Neutron capture and spallation: potential contributors to Kr and Xe in the martian atmosphere

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We have reported on the in situ measurement of the stable isotopes of both krypton and xenon in the atmosphere of Mars with the Sample Analysis at Mars investigation on the Curiosity rover[1]. Now we propose mechanisms to explain departures of some of the Xe isotopic ratios from the fractionation curve predicted for loss of an initially solar-like atmosphere by hydrodynamic escape (HE)[2].

The Kr data generally agree with the solar wind (SW) composition, except for enrichments of ^{80}Kr and ^{82}Kr consistent with addition of ^{79,81}Br(n,β^-)^{80,82}Kr neutron capture products outgassed from the regolith, as has been observed to a lesser extent in the EETA79001 shergottite meteorite.[3, 4]

Xe isotope ratios ^{130}Xe/^{132}Xe and $^{134\text{-}136}$Xe/^{132}Xe are in excellent agreement with meteorite measurements and support the conclusion that the atmospheric Xe composition on Mars (except for radiogenic ^{129}Xe) is consistent with SW fractionated by HE. However $^{124\text{-}128}$Xe/^{132}Xe and ^{131}Xe/^{132}Xe exhibit significant enrichment above their expected values based upon the meteorite literature, which can be a signature of the presence of spallation and (n,β^-) products.[5] We will present a scenario for potential contributions from both spallation and neutron capture in the martian regolith with degassing into the atmosphere.

The measurement of these heavy noble gases directly from the atmosphere of Mars provides a reference point for teasing apart the various non-atmospheric contributions to the Kr and Xe inventories in the martian meteorites, and further helps in understanding the larger issue of surface-atmosphere interactions on Mars.

[1] Mahaffy, P.R., et al., (2012) **Space Sci Rev**. **170** (1-4): p. 401-478. [2] Pepin, R.O., (2000) **From Dust to Terrestrial Planets**., Springer. p. 371-395. [3] Becker, R. and R. Pepin, (1984) **EPSL**,. **69**(2): p. 225-242. [4] Swindle, T., et al., (1986) Geochim. et Cosmochim. A., **50**(6): p. 1001-1015. [5] Rao, M., et al., Icarus, 2002. **156**(2): p. 352-372.