

Ar ADSORPTION AND THE LUNAR ATMOSPHERE; T. J. Bernatowicz, F. A. Podosek and F. E. Kramer, McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130

A major constituent of the lunar atmosphere is  $^{40}\text{Ar}$ , originating from decay of  $^{40}\text{K}$  in the lunar interior. The lifetime of Ar exhaled from the moon is short, on the order of months, due to the interaction of solar radiation with the lunar atmosphere. Neutral Ar atoms effusing from the moon's surface are bound in ballistic trajectories, and on contact with the regolith may penetrate the lunar soil to finite depths by a random walk whose duration is controlled by the temperature and adsorptive properties of the regolith. Ar atoms in the atmosphere may be ionized by photoionization or charge exchange with the solar wind and accelerated by the solar wind electromagnetic field; about one half of the ions are implanted in the lunar surface with energies of  $\sim 1\text{KeV/nucleon}$ , while the rest escape [1]. The life history of an atmospheric Ar atom may thus be influenced by rather complex interactions with the lunar surface, gravitational field and radiation environment.

Direct measurement of the atmospheric  $^{40}\text{Ar}$  concentration and its temporal variations was made by the Apollo 17 mass spectrometer. The first variation is synodic, consisting in the gradual decrease of atmospheric  $^{40}\text{Ar}$  after lunar sunset, presumably due to enhanced adsorption on the cooling regolith. Concentrations are a minimum at midnight and exhibit an abrupt pre-sunrise increase due to influx of desorbed Ar from the approaching sunrise terminator. The other variation is a change in the absolute  $^{40}\text{Ar}$  amount (by as much as a factor of 2; ref. [2]) in the atmosphere, with an inferred 6-7 month periodicity. These latter variations may reflect changes in lunar seismicity or seasonal variations in shading of portions of the lunar surface [3]. Exospheric simulation models developed by Hodges [3], which incorporate theoretical modeling of the sorptive properties of the regolith, are capable of reproducing the observed synodic variations in atmospheric  $^{40}\text{Ar}$  but predict heats of adsorption of at least 6 kcal/mole. This value is rather large in comparison with results obtained by conventional techniques (1 to a few kcal/mole). It is possible that this difference is attributable to site-competition effects caused by atmospheric contamination which is not present in the more pristine lunar materials.

In the present experiment we address this possibility using the adsorption technique of Podosek et al. [4] which we have previously applied to Xe adsorption on terrestrial and lunar samples crushed in vacuum to minimize interference by atmospheric contamination [5]. In our protocol small fractions of a monolayer of gas are adsorbed (Henry's law regime) on newly created surface, a situation which presumably mimics the natural lunar environment. The principal data obtained by this technique are Henry constants which are related to desorption lifetimes in a manner essentially independent of any particular thermodynamic model. It is noteworthy that for the case of Xe [5], small fractions of the fresh lunar mineral surfaces exhibited remarkably large adsorption potentials ( $\sim 14$  kcal/mole). The figure depicts our preliminary Ar adsorption results for uncrushed terrestrial labradorite which has been exposed to air, but is untreated except for pre-analysis high vacuum exposure. Each datum is the result of equilibration at the indicated temperature for 16 hr, at  $P(\text{Ar}) \leq 1.6 \times 10^{-9}$  atm. The data were collected in two series, separated by a continued vacuum exposure interval of 2 weeks. The presence of at least two kinds of adsorption sites is indicated by the nonlinearity of the data. The simplest model compatible with both data sets is that the sample surface has more and less energetic fractions, whose associated adsorption

enthalpies are roughly 1 and 2.5 kcal/mole. We infer that the less energetic (more available) sites remained constant in amount throughout the experiment, but that between the first and second series site competition with active species was reduced on the more energetic sites, giving rise to enhanced Ar adsorption at lower temperatures. The dashed line shows the predicted temperature distribution of Henry constants. The model is seen to be in crude agreement with the elevated Henry constants observed for the higher ( $\geq 70^\circ\text{K}$ ) second series temperatures. Further experiments on vacuum crushed terrestrial labradorite and lunar rocks are in progress.

