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The Search for a Solar Record in Lunar Paleoregoliths through Numerical Modeling and Analogous Experiments

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We have performed numerical modeling to simulate the heat transfer from a lunar lava flow into the underlying regolith in an effort to understand the survival potential of extra-lunar particles embedded in paleoregoliths. Regolith samples collected at the lunar surface were brought back during the Apollo missions. These samples contained solar wind, solar flare, and galactic cosmic ray particles but scientists were unable to determine the history of extracted particles because of uncertainty in exposure age and over-saturation of particles due to continued exposure at the lunar surface. Regolith deposits that have been covered by a lava flow would be protected from further bombardment and the lava will provide samples for isotopic dating, revealing the exposure age of the deposit. However, the lava will heat the regolith, volatilizing the extra-lunar particles and destroying the record of solar history. We have created a numerical model to constrain the depths to which a lunar lava flow will bake volatiles out of the underlying regolith. To verify our numerical results we have begun a series of experiments both in the laboratory and in the field at Kilauea Volcano, Hawaii. Our field experiment consists of a 20x20x10 cm box filled with lunar regolith simulant (GSC-1). The boxes are embedded with thermocouples at fixed depths and placed in the path of an active lava flow. We then monitor the temperature change within the regolith simulant as the box is overrun by lava. Surface heat loss and flow lobe morphology are monitored by thermal and stereo cameras. Preliminary trials in the active flow fields at Kilauea have proved the validity of our experimental concept. We will return in early 2011 to continue tests with our device. We are also developing a set of complementary laboratory experiments using a similar device and remelted basalt as a flow analog. These experiments will provide a controlled measurement of thermal conduction within the regolith simulant. The experimental measurements will be compared to computational results to verify the numerical model. Application of the verified numerical model to the lunar environment will allow us to accurately predict the depths to which regolith-implanted volatiles will be released beneath a lava flow. We can then compare inferences from the simulations to estimated lava flow thicknesses and ages at specific locations on the Moon to determine the likelihood of preservation implanted volatiles. Recommendations will be made for exploration of these sites during future manned missions to the Moon.