AR-AR AGES OF NWA 2977 AND NWA 3160 – LUNAR METEORITES PAIRED WITH NWA 773

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On the basis of similarities in chemical composition and mineralogy it has been suggested that NWA 2977 and NWA 3160 are paired with NWA 773 [1,2]. Previously we determined the Ar-Ar age of NWA 773 to be 2.91 ± 0.02 Ga [3] and a Sm-Nd isochron age of 2.865 ± 0.031 Ga has been reported [4]. Our aim here is to determine Ar-Ar ages for two other lithologies inferred to be from the same meteorite in order to assess their pairing relationships.

Samples and method The Ar-Ar dating technique has been applied to bulk samples of NWA 3160 a porphyritic olivine basalt [5] and NWA 2977 a cumulate olivine gabbro [1,6] in an attempt to determine the crystallisation age and exposure history experienced by these meteorites on the lunar surface. NWA 2977 is an olivine-rich, two-pyroxene cumulate gabbro composed of olivine ($Fa_{31.7}$, FeO/MnO = 96), pigeonite ($Fs_{26.6}$ $Wo_{6.7}$), augite ($Fs_{16.2}$ Wo_{29}), and plagioclase (An_{92}) with minor amounts of Ba-K-feldspar, chromite, ilmenite, and merrillite [6]. Larger pigeonite grains commonly enclose equant olivine grains, which contain abundant melt inclusions. Plagioclase is partially converted to maskelynite, and pyroxenes and olivine exhibit shock lamellae and undulatory extinction. NWA 3160 has a groundmass of spinifex olivine (Fo_{29}) and skeletal pyroxene ($En_{37\text{-}39}$ $Wo_{11\text{-}13}$) set in a fine grained matrix of pyroxene ($En_{35\text{-}39}$ $Wo_{20\text{-}23}$), glass and olivine (~Fo_{22}) [5]. It is a low to very-low Ti basalt and the abundances of Fe, Sc. Cr and Co are similar to those in Apollo 12 and 15 olivine basalts [5]. However, the concentrations of Na_2O and Eu are lower and the REE pattern shows enrichment in the light elements and is overall slightly higher than Apollo olivine basalts [5]. Both samples were analysed by Ar-Ar stepped heating in a Ta resistance furnace over the temperature range 300-1600°C.

NWA2977 This sample contains negligible levels of trapped Ar. The age spectrum shown in Fig 1a overlaps with that obtained previously for the cumulate fraction of NWA 773. The total age obtained by integrating Ar released over all temperature steps is 2.62 ± 0.04 Ga (all errors are quoted at the 2σ level). However, summing just Ar released at high temperature (1400-1600°C), where the spectrum is relatively flat and comprising 57% of the ^{39}Ar release, corresponds to an age of 2.77 ± 0.04 Ga. This is in good agreement with the Ar-Ar age of 2.67 ± 0.04 previously obtained for the cumulate in NWA 773 [3].

NWA3160 This sample contains a minor component of trapped Ar with ^{36}Ar/^{38}Ar for most temperature steps being close to the solar value of 5.35. Variations in the proportions of trapped and radiogenic ^{40}Ar released in different temperature steps means it is not possible to obtain a precise ^{36}Ar/^{40}Ar for the trapped component. The age spectrum has a notable humped-shape with older apparent ages at intermediate temperature release (Fig. 1b). This may be due to recoil of ^{39}Ar in the finer-grained texture of this lithology. Assuming no correction for trapped ^{40}Ar, then an integrated age of 2.65 ± 0.04 Ga is obtained, similar to NWA773 and NWA 2977.

Previously, trapped Ar was identified in the breccia portion of NWA773 with a ^{36}Ar/^{40}Ar value of ~1.3 [3].

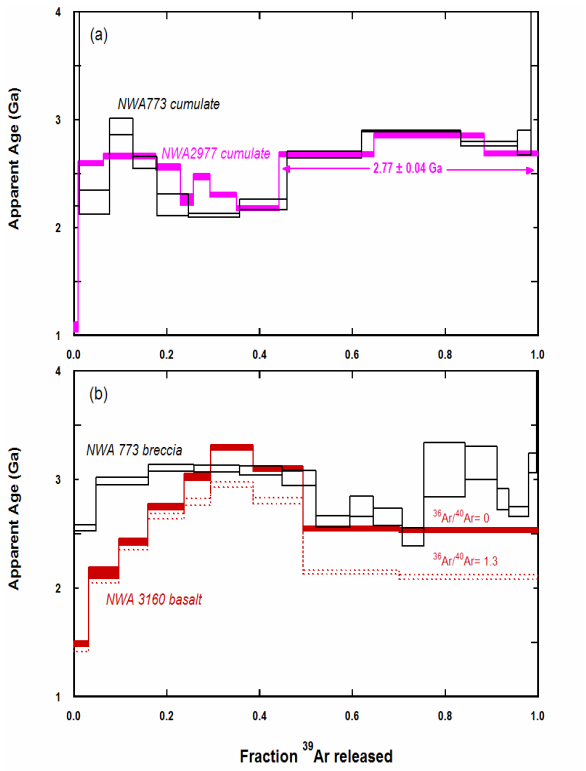

Figure 1 Ar-Ar age spectra for lunar basaltic meteorites: (a) NWA 2977 and (b) NWA 3160 compared with NWA 773 [3].

Fig 1b shows the effect of correcting the age spectrum using this trapped ratio. This leads to a lower integrated age of 2.39 ± 0.04 Ga. At present, it is not clear whether this lithology is really younger or whether as-

sumptions concerning the trapped Ar correction are incorrect.

Cosmic Ray Exposure (CRE) age The lack of bulk compositional data for NWA 2977 means that CRE ages have been calculated using the 2π production rate of 1.044×10^{-8} cm^3 $^{38}Ar/g/Ma$ obtained for NWA 773 and NWA 3160 (bulk composition from Ryan Zeigler, personal communication). The calculated total CRE age for NWA 3160 is ~29 Ma and for NWA 2977 is ~12 Ma. These ages are younger than those reported for NWA 773 cumulate (82 ± 3 Ma) and breccia (153 ± 6 Ma) [3], suggesting a shorter residence on the lunar surface or samples from a deeper source in the regolith.

Pairing relationships The Ar-Ar results show that cumulates in NWA773 and NWA2977 have indistinguishable age spectra and crystallisation ages of 2.7-2.8 Ga which establishes their paired relationship. Neither of these meteorites contains trapped solar Ar but they have different exposure/burial histories indicated by contrasting levels of cosmogenic Ar. NWA 3160 is more similar to the breccia portion of NWA 773 again confirming a pared relationship. Both meteorites contain appreciable trapped Ar making it more problematic to obtain reliable Ar-Ar ages. Both have a similar-shaped age spectrum and are consistent with a 2.7 Ga age. Recoil of ^{39}Ar may have played a more significant role in defining the range of apparent ages in these samples.

References: [1] Zeigler et al (2006) Ant. Met. XXX, 125-126, NIPR. [2] Joliff et al (2007) 38th LPSC. [3] Fernandes V.A. et al. (2003) MAPS 38, 555-564. [4] Borg L. et al. (2004) Nature 432, 209-211. [5] Zeigler et al. (2006) 37th LPSC, abst.#1804. [6] Bunch et al. (2006) 37th LPSC, abst.#1375.

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