe/Mn=11.1) + GL ($An_{86}Ab_{13}$ – $An_{95}Ab_4$) to PX (En_{50}-Wo_{21}; MG#62; Fe/Mn=39) + GL ($An_{70}Ab_{28}$).

MFPs of group II are composed of 10-30 mm euhedral crystals of olivine Fo_{89} (Fe/Mn=26) normally zoned to Fo_{81} (Fe/Mn=35), which embedded into a glassy mesostasis $An_{80}Ab_{18.5}Or_{1.5}$ with tiny skeletal crystals of pyroxene.

The group III includes two large fragments of MFPs, consisting of xenolithes. The main mass of clast #10 composes of elongated microlithes of Px (En_{60}-Wo_{32}) and feldspatic glass ($An_{47}Ab_{52}$).

Xenolithes of medium-grained rock consists of prismatic crystals of Pl ($An_{50}Ab_{50}$) with interstitial minor pyroxene ($En_{70}Wo_{24}$). The rock joints the surrounded breccia fragments and most likely it is an impact melt.

Fragment #74 consists of pyroxene microlithes En_{52}-Wo_{31} (MG#=77, Fe/Mn=12) with interstitial glass $Ab_{65}An_2Or_{14}$ and 200-400 μm xenocrysts of Pl $Ab_{70}An_{27}Or_3$ and Px $En_{36}Wo_{36}$ (MG#=56; Fe/Mn=17) with pyroxene composition in the reaction rim En_{50}-Wo_{36} on the contact with the host rock.

Carbonaceous chondritic fragments. CCs are widely distributed in NWA 6356. The largest observed CC is 2x0.5 mm of size, and has a best preserved chondrite texture. It consists of chondrules, glass fragments, zoned olivine grains, pyroxene and troilite, embedded into fine-grained phillosilicate matrix (60 vol %). The texture and composition of the CC are corresponding to CM2-like chondrite [2]. The smaller fragments have no chondrules and widely vary in matrix/objects ratio, contents of opaque phases and Ni content in sulfide.

Several objects in the breccia were identified as fragments of barred and granular olivine chondrules. BO chondrules consist of normally zoned (Fo_{74}-Fo_{66}, Fe/Mn=30) Ol and minor interstitial SiO_2-rich glass. Some of chondrules contain K_2O-rich glass (up to 3 wt %). Granular chondrules consist of homogeneous Ol (Fo_{75-82}; Fe/Mn=54-74).

Oxygen isotopic composition of the meteorite is $\delta^{17}O$ 3.32 ‰; $\delta^{18}O$ 7.84 ‰; $\Delta^{17}O$ -0.764 ‰, that certainly consistent with ureilite classification of NWA 6356.

Discussion. Mineral chemistry data and oxygen isotopic composition suggest that NWA 6356 is an ureilitic polymict breccia [1, 3], mostly composed by fragments of coarse-grained dunite-like rocks. The MG# of low-Ca Px is similar to that of Ol and Px inclusions in the Ol, indicating a single igneous source of these phases. Small degree of thermal metamorphism indicated by zoning of olivine and a low abundance of impact melt show an insignificant maturity of breccia. High-MgO olivine, associated with inclusions of carbon, FeNi-metal and Fe silicides is a result of high temperature reduction similar to established mechanism proposed for other ureilites [1]. Increasing of MgO content in Ol and the replacement of Ol around troilite-filled veins are probably result of partial reduction of olivine by S, observed before in several achondrites [4-6]. Well- preserved zoning in C- and S-reduced olivines suggest that these alterations were formed during the same thermal event. Brecciation of reduced olivine and absence of reduction features in the matrix of breccia show that reduction reactions took place in unbrecciated rock.

Several texturally different types of graphite probably were formed by multiple carbon injections. Graphite crystals enclosed in olivine seem to be igneous [3]. However, vermicular veins of graphite looks like later injections. The olivine fragment enriched in graphite veins, could represent a lithology different from the dominant lithology of NWA 6356. The diversity of carbon sources in polymict ureilites was suggested based on isotopic composition of C in DaG 319 [7]. Unusual forsteritic clasts of population-I could have affinity to forsterite fragment found in polymict ureilite DaG 999 [8]. Absence of features of solid reduction allows to propose that these forsterites were crystallized from highly reduced melt. The nature of forsteritic population II remains unclear, but it is obviously igneous. However, the low content of Cr in the olivine does not correspond to the ureilite source. The texture of feldspatic veins in forsterite could be a result of filling of cracks by melt, and had never been observed in ureilites before.

Crystalline feldspar-pyroxene rocks are gabbroic in composition. The CFPs containing of An-rich feldspar have not been observed before in polymict ureilites. The CFP pyroxene is similar to pyroxene fragments in the breccia, so CFPs could have the similar source as the dominant ultramaphic lithology. The CFPs could probably be a source of MFPs of group I. Texturally all of MFPs are similar to those described in [9]. However, most of MFPs are differed from each other, several of them contain xenolithes and join the surrounding breccia fragments. Probably, several of MFP are not pristine and were formed by assimilation of different lithologies by melt during impact or endogenous processing.

The NWA 6356 polymict ureilite contains one of the best preserved carbonaceous chondrite fragments that ever found in polymict ureilites. Compositions of CCs matrices mostly correspond to that of CM-chondrites. However, some differences in mineralogy and chemistry of CCs point to several CC impactors.. The origin of chondrule fragments is not clear based on their mineral chemistry. The chondrules could originate from CCs fragments, or from disrupted ordinary chondrite impactors, as was showed for chondrules in DaG 319 [I]. However oxygen isotopic composition of NWA 6356 does not reflect a presence of exogenic component into the breccia and could support the CCs origin of the chondrule fragments.

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