LUNAR METEORITE NORTHEAST AFRICA 001: AN ANORTHOSITIC REGOLITH BRECCIA WITH MIXED HIGHLAND/MARE COMPONENTS.

Jakub Haloda[1,2], Anthony J. Irving[3] and Patricie Tycova[1,2], [1]Institute of Geochemistry, Charles University, 128 43 Prague 2, Czech Republic, [2]Czech Geological Survey, Barrandov, 150 00 Prague 5, Czech Republic (haloda@cgu.cz), [3]Department of Earth and Space Sciences, University of Washington, Seattle, WA 98195, USA (irving@ess.washington.edu).

Introduction: Northeast Africa 001 (NEA 001) is a 262 g lunar meteorite found in 2002 in northern Sudan. This rock is a clast-rich anorthositic regolith breccia with minor mare basalt component.

Petrography: NEA 001 is a polymict regolith breccia composed of various types of lithic clasts (up to 1 cm in size), isolated mineral fragments, glass fragments and spherules embedded in a well-consolidated microcrystalline impact melt matrix (Fig. 1). The rock is heavily fractured as a result of multiple shock events, but it remains coherent due to the presence of impact-melt matrix. Typical composition of the impact-melt matrix is (wt%): SiO_2 = 45.7, Al_2O_3 = 24.1, FeO = 7.2, MgO = 7.4, CaO = 14.6, Na_2O = 0.5, TiO_2 = 0.5.

Figure 1. Photograph of 120 g specimen of NEA 001.

Mineral fragments are in most cases smaller than 100 μm in size, including plagioclase, pyroxene and olivine, with minor Mg-Al spinel, chromite, ilmenite, troilite, FeNi metal and silica. Plagioclase compositions vary in range $An_{92-99}Or_{<0.2}$. Pyroxene mineral fragments show a wide range of compositions Wo_{2-39} En_{13-80} (Fig.2). Several pyroxene fragments possess exsolution lamellae up to 10 μm wide, some of the pyroxene grains have marginal symplectitic intergrowths of fayalite+hedenbergite+silica after former pyroxferroite. Olivine fragments (Fig. 2) vary from Fo_{48} to Fo_{82}, with rare Fe-rich grains falling outside that range (Fo_{9-22}). Analyses of the Fe/Mn atomic ratio in pyroxenes (Fe/Mn = 43-86 atom%) and olivines (Fe/Mn = 93-100 atom%) within the sample affirms the lunar origin. The Fe and Mn concentrations of pyroxene are plotted in Fig. 3, after [1]. We have observed regolith components such as glass spherules and fragments set within the matrix. Some glasses are partially devitrified, containing plagioclase and pyroxene crystals (Fig. 4). The matrix glass and glass fragments have largely anorthositic compositions (<6 wt% FeO), however some glass fragments are relatively high in Fe and Ca/Al ratio.

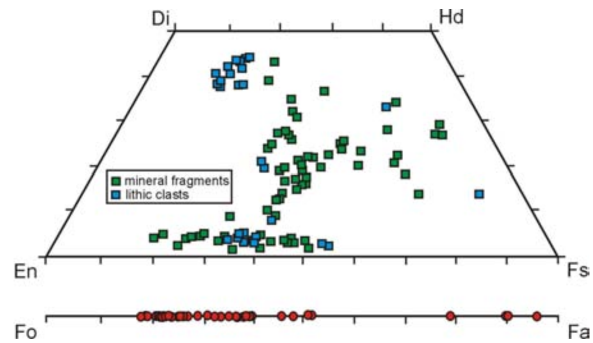
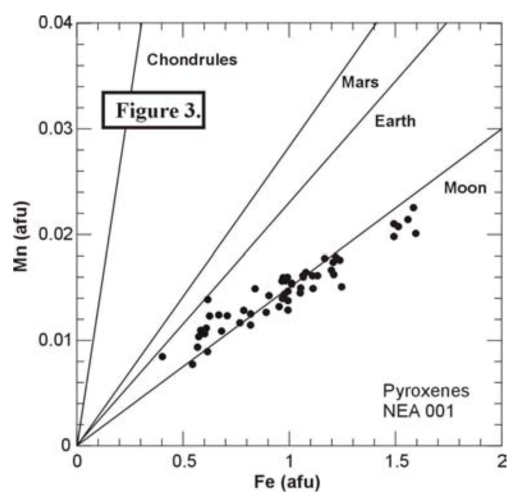


Figure 2. Pyroxene and olivine compositions in NEA 001. Note that some pyroxene grains fall within the field for mare basalts [2], suggesting that they were not derived from highland lithologies.



Highland clasts: Lithic clasts are mainly of anorthositic lithologies and the most abundant are impact-melt breccias, plagioclase/glass intergrowths and regolith breccias (mixture of glass and mineral fragments) commonly showing breccia-in-breccia textures. Fragments of primary igneous rocks of anorthositic to gabbroic composition are common, containing plagioclase

An_{95-97}, low-Ca pyroxene $En_{46-65}Wo_{2-5}$ and high-Ca pyroxene $En_{35-48}Wo_{37-44}$ and rare olivine Fo_{79}.

Mare basalt clasts: Sparse clasts of mare basalts of VLT-mare affinities are present (Fig. 4). These clasts show commonly porphyritic to ophitic textures with plagioclase (An_{91-96}), pyroxene (pigeonite to augite), olivine and accessory ilmenite. One small basaltic clast (0.1 x 0.1 mm in size), with porphyritic texture is composed of strongly zoned pyroxene, plagioclase (An_{86}), ilmenite laths, accesory apatite, FeNi metal and troilite. The presence of ilmenite in the basaltic clast suggests this may not be a VLT composition, however the small sample size precludes any definitive conclusions.

