The boundary conditions for alkali Exospheres around Mercury and the Moon

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Goal: Provide context for understanding observations from LADEE, MESSENGER and ground-based telescopes by determining the lifetime of Na and K in a porous soil.

Approach: Quantify the competition between desorption and diffusion within the top 1 mm of the soil, which supports the exosphere reservoir, with a Monte Carlo model of desorption and diffusion in regolith beds simulated from a sphere packing code.

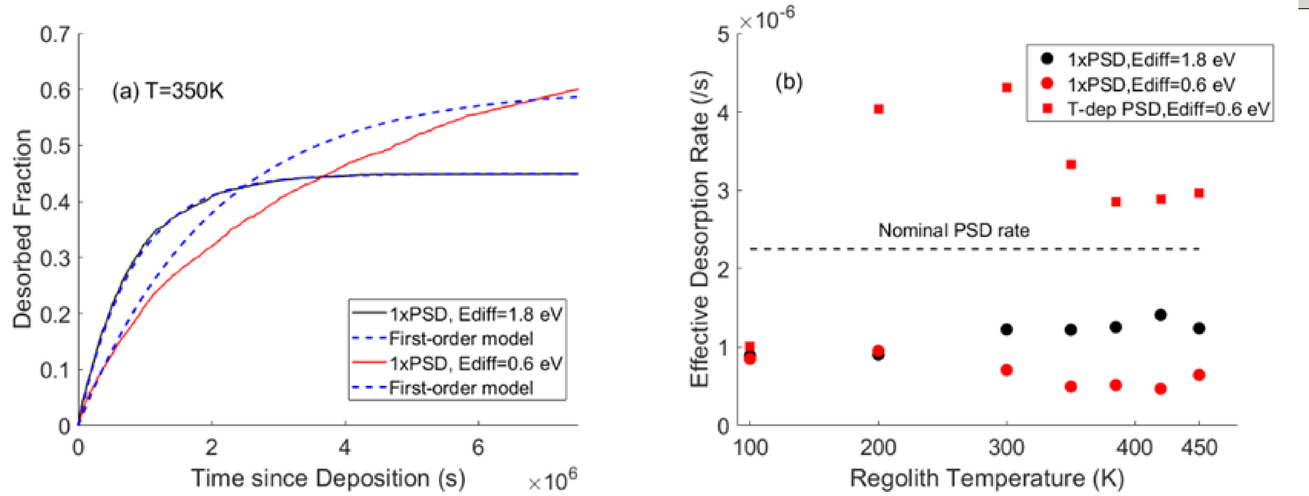

Figure 1: The fate of a Na/K adsorbate depends on adsorbate mobility.
(a) Desorbed fraction as a function of time from simulated soil kept at T=350 K with reduced (Ediff = 1.8 eV) and increased (Ediff=0.6 eV) mobility;
(b) Effective photon-stimulated desorption (PSD) rate as a function of temperature for constant and temperature-dependent PSD yield.

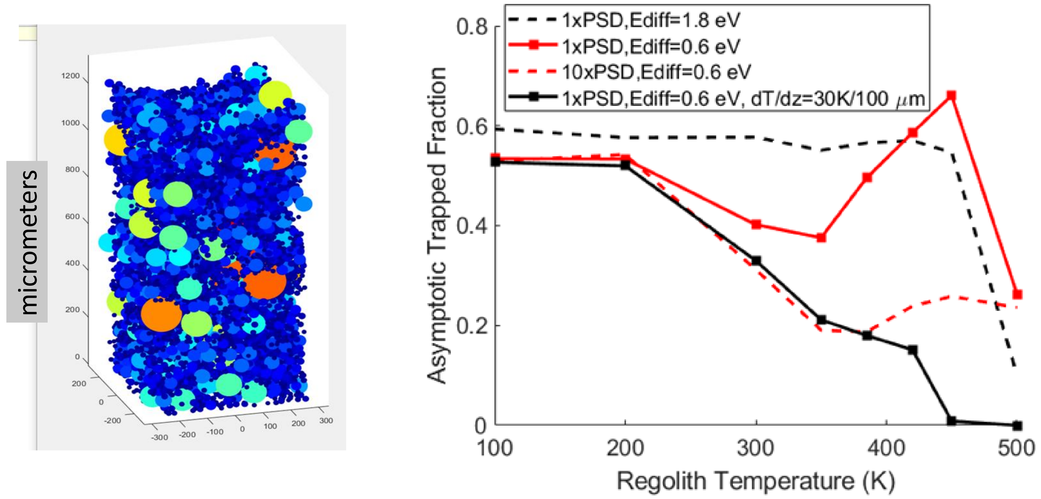

Figure 2: The surface microstructure (left) traps a measurable fraction of deposited adsorbates at lunar temperatures. The trapped fraction reduces when adsorbed atoms are mobile (Ediff=0.6 eV, red lines), especially when temperature gradients with depth are considered (squares with black line).

CONCLUSIONS

- At lunar temperatures microphysical shadows trap one-fifth to two-thirds of recycled adsorbates, depending on the assumed adsorbate mobility, photodesorption cross section, and soil thermal gradient.
- A transition from a retentive surface to full outgassing at T>500K will produce complex feedback mechanisms of alkali circulation at Mercury.

IMPLICATIONS

- Either lunar alkali gases are short-lived (1-3 bounces) by getting stuck to the underside of grains, OR
- Lunar alkali atoms could be long-lived (repeated bounces till ionization) but at reduced (diffusion-limited) desorption rate