

ADSORPTION AND EXCESS FISSION XENON II: Xe Adsorption on a Vacuum Crushed Mineral, Bernatowicz T., Honda M., Podosek F. and Kramer F., McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130 USA.

We have previously reported [1] the results of Xe adsorption studies on lunar soil 10084, conducted to examine whether adsorption might play an important role in producing the "excess fission Xe effect" in gas-rich highland breccias [2]. This effect is evidently a redistribution of ^{238}Pu -fission Xe from the lunar interior to the surfaces of lunar soil grains. Using a technique which employs a noble gas mass spectrometer as a partial pressure manometer, we obtained values for the Henry constants $H(T)$ for Xe adsorption by 10084 which were used to estimate the sorptive properties of lunar soil at characteristic regolith temperatures. We tentatively concluded that: (1) lunar soil is not a sufficiently good sorbent of Xe (by several orders of magnitude in H) to account for the effect, either by adsorption equilibrium with the transient atmosphere, or in a model where Xe is fixed while diffusing through the regolith; (2) adsorption can play an important role only in models which concentrate excess Xe in time or space -- conditions which contradict the ubiquity of the effect in gas-rich highland breccias. The major qualification to these conclusions is the possibility that lunar soil might be a much better adsorbent on the moon than is evident in the laboratory. One possible reason for this is that freshly created mineral surfaces may be very good sorbents until irreversibly poisoned by exposure to air. The present experiments are designed to investigate this possibility.

To assess the consequences of atmospheric exposure we have measured $H(T)$ for a single crystal of (terrestrial) labradorite after each of four sequential processing steps: (1) fracture into 1cm chips (in air), (2) crushing in high vacuum (10^{-7} torr), (3) exposure to air for several days, and (4) heating for one day at 370°C in vacuum. The data are shown in Fig. 1; the lines are fits to a statistical mechanical model $H(T) = cT^{3/2} e^{-\Delta E/RT}$, where ΔE is the adsorption potential and c is a constant proportional to the surface area of the sorbent [1,3]. Vacuum crushing of the labradorite results in an order of magnitude increase in $H(T)$ in the temperature range of observation, as well as an increase in ΔE from about 5 to 7 kcal/mole. Presumably, this effect is due to the creation of surfaces with greater binding energy which dominate adsorptive behavior in this range. Exposure of the newly created surfaces to air decreases $H(T)$ in the experimental range but not back to the original value and without appreciable decrease in ΔE . Subsequent vacuum heating of the sample not only reverses the effect of air-exposure but results in a substantially higher $H(T)$ (Fig. 1) (possibly because occluded gases released during crushing were sorbed on the fresh surfaces).

In Fig. 2 we compare our experimental results for 10084 and labradorite. Both samples exhibit a ~ 2 kcal/mole increase in ΔE with heating to 370°C , but the crushed/heated labradorite is not a strikingly better sorbent than the heated lunar sample. Figure 3 illustrates the extrapolation of the 10084 data to regolith temperatures (minimum persistent temperature 260°K). The crescent indicates the Henry constant which would be needed if adsorption were to account for the excess fission Xe effect by limiting the speed of diffusion of Xe through the regolith after emanation from the interior [1]. Comparison of Figs. 1-3 indicates that while exposure to air does indeed decrease the efficiency of adsorption, the effect is not large enough to account for a five-order-of-magnitude difference at the relevant temperature, and moreover that the effects of air exposure are not necessarily irreversible. Our results thus do not support the hypothesis questioned: that lunar soil is an enormously better sorbent on the moon than in the laboratory because of poisoning by air.

If values of ΔE for in situ lunar regolith are close to our measured values (5-7 kcal/mole), impossibly high specific areas ($\sim 10^8 \text{ cm}^2/\text{g}$) are required for adsorption to account for the excess fission Xe effect; conversely, if realistic areas ($\sim 10^1 - 10^4 \text{ cm}^2/\text{g}$) are used, high adsorption potentials (12-15 kcal/mole) are required. While we cannot totally eliminate the possibility that a small amount of surface with such high energy was present but not observed in either 10084 or labradorite because of site competition effects, there is no reason to postulate its existence. Assuming that the maximum mean residence time of Xe in the lunar regolith is no more than that of Rn (87 days; [4]), the corresponding maximum adsorption potential is 6.4 kcal/mole for the regolith, a value which is compatible with our experimental results. Furthermore, our experiments yield no evidence for the irreversibility (chemisorption) which would characterize extremely high adsorption potentials. Thus, independently of details in the quantitative interpretation of the adsorption phenomena, we again conclude that adsorption is an inadequate mechanism to account for the presence of excess fission Xe in lunar samples.

