Ar-Ar Dating of Martian Chassignites, NWA2737 and Chassigny, and Nakhlite MIL03346.

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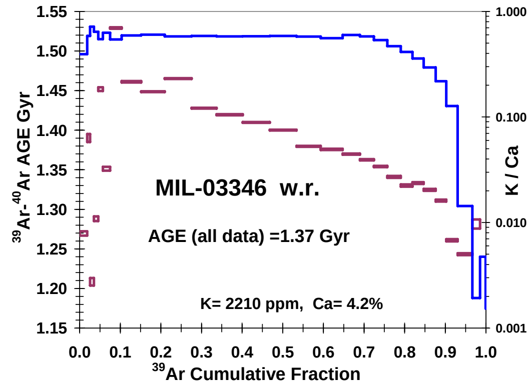
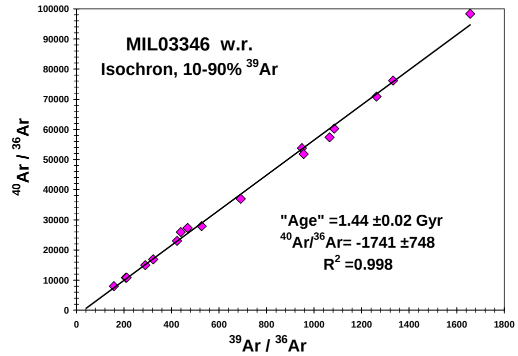
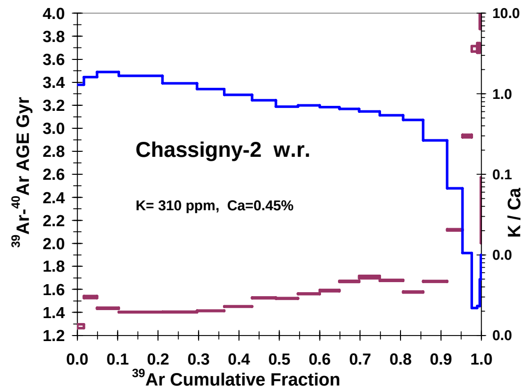
Introduction. Until recently only three nakhlites and one chassignite had been identified among martian meteorites. These four exhibit very similar radiometric ages and cosmic ray exposure (CRE) ages, indicating that they may have derived from a common location on Mars and were ejected into space by a single impact. This situation is quite different from that of martian shergottites, which exhibit a range of radiometric ages and CRE ages (1). Recently, several new nakhlites and a new martian dunite (NWA2737) have been recognized. Here we report our results of ^{39}Ar-^{40}Ar dating for the MIL03346 nakhlite and the NWA2737 "chassignite", along with new results on Chassigny.

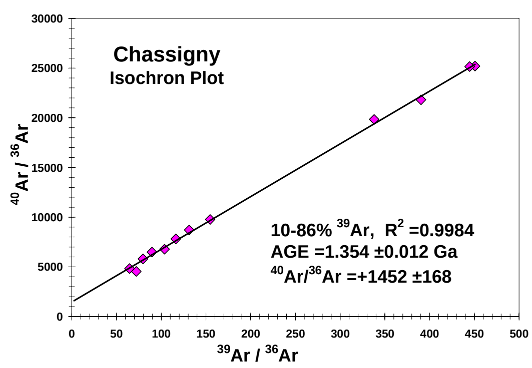
MIL03346 nakhlite. The measured Ar-Ar age spectrum for a whole rock sample (Fig. 1) shows a steady decrease in age from ~1.5 Gyr to ~1.3 Gyr and a constant K/Ca over ~7-80% of the ^{39}Ar release. Small diffusion loss of ^{40}Ar is seen at <7% ^{39}Ar release. An isochron plot (Fig. 2) of ^{40}Ar/^{36}Ar vs. ^{39}Ar/^{36}Ar for 16 extractions (10-90% ^{39}Ar) define an age of 1.44 ±0.02 Gyr and a ^{40}Ar/^{36}Ar intercept of (minus) -1741 ±748. The high ^{40}Ar/^{36}Ar ratios observed in some extractions indicates that radiogenic ^{40}Ar greatly dominates over trapped ^{40}Ar. If we correct this isochron for cosmogenic ^{36}Ar (and omit one datum that dominates the slope), the age becomes 1.42 ±0.01 Gyr and the intercept (minus) -1778 ±913. The large negative intercept indicates that the entire age spectrum has been affected by ^{39}Ar recoil, causing the isochron to rotate counter-clockwise and yield a higher age and lower intercept. The total Ar-Ar age of 1.37 Gyr averaged over all extractions may average out the effects of ^{39}Ar recoil and may approximate the actual Ar-Ar age. This interpretation implies our sample released no trapped martian ^{40}Ar.

