ON THE STOICHIOMETRY OF METAL ABUNDANCES IN THE LUNAR ATMOSPHERE; B. C. Flynn and S. A. Stern, Southwest Research Institute, Boulder, Colorado.

We present preliminary results of an ongoing effort to determine to what degree metal abundances in the lunar atmosphere are stoichiometric (i.e., reflective of the lunar surface composition). From Apollo sample returns, we know that several species are more abundant at the lunar surface than either Na or K [1], which are the only atmospheric constituents to have been observed from Earth [2-5]. Production of the atmosphere by solar wind sputtering has been inferred from monitoring atmospheric brightness through lunar crossings of the Earth’s magnetotail [6]. Assuming solar wind sputtering is the dominant source of Na and K then, by simple stoichiometric arguments, one might expect that relatively abundant lunar surface constituents such as Si, Al, Ca, Mg, Fe, and Ti are more abundant in the lunar atmosphere than Na and K. Furthermore, observations of K [2] indicate that K production behaves stoichiometrically relative to Na.

Using the coudé spectrograph (at $\Delta \lambda \simeq 60,000$) of the 2.7 m reflector at the University of Texas McDonald Observatory, we searched for solar resonant scattering lines of Ca (4227 Å), Ti (5036 Å), and Li (6708 Å). We chose these species for our initial search because of their lunar surface abundances and their chemical similarity to Na and K. Atmospheric spectra were taken $\simeq 20''$ above the subsolar limb of the Moon near last quarter on 30 July 1994. We also obtained spectra of the lunar surface $\simeq 20''$ from the subsolar point for absolute calibration purposes.

A 10 min. exposure resulted in strong detections of kiloRayleigh-strength Na emission (5890 and 5896 Å). However, only upper limits were obtained for Ca (40 min.; <360 Rayleighs), Ti (13 min.; <120 Rayleighs), and Li (35 min.; <30 Rayleighs) (see Fig. 1). In the cases of Ca and Ti, these upper limits are more than an order of magnitude lower than the simple stoichiometric model predicts, whereas the Li upper limit is less constraining.

We interpret these results as indicating that the mechanism(s) that produce the lunar Na and K atmospheres may somehow favor those species over more or comparably abundant lunar surface species. We conclude that lunar atmospheric production is not entirely stoichiometric. This may be due to micrometeorite gardening, which can reduce the effective age of the surface so that sputtering yields do not approach stoichiometry [7]. In this case, the atmosphere may be dominated by volatiles. However, spectroscopic searches for other abundant lunar surface species such as Si, Al, and Mg should be conducted before a more firm conclusion may be drawn.

REFERENCES

On the Stoichiometry of Metal: Flynn and Stern

Column Abundances Relative to Na

Model-Data Comparison

Fig. 1. Upper panel: Upper limits on (open circles) and stoichiometric predictions of (filled circles) atmospheric abundances relative to Na. Note that K observed abundances agree with the stoichiometric model. Lower panel: Ratios of observed upper limit abundances to predicted abundances for each species.