### References

- [1] Manka R. and Michel F. (1971), *Proc. 2nd Lunar Sci. Conf.*, 1717.
- [2] Hodges R. and Hoffman J. (1974), *Proc. 5th Lunar Sci. Conf.*, 2955.
- [3] Hodges R. (1980), *Proc. 11th Lunar Sci. Conf.*, 2463.
- [4] Podosek F. et al. (1981) *Geochimica* 45, 2401.
- [5] Bernatowicz T. et al. (1982), *Proc. 13th Lunar Sci. Conf.*, A465.

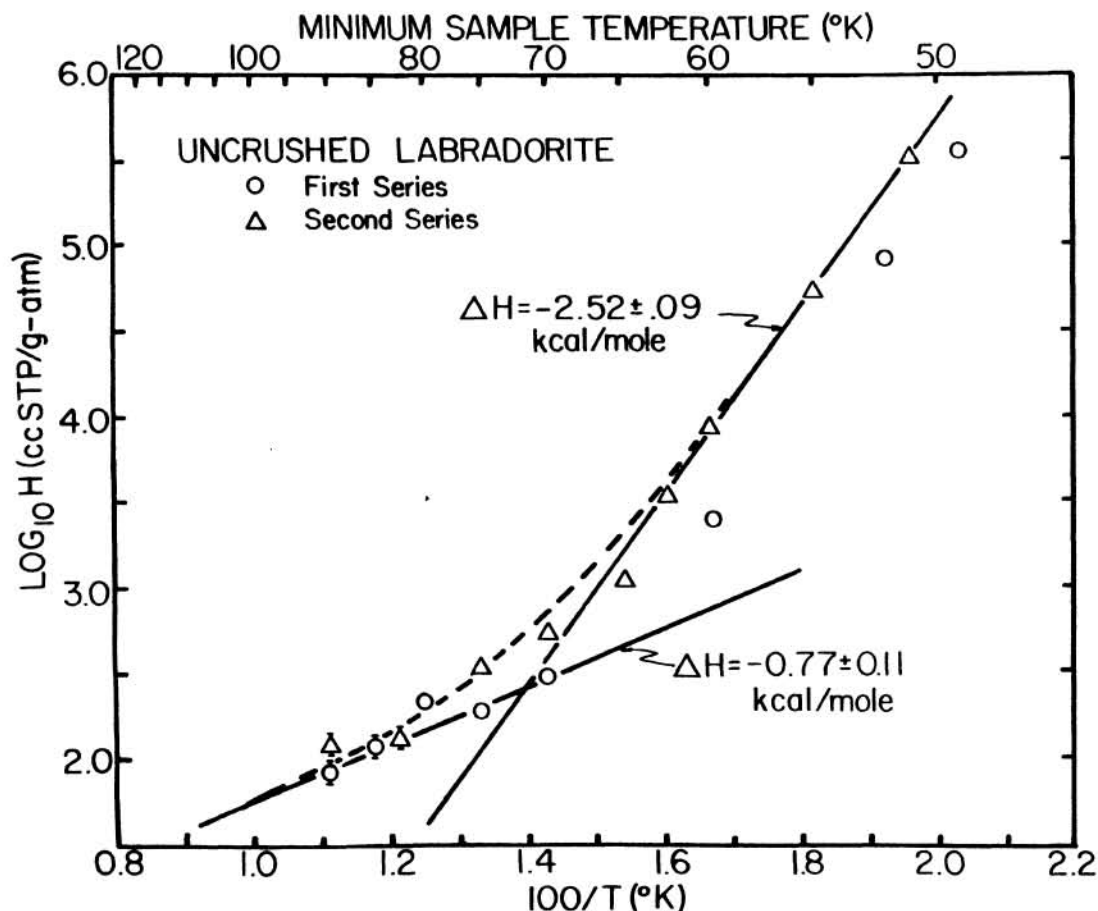


Figure 1: Temperature dependence of Henry constants for Ar adsorption on uncrushed terrestrial labradorite. See text for discussion.