Chassigny. The Ar-Ar age spectrum for a whole rock sample (Fig. 3) gives a minimum age of ~1.4 Gyr at relatively low extraction temperature, rising up to an apparent ages of >2 Gyr at the highest extraction temperatures. The highest ages are associated with Ar release from a phase with much lower K/Ca and probably represent release of trapped martian Ar from mafic minerals. The first few extractions released some terrestrial Ar contamination, which explains the slightly higher ages at <10% ^{39}Ar release. An isochron plot (Fig. 4; not corrected for cosmogenic ^{36}Ar) for 12 extractions releasing 10-86% of the ^{39}Ar give an age of 1.354 ±0.012 Gyr and an ^{40}Ar/^{36}Ar intercept of 1452 ±168. If we apply an approximate correction for cosmogenic ^{36}Ar, the age and slope (R^2=0.999) become 1.415 ±0.012 Gyr and 1787 ±845. These two Ar-Ar ages bracket the recently reported Sm-Nd age of 1.36 ±0.03Gyr (2).



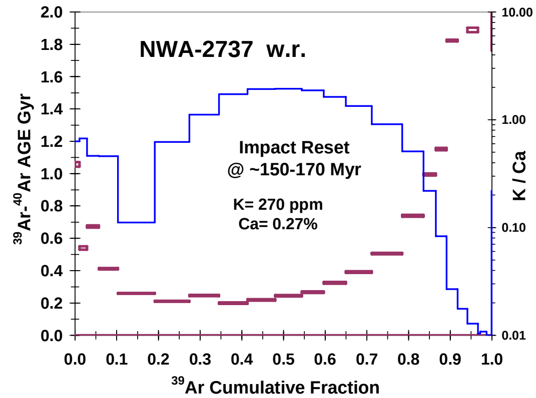


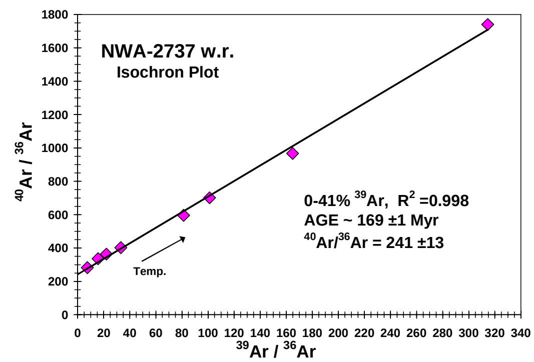


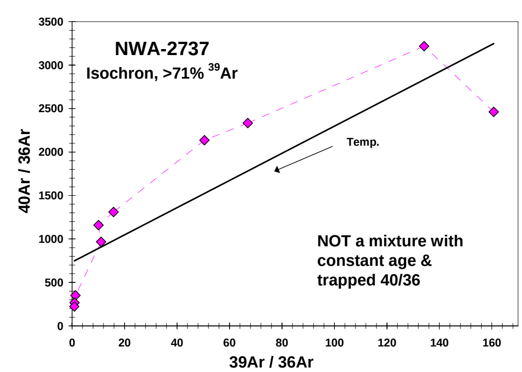


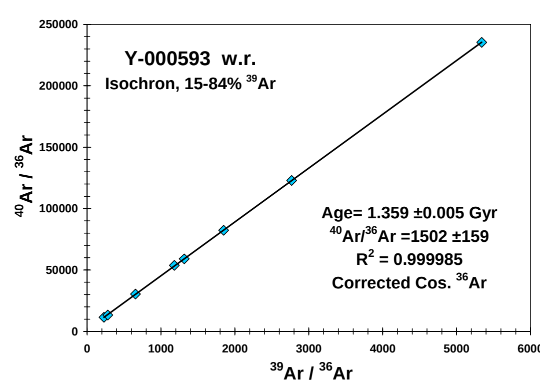
NWA2737 dunite. This meteorite is similar to Chassigny in overall chemical composition, but it is somewhat more Mg-rich (3). NWA2737, however is dark brown in color and its texture suggests strong shock alteration (3). (Our sample was furnished by J-A Barrat.) The Ar-Ar age spectrum of NWA2737 (Fig. 5) is very different from that of Chassigny and is indicative of extensive (but not complete) shock degassing of Ar long after NWA2737 formation. (The Sm-Nd age of NWA2737 is 1.42 ±0.06 Gyr (4)). Across intermediate extraction temperatures the Ar-Ar age is nearly constant at ~0.20-0.25 Gyr, then rises steadily to values of >2 Gyr. (The summed age is 0.61 Gyr.) The first few extractions released terrestrial Ar contamination, which accounts for their slightly higher age. An isochron plot (Fig 6; corrected for cosmogenic ^{36}Ar) of eight extractions releasing 0-41% of the total ^{39}Ar give an Ar-Ar age of 169 ±4 Myr and an ^{40}Ar/^{36}Ar intercept of 