

DE85 007948

ADSORPTION OF Hg ON LUNAR SAMPLES; G. W. Reed, Jr. and S. Jovanovic, Argonne National Laboratory, Argonne, IL 60439

Understanding the presence, migration mechanisms and trapping of indigenous gases and volatiles on the moon is the objective of this study. The rare gases Ar and Xe and highly volatile Hg⁰ and Br⁰ (and/or their compounds) have been determined to be present in the lunar regolith. Evidence for these elements in the moon was recently reviewed (1). Studies of the sorption behavior of Xe on lunar material have been carried out (2,3).

We report here preliminary results of a study designed to rationalize the behavior of Hg in lunar material. Pertinent existing data fall into two categories. 1. The activation energies for desorption of Hg, excess-Ar, and unsupported fissionogenic-Xe are all between 5 and 8 kcal/mole. In contrast to Ar and Xe, data for Hg span a temperature range from low ambient lunar daytime subsurface temperatures to temperatures of ~1200°C (1). A trapping and migration mechanism must explain this observation. 2. Hysteresis loops were observed in atomic absorption measurements of Hg desorption and sorption from lunar samples cycled between room temperature and temperatures up to 350°C (4). One of the possible explanations of this phenomenon was that the time (10 min.) allotted for attaining temperature equilibrium at each temperature step was too short to permit Hg present in grain boundaries, fissures and dislocations to escape. There is an extensive literature on hysteresis loops observed in physical adsorption of gases on porous solids.

Data obtained, so far, in the current study appear to support the probability that porosity may be the key factor in adsorption and retention of volatiles in lunar material. The experiments are designed to measure tracer Hg sorption on degassed samples and sorption rates at different equilibration temperatures. Tracer Hg sorption distribution is attained during equilibration-temperature runs at various durations. Subsequently linear heating release patterns and the energetics of desorption of the sorbed Hg are measured. In all experiments ~10⁻⁷-10⁻⁸ gm of Hg tracer is transferred to a manifold containing three previously degassed lunar samples. The manifold system (~20 ml volume) is inserted completely into an oven and samples are removed after various times. Exploratory experiments were conducted to determine the possible effect of degassing temperature on Hg sorption.

A test experiment on a terrestrial basalt established that sulfides could interfere if degassing is at low temperatures (~170°C). Two lunar samples degassed at 150°C and at 850°C and a terrestrial basalt degassed at 850°C were included in the experiment reported here. The manifold assemblage was held at 250°C for eight days to obtain more rapid equilibration than might be possible at ~130°C, the maximum lunar subsolar temperature. Details will be given. The fingers containing the samples were sealed off from the manifold, opened in a vacuum system and Hg was extracted in temperature steps from RT to 1200°C.

The results obtained, specifically pertinent to this study, are: 1. The Hg release patterns indicate that S²⁻ phases do not interfere with Hg sorption behavior in the lunar samples. Sulfides are removed from the terrestrial basalt by high temperature degassing. 2. The lunar sample degassed at 850°C contained ~3X more total Hg than the sample degassed at 150°C, Table 1. This was also the case for the Hg fractions released at each temperature step. The inference is that high temperature degassing

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empties more sites for Hg sorption. It is unlikely that Hg is merely surface adsorbed. 3. The adsorbed tracer Hg was released at each temperature step, all of which were for 1 hour except the 130°C step, Fig. 1. This means that some of the Hg has entered very retentive sites. 4. The protracted 130°C release provides further evidence for tracer Hg migration into relatively inaccessible sites. Heating at 130°C caused 70-80% of the sorbed Hg to be released, Fig. 1. This is typical behavior for Hg release from silicates and oxides equilibrated at low temperatures. The 130°C extraction was in two steps, one hour and 16 hours. The lunar sample degassed at 850°C released 69% of the total Hg at 130°C, of this, 60% was released during the first hour and 8.9% over the next 16 hours. The sample degassed at 150°C released 80% of the total sorbed Hg at 130°C; of this, 55% was released during the first hour and 26% over the next 16 hours. The Hg fraction released after the first hour can be thought of as approximating the amount that would have been released in an isothermal extraction at 130°C. In isothermal heating experiments, the fraction (F) released plotted as F² vs. time should give a straight line if the release is diffusion controlled. The slope of this line is proportional to D/a², where D is the diffusion coefficient and a² is the grain size. The latter is the same for both samples. The apparent steeper slope for the 150°C degassed sample indicates Hg diffusion at a greater rate than for the 850°C degassed sample.

In conclusion, our preliminary observation is that 850°C degassing caused more "adsorption" sites to become available while apparently not changing the nature of the sample. Thermal equilibration at 250°C with tracer Hg caused sites emptied by degassing to be filled. Subsequently, these sites were not emptied in one hour stepwise heating extraction steps until higher or melting temperatures were reached. These observations along with those previously noted (1,4) for Hg release in lunar samples suggest that microporosity may provide the sites for volatiles. The more detailed kinetic and isothermal and linear heating release data on degassed lunar samples equilibrated with tracer Hg at different temperatures will provide the framework for modeling of migration and trapping mechanisms of volatiles in/on the moon.

References: (1) Jovanovic, S. and Reed, Jr. G. W. (1982) Conf. on Planet. Volatile, p. 94-98. (2) Podosek, F. A. et al. (1981) Proc. Lunar Planet. Sci. Conf. 12th, p. 891-901. (3) Bernatowicz, T. et al. (1982), Proc. Lunar Planet. Sci. Conf. 13th, p. A465-A476. (4) Reed, G. W. et al. (1971) Science 172, 258-261. (This work has been sponsored by NASA.)

TABLE 1. Stepwise heating release of ²⁰³Hg tracer adsorbed on a degassed lunar soil and a terrestrial basalt sample.*

Exp. No.	Wt. (mg)	Sample	Degassed Temperature	²⁰³ Hg c/n/100 mg Sample				Total
				130°C	250°C	450°C	1200°C	
2	96	74261	130°C	26(12)*	5.7	3.9	1.9	47
2	145	74261	850°C	77(12)	18	20	3.0	130
1	178	EPR ba	170°C	0.38(0.39)	0.94	0.93	2.6	5.5
2	211	EPR ba	850°C	38(9.4)	16	3.1	1.3	67

* All one hour heating steps except 30 minutes at 1200°C and 16 hours second 130°C step (in parentheses).

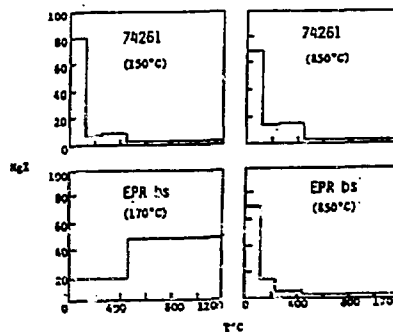


Figure 1. Hg release during stepwise heating of samples equilibrated at 250°C with tracer Hg. Samples are lunar soil 74261 and tholeiitic basalt (EPR ba). Prior to equilibration with Hg, samples were degassed at temperatures given in ().

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