POSSIBLE SOURCE REGION OF NORTHWEST AFRICA (NWA) 13637 LUNAR REGOLITH BRECCIA IN CONNECTION WITH GLASS SPHERULES AND BASALTIC CLASTS.

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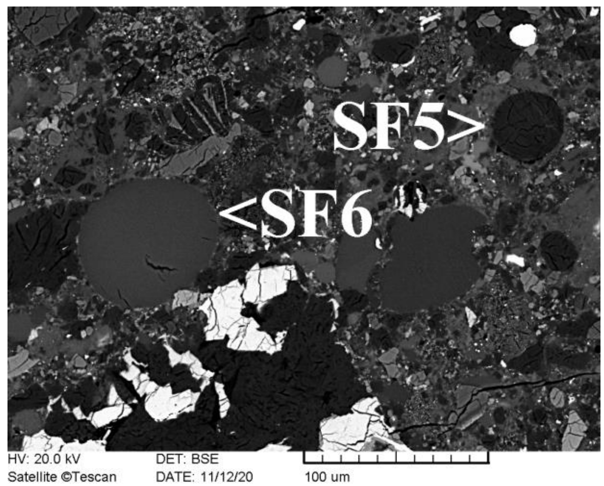
Introduction: The recently classified Northwest Africa (NWA) 13637 is a lunar feldspathic regolith breccia meteorite. The stone was collected near the strewn field of Northwest Africa (NWA) 11228 in Algeria and therefore it may be in close relation with Northwest Africa (NWA) 8673 clan. Lunar meteorites are important for planetary science because they sample and deliver us material from such lunar near and far side regions where neither Luna nor Apollo missions did not have the chance to collect regolith and stones. These lunar and other types of meteorite samples can help us to understand planetary processes [1,2,3,4,5,6], effects, clues and processes of impacts [7], mark the location of future sampling and remote sensing missions [8] and for educational purposes [9].

Sample and Methods: The analyzed sample was a carbon-coated thick section (~200 µm thickness) of NWA 13637 originally sized 2×2×1.5 cm which has a total mass of 8.6 grams. The meteorite was analyzed by INCA Energy 200 Oxford Instrument Energy Dispersive Spectrometer with JEOL Superprobe 733 Electron Microprobe at CSFK GKI, and operated at a 20 keV accelerating voltage with a 6 nA beam current. The diameter of the focused beam was 1 µm. Acquisition time was 40 s for point analyses. Backscattered Electron (BSE) images were obtained with Amray 1830 Scanning Electron Microscope with EDAX PV9800 Energy Dispersive Spectrometer at Department of Petrology, Eötvös Loránd University, and operated at 20 keV accelerating voltage with a 5 nA beam current.

Results: The NWA 13637 meteorite is a complex and polymict lunar feldspathic regolith breccia with many glass spherules. The matrix is fine-grained (<100 µm) and consisted of angular and sub-rounded mineral and rock fragments. Inside the matrix there are thin shock veins and tiny melt pockets. The major mineral phases of the matrix are olivine, pyroxene and feldspar, the accessory phases are FeNi metal (<0.75 mm), chromite and troilite. The fine-grained matrix material is combined with impact glassy phase, but melt flow textures are not presented in the sample. The average composition of the matrix is SiO_2=44.2±0.4, TiO_2=0.5±0.0, Al_2O_3=26.4±1.1, Cr_2O_3=0.2±0.0, FeO=6.0±0.7, MgO=10.1±0.7, CaO=13.1±0.6 (N=3, all in wt%).

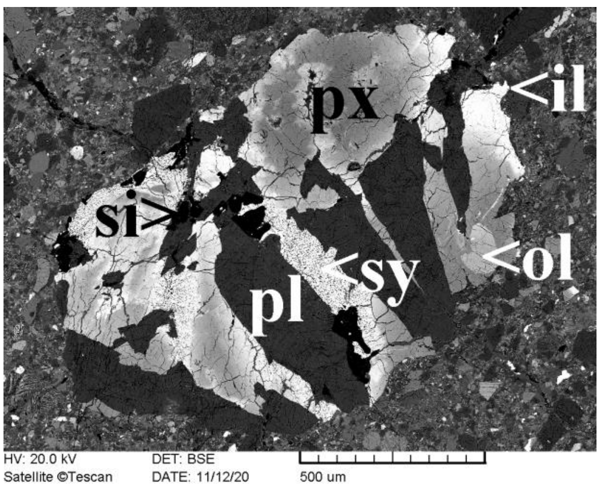
Clast types are wide in range, impact melt clasts are most common. Impact melt breccia, granulitic breccia, basalt, various plutonic rocks, anorthosite and granulite clasts are presented too. Most clasts are fractured. Diameters of the rock fragments are up to 2 mm, the largest clast is an impact melt breccia, therefore breccia-in-breccia structure is fairly observable. The major mineral phases are also olivine, pyroxene and feldspar. Accessory chromite, FeNi metal, silica, ilmenite, troilite, apatite and baddeleyite are presented too within clasts.