242 ±13. This intercept may differ slightly from the terrestrial atmospheric value because of uncertain corrections for cosmogenic ^{36}Ar. There is a tendency for the corrected age spectrum to slightly increase with increasing temperature over 0-41% ^{39}Ar release, suggesting that a small residue of undegassed ^{40}Ar may remain. We conclude that NWA2737 was strongly degassed of radiogenic ^{40}Ar ~160-170 Gyr ago, probably as a result of a strong shock heating event on Mars. This event is not observed in the Chassigny Ar-Ar data. An isochron plot (Fig. 7) of those extractions releasing >71% of the ^{39}Ar and showing older ages is not linear, but varies in a progressive manner with extraction temperature (dotted line). This indicates that ^{40}Ar released in these extractions has more than two components. Either the ^{40}Ar/^{36}Ar of a trapped martian component varies and the age remains constant, or the apparent age varies while the ^{40}Ar/^{36}Ar of a trapped martian component remains constant (probably with ^{40}Ar/^{36}Ar <500), or both parameters may vary.

Trapped ^{40}Ar/^{36}Ar. The trapped martian ^{40}Ar/^{36}Ar ratio deduced for Chassigny (~1450-1800) is similar to a trapped ^{40}Ar/^{36}Ar of ~1500 we determined for the Y-000593 nakhlite (5), as shown in Fig. 8. These ratios are also similar to ratios of ~1750-1900 estimated for some shergottites (6). This similarity suggests that the ^{40}Ar/^{36}Ar ratio in the martian atmosphere has not changed appreciably over the past ~1.4 Gyr. Assuming the same can be said for martian atmospheric ^{129}Xe/^{132}Xe, the lower trapped ^{129}Xe/^{132}Xe observed in nakhlites compared to shergottites is consistent with the additional presence in nakhlites of martian mantle Xe.









References. (1) Nyquist et al., Space Sci. Rev. 96, 105, 2001; (2) K Misawa et al., LPSXXXVI, #1698, 2005; (3) P. Beck et al., LPSXXXVI, #1326, 2005; (4) K. Misawa et al., MAPS, A104, 2005; (5) Misawa et al., Antarct. Met. Res, 18, 133, 2005; (6) Bogard & Garrison, MAPS 34, 451, 1999.