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REFERENCES: [1] Podosek F. *et al.* (1982) *PLPSC* 12th (in press). [2] Bernatowicz T. *et al.* (1978) *PLPSC* 9th, 1571-1597. [3] Podosek F. *et al.* (1982) *Geochim. Cosmochim. Acta* (in press). [4] Hodges R. (1977) *Phys. Earth Planet. Int.* 14, 282-283.

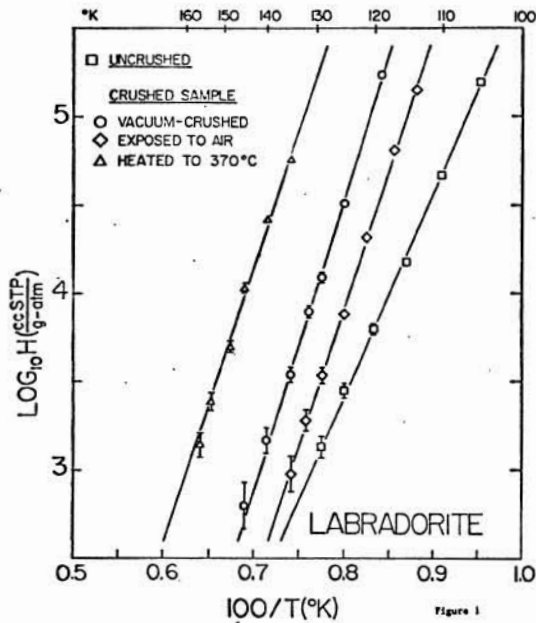


Figure 1

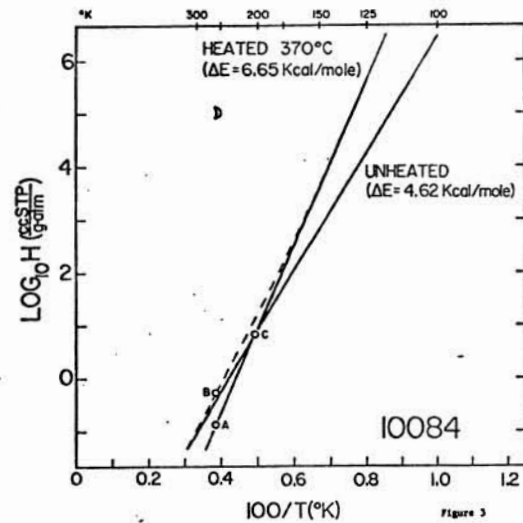


Figure 3

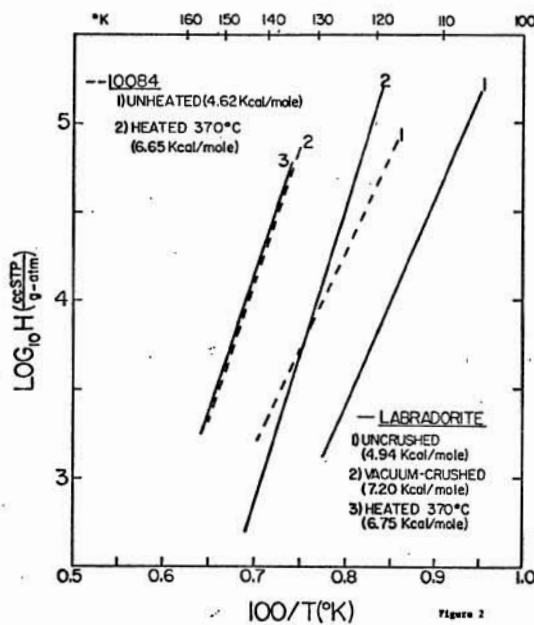


Figure 2

Fig. 1 Experimental data for Xe adsorption (Henry constants) on terrestrial labradorite. The lines are fits to the functional form $H(T) = \text{constant} \times T^{-3/2} \exp(\Delta E/RT)$.

Fig. 2 Comparison of Xe adsorption parameters for labradorite (Fig. 1) and lunar soil 10084 [1]. The extent of the lines is the experimental range.

Fig. 3 Extrapolation of Xe adsorption parameters for 10084 [1]. The dashed line is a more realistic extrapolation of the data for the heated sample which is based on surfaces of two different adsorption energies. The crescent at $H=10^3$ for regolith temperature 260°K marks the level at which adsorption can be invoked as a plausible mechanism for the excess fission Xe effect [1].