1. Figure **BSE image of impact origin glass spherules in the matrix of NWA 13637. SF5 shows radial texture, while SF6 is homogenous.**

The maximum diameter of the impact and volcanic spherules is 100 µm. Many spherules are intact from moderate shock effects that affected the source regolith. Most of the lunar spherules are impact in origin (from surface regolith melting) and lesser amount of the spherules are formed in volcanic processes (pyroclastic eruption products). The two types of spherules can be separated by their textures and MgO/Al_2O_3 [10,11]. The MgO/Al_2O_3 of the skeletal-dendritic textured SF1 spherule is 1,40 which is consistent with the higher ratios of Apollo volcanic glasses (MgO/Al_2O_3>1,25) [11]. On the other hand, SF2, SF3, SF4, SF5 and SF6 spherules have lower ratios (0.31-0.44; MgO/Al_2O_3<1,25) which reflect their impact origin [11]. SF5 spherule has radial texture (Fig. 1), however SF2, SF3, SF4 and SF6 spherules are homogenous in texture. The average composition of the impact glass spherules is SiO_2=43.3±3.7, TiO_2=0.3±0.1, Al_2O_3=26.1±1.8, Cr_2O_3=0.2±0.1, FeO=5.7±2.4, MnO=0.0±0.1, MgO=9.5±1.0, CaO=15.1±0.8, Na_2O=0.2±0.2 (N=12, all in wt%).

All of the analyzed four basaltic clasts show VLT basalt affinity which confirmed by the Fe# (atomic Fe/[Mg+Fe]) and Ti# (atomic Ti/[Ti+Cr]) of pyroxenes within these clasts [12]. Basaltic clasts (380-1400 μm) exhibit porphyritic, ophitic (Fig. 2) and poikilitic textures. The major mineral phases within these basaltic fragments are pyroxene and feldspar, minor and accessory phases are olivine, silica, ilmenite, symplectitic intergrowths and troilite.



***2. Figure* BSE image of a basaltic clast exhibits ophitic texture (il=ilmenite, ol=olivine, pl=plagioclase, px=pyroxene, si=silica, sy=symplectite).**

Discussion: The NWA 13637 meteorite is a lunar feldspathic regolith breccia as a consequence of the analyses. Within its matrix material there are several impact origin glass beads which is a characteristic feature of regolith breccias. Therefore, the material launched from not deeper than the upper few meters of the lunar crust.

The features of the source region of the meteorite can be measured by the composition of VLT basaltic clasts and glass beads. Lunar soils are comparable with impact glass spherules, because impact spherules reflect to the source regolith from which they melted and recrystallized [13]. If we compare the composition of NWA 13637 impact glass spherules with the average composition of collected soils of the Apollo and Luna missions, we find that the Apollo 16 soils (SiO_2=45.0, TiO_2=0.54, Al_2O_3=27.3, Cr_2O_3=0.33, FeO=5.1, MnO=0.30, MgO=5.7, CaO=15.7, Na_2O=0.46, K_2O=0.17, P_2O_3=0.11, S=0.07; all in wt%) [14] are approximate the best with NWA 13637 glass spherules and average matrix composition. Although there is a notable difference in MgO-content of the compared compositions.

Based on the results of the study, it seems that the source region of NWA 13637 lunar feldspathic breccia meteorite is similar to the material that covers the landing site of the Apollo 16 mission. Therefore, the regolith of the source region of the meteorite may be a material that is similar to the boundary of Procellarum KREEP Terrane (PKT) and outer-Feldspathic Highlands Terrane (FHT-O) and the source regolith should contain VLT basaltic material which is in relatively close to the region from which the NWA 13637 launched.

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