The abundance and isotopic composition of helium, neon, argon, krypton and xenon have been measured in the gases released by the stepwise heating of lunar fines, # 15601.64. The extraction temperatures were varied from 100°C to 1500°C in 100°C steps. The release pattern shows a preferential release of the lighter weight isotopes at low extraction temperatures.

Due to the role of isotopic fractionation, it is not possible to resolve any of the five noble gases into a mixture of spallation and fission components with a unique solar wind-implanted component.

In order to compare noble gases in # 15601.64 with noble gases in meteorites and in the atmosphere, the following equation (1, 2) is used to calculate the enrichment, r, of the heavy isotope of mass $m_2$ relative to a lighter isotope of mass $m_1$:

$$\log r = \left[\frac{m_2-m_1}{m_2+m_1}\right] \log \left[\frac{\text{Initial Volume}}{\text{Final Volume}}\right] \ldots (1)$$

Due to the strong depletion of noble gases in meteorites and in the earth's atmosphere, the isotopic composition calculated from the above equation shows a marked deviation from linearity across the isotope ratios of xenon and krypton.

When corrections are applied for the spallation component, our results indicate that the variations observed in the isotopic composition of neon in the different temperature fractions of lunar fines define a pattern which fits eq. (1) and extrapolates to atmospheric neon. This same fractionation pattern seems to fit the variations observed in trapped neon from gas-rich meteorites (3) and carbonaceous chondrites (4).

Variations observed in the isotopic composition of krypton from different temperature fractions of lunar fines, after subtraction of the spallation component, also fit closely to the pattern described by eq. (1), and this same
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isotopic fractionation pattern extrapolates to atmospheric (5) and AVCC (6) krypton.

The isotopic composition of xenon observed in the gases released from lunar fines at various extraction temperatures also appears to result from spallation reactions and from isotopic mass fractionation. Although the fractionation effects across the isotopes of xenon are minimal, the fractionation pattern appears to extrapolate better to AVCC xenon (6) than to atmospheric xenon (7), particularly for $^{134}$Xe and $^{136}$Xe. Our results seem to confirm the suggestion that solar and AVCC xenon may be related by isotopic fractionation (8), but that atmospheric xenon is distinct from xenon observed in other parts of the solar system. This observation is in conflict with the suggestion that solar and atmospheric xenon are related by simple isotopic fractionation (9). No evidence for decay products from $^{129}I$ or $^{244}Pu$ was observed.

The helium and argon released from # 15601.64 also appear to be a mixture components from spallation, radioactive decay, and isotopic fractionation of solar wind implanted gases. The role of isotopic fractionation is difficult to resolve due to the small number of nonradiogenic isotopes of these two gases. The $^{40}\text{Ar}/^{36}\text{Ar}$ ratio varied from 0.57 to 33.1 and the $^{38}\text{Ar}/^{36}\text{Ar}$ varied from 0.172 to 0.208. The $^{4}\text{He}/^{3}\text{He}$ ratio varied from 1356 to 2169 (10).

References and Notes


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