Attempts at understanding the well-documented secular increase of the trapped lunar 15N/14N ratio (1,2) have been sorted into two classes (3): I. those which propose a change in the isotopic composition of the solar wind source reservoir; II. those which rely upon mechanisms peculiar to the lunar environment exclusive of compositional changes in the solar wind itself. Following, a comparison of the predictions of these two classes of models is made with recent measurements of lunar samples. In doing so, we consider the response of an "ideal" grain detector (i.e., one placed on the moon for well-defined intervals and subject to no regolith complications unrelated to ion implantation) subsequently studied by the stepwise temperature release technique.

Type I Models Independent of the uncertain mechanism for generating a secular increase in the solar 15N/14N ratio (and for which no completely satisfactory model has been developed), the consequences for implantation into an ideal detector are nonetheless predictable. A schematic temperature release profile is illustrated in Figure 1. An essentially flat intermediate T release should obtain with a composition which depends upon the epoch of irradiation, increasing from a low value (δ2N-20%) at early times to a modern high value (δ2N+12%). Also represented are the effects of terrestrial gas adsorption at low T and spallogenic gas release, greater in the ancient sample, at high T.

Type II Models Two varieties of this sort have been suggested. Variety A (4,5) supposes that an indigenous lunar gas with composition δ1 was preferentially released early in the moon's history and reimplanted via the Manka-Michel mechanism (6) along with the solar wind N having a constant composition δ2. The secular variation is ascribed to a declining contribution of the indigenous fraction with time analogous to the explanation for excess 40Ar in lunar soils (7). This situation is illustrated in Figure 2. In the instance of a larger B/v ratio for the ancient solar wind by a factor of about 10 (B=solar wind magnetic field strength; v=solar wind velocity), the release profile for the ancient sample would more closely resemble that in Figure 1 owing to the enhanced implantation energy of the lunar component that would result. Variety B (8) supposes that the solar wind composition has been constant at δ1 but that the flux was much larger in the past. Recirculation of the old solar wind implanted gas through the lunar atmosphere by impact vaporization and Manka-Michel reimplantation is necessarily fractionating giving a lower-energy atmospheric component with composition δ2. The expected thermal release pattern is shown in Figure 3.

Discussion At present all published data for recently exposed samples fit the pattern shown in Figure 3 and thus support models of type II B. However, natural lunar samples, as opposed to an ideal detector, have complexities not taken into account above: i. multiple surface exposures can occur; ii. agglutination forms particles with mixed histories and possibly distinctive thermal release properties. Problem i. can be minimized by studying well-characterized samples with simple exposure histories. Becker and Clayton (4) have hypothesized that point ii. explains the observed release patterns of recently exposed bulk soil samples (similar to that in Figure 3) if agglutinates give up their old gas at preferentially higher temperatures than mineral fractions. In this case the release curves for bulk soils would be more complex than those of the ideal detector and they would fail to be diagnostic. However, this proposal remains to be tested by studying thermal release curves for mineral separates. The encouraging recent development of
LUNAR NITROGEN

Ray, J.

Static mass spectrometry for N will undoubtedly speed the resolution of this issue by permitting the analysis of smaller, better sorted samples (9). Meanwhile, in the absence of a flat release profile for a recently exposed sample, model type IIb must be regarded as the clear favorite.

That conclusion, however tentative, is nonetheless reassuring considering: 1. the improbability of large isotopic changes in the sun (5) which renders unlikely model type I; 2. the immense cosmogonic challenge presented by the model IIa hypothesis of indigenous lunar nitrogen of strikingly different composition from terrestrial despite the identical isotopic compositions of terrestrial and lunar oxygen.

References