OPPORTUNITIES FOR LUNAR AND SOLAR SYSTEM SCIENCE THROUGH SAMPLING & ANALYSIS OF THE LUNAR REGOLITH.

OPPORTUNITIES FOR LUNAR AND SOLAR SYSTEM SCIENCE THROUGH SAMPLING & ANALYSIS OF THE LUNAR REGOLITH. K. H. Joy[1] [1]Department of Earth and Environmental Sciences, The University of Manchester, Manchester, UK (Katherine.joy@manchester.ac.uk)

Introduction: The Moon's surface is covered by a soil-like structure termed the lunar regolith. It was generated over Myr to Gyr years by continual impact resurfacing, micrometeorite bombardment, and interact ion with high energy solar and cosmic-ray particles. The rate of regolith formation at different points in the Moon's past is debated, but it is likely dominated by large-scale basin ejecta deep megaregolith turnover during an early phase of high bombardment (>3.7 Ga) [1], compared with more surficial regolith formation (1ry and 2ry crater ejecta and micrometeorite bombardment) recent (<3.5 Ga) processes [2].

The lunar regolith comprises comminuted micron to metre-scale fragments of lunar bedrock (mineral and lithic rock component), along with fragments of impactites, impactor debris, and glass-rich structures such as agglutinates [3]. It has previously been sampled directly by the six Apollo and three Luna missions as scoop, trench, drive tube, and deep-core (2-3 m depth) samples, and in regolith breccias (ancient fused soils) found at the Apollo landing sites [1] and that have been ejected off the Moon as lunar meteorites [4-5].

Analytical approaches: It is important to understand existing the physical properties and mineralogy/chemistry of lunar regolith samples. This is executed in various ways including non-destructive methods such as preparation of geological thin sections/polished blocks (see also new particle 3-d analysis approaches [6]) or spectral analysis. Alternatively, destructive analysis might involve geotechnical, geochemical or chronological analysis of bulk samples or individual regolith lithic or mineral fragments. Often regolith samples are sieved into representative grain sizes prior to analytical investigation.

Scientific importance: The lunar regolith provides a record of the Moon's geological history and its interaction with the dynamic inner Solar System space environment [7]. This archive is important for our understanding of the evolution of both the Moon and terrestrial planets, including the Earth [7].

Lunar science: Geological processes: The petrography, chemical budgets and crystallization ages of basaltic and magmatic rocks and minerals provide insights to the volcanic and magmatic evolution of the Moon. Coupling knowledge of sample age to crater counting model ages of the collection sites enables better calibration of the lunar impact cratering curve and our understanding of the Moon's impact bombardment history [1,7]. Regolith evolution: Volatile element, noble gas geochemistry/radionuclide, and fission track analysis (especially if conducted within a stratigraphic core sample) can help to understand airless body regolith evolution (gardening, space environment interaction: maturation processes) and past impact mixing processes [3].

Solar System science: Impactor records: Petrological, geochemical and isotopic sample data provides evidence of the parent-bodies of impactors [8]. Constraining the temporal flux of such impactor delivery helps to understand the timing of impact bombardment, informing models of the Solar System's dynamical environment and transfer of volatiles [8]. Solar and galactic records: The isotopic fingerprint of present and past interactions with the solar wind and galactic cosmic rays is potentially preserved within present day and ancient palaeoregoliths, helping to investigate astrophysical scale processes [9].

Exploration: Human health hazard assessment: Humans to the Moon will involve traversing and operating on the lunar surface. The small, angular, particle size, and active surface of regolith has been shown to be a potential toxicity hazard [10]. Understanding the diversity of the physical properties of regolith across different potential landing sites (notably young immature regolith), will help develop our knowledge of the risks to human health. Resource potential: Characterization of new regolith sites offer opportunities to assess resource potential across the Moon and develop strategies for beneficiation, manufacturing and *in situ* resource utilization in support of exploration architectures [11].

Chang'e 5 mission regolith sampling: Regolith will be collected by the upcoming Chang'e 5 mission to the Mons Rümker region of northern Oceanus Procellarum. Investigation of small-sized regolith samples (including individual fragments/mineral grains) working through a planned analysis chain of analytical techniques to maximize complementary analysis provide an opportunity to address key scientific questions [7].

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