REVISITING NWA 3141, 8266, AND 8594: TWO EUCRITES AND A HOWARDITE?

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Introduction: Scanning electron microscopy was used to study the petrology of monomict eucrites Northwest Africa 3141, 8594 and 8266. The analysis carried out in this study supports the official classifications of NWA 3141 and 8594, but suggests that NWA 8266 is a polymict breccia.

Results: Northwest Africa 3141 is a coarse-grained monomict breccia consisting of clasts of subhedral feldspar and pyroxene in a recrystallized matrix. Modal abundance (in vol%) of minerals present is dominated by calcic feldspar (51.5) and pyroxenes (41.1), with minor phases of silica polymorph (5.4), ilmenite (0.62), troilite (0.29), and chromite (0.16). Geochemical analysis shows that the plagioclase is anorthite ($An_{86.7\text{-}90.3}$), and that pyroxene is presented in two phases (exsolved pigeonite $Wo_{6.6\text{-}14.9}En_{19.0\text{-}33.7}Fs_{26.0\text{-}42.2}$; augite $Wo_{30.5\text{-}41.2}En_{28.4\text{-}29.4}Fs_{69.5\text{-}78.1}$; pyroxene Mg# 27-36).

Northwest Africa 8266 is a matrix-supported polymict breccia of various angular to subrounded eucritic fragments. The sample is composed (in vol%) of pyroxene (62.1), calcic feldspar (34.7), olivine (0.2), and metal phases ilmenite (0.5), chromite (0.3), and troilite (0.1). Feldspars are anorthite ($An_{86.9\text{-}100.0}$), and both pigeonite and pyroxene are present (pigeonite $Wo_{4.6\text{-}10.9}En_{30.8\text{-}39.0}Fs_{19.5\text{-}37.5}$; augite $Wo_{26.3\text{-}44.6}En_{27.5\text{-}31.2}Fs_{64.7\text{-}81.6}$; Mg# 36-54). Olivine is fayalitic ($Fa_{83.4\text{-}87.3}$; Mg# 11-17). Clast textures include cumulate eucrites, basaltic eucrites, brecciated clasts which show recrystallization in places, fine-grained granulitic clasts, and relict grains of olivine, feldspar and pyroxene.

Northwest Africa 8594 is a monomict eucrite composed of angular feldspar laths and interstitial zoned pyroxene in a recrystallized matrix. The sample (in vol%) is predominately composed of calcic feldspar (72.46) and pyroxene (24.2). Minor phases include olivine (0.57), ilmenite (0.7), troilite (0.4), and chromite (0.1). The feldspars present are anorthite ($An_{88.3\text{-}96.9}$), and pyroxenes are dominated by pigeonite (23.9 vol%; $Wo_{6.8\text{-}11.2}En_{32.2\text{-}46.1}Fs_{24.8\text{-}36.9}$; Mg# 37-50) although a small amount of augite (0.3 vol%; $Wo_{21.6\text{-}36.0}En_{24.7\text{-}27.0}Fs_{57.7\text{-}74.4}$; Mg# 33-38) is also present. Olivine is fayaltic ($Fa_{61.2\text{-}65.3}$; Mg# 14-29), and only observed in the matrix.

Discussion: NWA 3141 and 8594 are monomict eucrites. NWA 3141 shares textural similarities with Millbillillie [1], whilst NWA 8594 is more similar to Nuevo Laredo [2]. NWA 3141 exhibits clear exsolution lamellae within pyroxenes, and blebby Si-polymorphs associated with shock metamorphism and thermal destabilization of pyroxene [3]. NWA 8594 displays compositionally zoned pyroxenes with Mg-rich cores. Wt% trends of MgO and FeO against SiO_2 suggest this is related to the primary crystallization of the mineral from magma. Small olivine crystals are observed in the matrix and have varying forsterite-fayalite compositions, suggesting that they were gathered from different sources. The monomict nature of these samples with the low quantities of matrix suggest that they may have been liberated from the brecciated floor of an impact crater [4].

Northwest Africa 8266 is classified as a monomict eucrite, but SEM has revealed a number of lithologies derived from clast types within the sample. The most notable clasts are granulitic, cumulate eucrites, and breccias. The granulitic clasts are the result of thermal recrystallization of basaltic eucrites, and is also observed in a number of other samples, such as Puerto Lapice [5] and Macibini [6], and suggest the parent rock underwent thermal metamorphism prior to brecciation and lithification. Cumulate clasts exhibit textures from gabbroic to feldspar lath-rich with individual clasts showing a wide range in mineral modes (in wt%: pyroxene 0.6-12.0; feldspar: 47.3-71.5; olivine: 10.0-31.3). Breccia clasts show thermal recrystallization in places, and record up to two previous impact to lithification events pre-formation of the NWA 8266 breccia. As such, the meteorite was likely lithified in an ejecta blanket or crater infill [4], and the classification as monomict is unsuitable. It is proposed that Northwest Africa 8266 is a polymict breccia, and is potentially a howardite.

References: [1] Yamaguchi, A., Takeda, H., Bogard, D.D., Garrison, D. 1994. Textural variations and impact history of the Millbillillie eucrite, *Meteoritics*, 29:237-245. [2] Duke, M.B., Silver, L.T. 1967, *Geochimica et Cosmochimica Acta*, 31:1937-1665. [3] Benzerara, K., Guyot, F., Barrat, J.-A., Gillet, P., Lesourd, M. 2002, *American Mineralogist*, 87:1250-1256. [4] Metzler, K., Bobe, K.D., Palme, H., Spettel, B., Stöffler, D. 1995, *Planetary and Space Science*, 43:449-525. [5] Llorca, J., Casanova, I., Trigo-Rodríguez, J.M., Madiedo, J.M., Roszjar, J., Bischoff, A., Ott, U., Franchi, I.A., Greenwood, R.C., Laubenstein, M. 2009. *Meteoritcs & Planetary Science*, 44:159-174. [6] Buchanan, P.C., Lindstrom, D.J., Mittlefehldt, D.W., Koeberl, C., Reimold, W.U. 2000, *Meteoritics & Planetary Science*, 35:321-1331