Discussion: The major lithologies present in NEA 001 correspond in chemistry to the ferroan anorthosite suite in lunar highland rocks. The regolithic nature of the meteorite is proven by the presence of glass spherules and fragments, but we have not observed agglutinates in the studied sample. There is also evidence of contribution of mare basaltic material in NEA 001 – fragments of Fe-rich augites and pigeonites, breakdown products of pyroxferroite, Fe-rich olivine and the presence of a few pristine basaltic clasts.

Regolith breccias are very common among lunar meteorites [3]. The presence of VLT basalts or mare basaltic component as clasts and fragments in lunar-highlands meteorites was reported earlier [4-8]. The distinctive coarse grainsize and specific mafic mineral compositions of NEA 001, together with the absence of agglutinates and KREEP materials, indicate that this specimen is different from other known lunar meteorites and probably represents an independent fall (see also bulk compositional data given by [9]). We conclude that the lunar source area for NEA 001 is a terrain of highlands rich in ferroan lithologies, with minor mare basalt components.

References: [1] Papike J.J. et al. (2003) *Am. Min., 88*, 469-472; [2] Papike J.J. (1998) in Planetary Materials, *Reviews in Mineralogy, 36*, ch. 5, M.S.A.; [3] Korotev R.L. et al. (2003) *GCA, 67*, 24, 4895-4923; [4] Taylor L.A. et al. (2004) *LPS XXXV*, CD-ROM #1755; [5] Nazarov M.A. et al. (2002) *LPS XXXIII*, CD-ROM #1293; [6] Semenova S. et al. (2000) *LPS XXXI,* CD-ROM #1252; [7] Arai T. et al. (2004) *LPS XXXV,* CD-ROM #2155; [8] Neal C.R. et al. (1990) *LPSC XXI*, 861-862. [9] Korotev R. L. and Irving A. J. (2005) *LPS XXXVI, this volume*.

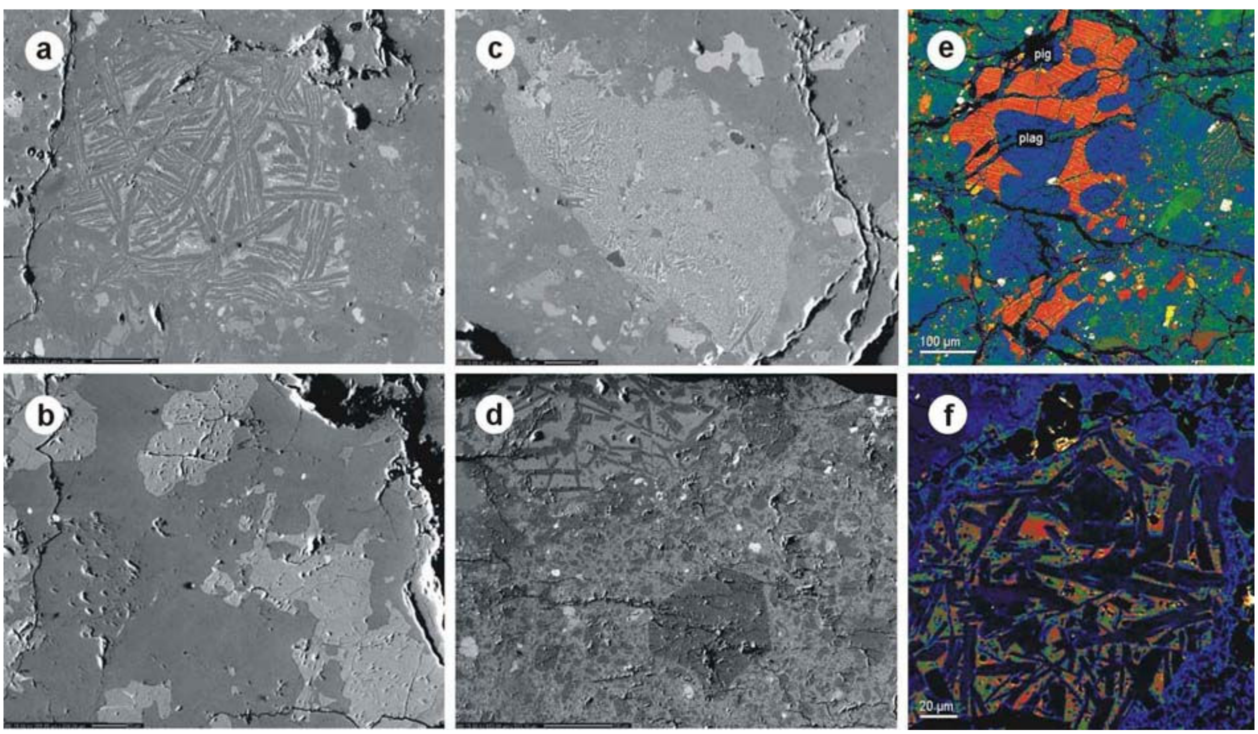


Figure 4. (a) Back scattered electron (BSE) image of a plagioclase/glass lithic clast (200 µm in longest dimension). (b) BSE image of anorthositic lithic clast (230 µm). (c) BSE image of devitrified glass fragment within regolith breccia. (d) BSE image of impact-melt breccia partially enclosing lithic clast of plagioclase+glass composition. (e) False-color BSE image showing primary igneous gabbroic clast of the ferroan highlands suite. (f) False-color BSE image of basaltic clast.