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Article

$^{40}Ar/^{39}Ar$ ages of Northwest Africa 7034 and Northwest Africa 7533

F. N. Lindsay, J. S. Delaney, C. GÖpel, G. F. Herzog, R. Hewins, M. Humayun ... See all authors

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Abstract

The Martian breccias NWA 7034, NWA 7533, and paired meteorites record events ranging in age from 4.47 Ga to <200 Ma. Published ages indicate a period of major disturbance at ~1.4 Ga, examined in detail here through $^{40}Ar/^{39}Ar$ dating of handpicked grains and two small chips. Argon diffusion parameters were obtained for six samples. Also presented are He, Ne, Ar, Kr, and Xe contents of two small (<100 μg), handpicked mineral separates, a felsic "Light" sample and a mafic/pyroxene-rich "Dark" sample. The $^{40}Ar/^{39}Ar$ ages of five samples, four containing >1 wt% K and thought to be rich in feldspar and one containing <~1 wt% K, cluster near 1.4 Ga. The $^{40}Ar/^{39}Ar$ ages of nine grains with low K contents have a wide range of apparent ages from 0.3 ± 0.1 Ga to 2.9 ± 0.1 Ga for individual temperature steps, and from 0.74 ± 0.06 Ga to ~2.1 Ga for plateau ages. Isochron ages are less precise, but generally agree with plateau ages. Only two isochrons have the significantly positive intercepts expected in the presence of terrestrial or Martian atmospheric argon. At higher release temperatures, activation energies for diffusion obtained from ^{39}Ar data for six samples are generally 160–200 kJ mol^{-1}, consistent with published values for feldspathic minerals. For three of these samples, lower temperature data on Arrhenius plots are best fit with a much lower activation energy of <100 kJ mol^{-1}. We attribute the low values to the effects of varying degrees of shock on feldspathic minerals and/or the presence of phases in vitrophyric spherules produced by hydrothermal alteration. The low activation energies place an upper limit of ~14 ka on the terrestrial age of NWA 7034. Much lower concentrations of cosmogenic (c) ^{3}He and ^{21}Ne in the Light than in the Dark separate indicate substantial losses concurrent with or postdating cosmic ray irradiation. A one-stage, cosmic ray exposure (CRE) age for the Dark separate from NWA 7034 is estimated to be between 7 and 10 Ma from the concentrations of $^{3}He_c$ and $^{38}Ar_c$, and of close to 15 Ma from the concentration of $^{21}Ne_c$. Most of the $^{40}Ar/^{39}Ar$ and noble gas data are compatible with (1) a heating and alteration event ~1.40 Ga caused by contact metamorphism, an impact, and/or the infiltration of hydrothermal fluids; and (2) at least one later event at lower temperatures that led to either loss of He and Ar from phases with low activation energies, or to gain of K. Most of the $^{40}Ar/^{39}Ar$ ages are consistent with the assembly of NWA 7034 1.4 Ga ago or perhaps earlier followed more recently by selective alteration. A more recent time of assembly is also consistent with these ages provided that the temperature stayed low. The five most precise $^{40}Ar/^{39}Ar$ ages of the samples analyzed are all ~1.4 Ga, a value seen frequently in other NWA 7034 chronometers and very similar to crystallization ages of nakhlites and chassignites (NC). Some CRE ages based on noble gases in NWA 7034 agree within their considerable uncertainties with those of NC. These two chronometric coincidences suggest that the NWA 7034 clan and the NC share a launch date on Mars. We propose that K-rich fluids derived from the nakhlite source area interacted with proto-NWA 7034 and modified the K/Ar ratios and ages of previously shocked feldspar grains, with the degree of modification depending on the degree of shock. The NWA 7034 clan may therefore be considered components from a metamorphic aureole around a nakhlite massif.

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