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LUNAR PALAEOREGOLITH DEPOSITS AS PRIORITY SCIENTIFIC TARGETS FOR FUTURE EXPLORATION: DECIPHERING THE HISTORY OF THE SPACE ENVIRONMENT OF THE INNER SOLAR SYSTEM AND ITS RELEVANCE TO THE ORIGIN AND EVOLUTION OF LIFE ON EARTH

Abstract

One of the principal scientific reasons for wanting to resume in situ exploration of the lunar surface is to access the record it contains of early Solar System history. Studies of Apollo samples have revealed that solar wind particles are efficiently implanted in the lunar regolith, which therefore contains a record of the composition and evolution of the Sun throughout solar system history. Recently, samples of the Earth's early atmosphere appear to have been retrieved from lunar regolith samples, and it has been suggested that samples of Earth's early crust may also be preserved there in the form of terrestrial meteorites. In addition, the lunar regolith may contain a record of galactic events, by preserving the signatures of ancient galactic cosmic ray (GCR) fluxes, and the possible accumulation of interstellar dust particles during passages of the Sun through dense interstellar clouds. Collectively, these lunar geological records would provide a window into the early evolution of the Sun and Earth, and of the changing galactic environment of the Solar System, that is unlikely to be obtained in any other way. Much of this record has clear astrobiological implications, as it relates to the conditions under which life first arose and evolved on Earth. We argue that this record will be best preserved in ancient, buried regolith (i.e. 'palaeoregolith') deposits, and that locating and sampling such deposits would be an important objective of future lunar exploration activities.

Locating and accessing this potentially rich geological archive of solar system history will require an exploration architecture comprising the following elements: (i) The ability to conduct 'sortie-class' expeditions to areas containing many inter-bedded lava flows (e.g. Oceanus Procellarum and the large near-side mare basins); (ii) Provision of surface mobility with a range of at least 100 km (ideally provided by a pressurized rover); (iii) The means to detect and sample palaeoregolith deposits (for detection, ground penetrating radar may be a suitable technique; for access, unless suitable outcrops can be located, provision of a drilling capability to c. 100m depths may be required; and (iv) Provision of adequate sample collection and return capacity (roughly estimated at several hundred kg per sortie). These mission requirements are compatible with those proposed under the umbrella of the recently developed ISECG Global Exploration Roadmap, and a greatly improved understanding of the early history of the solar system would therefore be a key scientific benefit of implementing this Roadmap.