

THE EFFECTS OF IMPACT PROCESSING ON LUNAR VOLATILE ELEMENT ISOTOPE GEOCHEMISTRY OF APOLLO 17 SOILS A.M. Gargano¹, J.I. Simon², and J.M.D. Day¹ ¹Scripps Isotope Geochemistry Lab, Scripps Institution of Oceanography, UCSD, La Jolla, CA, 92037, USA (amgargano@ucsd.edu), ²Center for Isotope Cosmochemistry and Geochronology, ARES, NASA JSC, Houston, TX 77058, USA.

Overview: Lunar materials are commonly characterized by extensive volatile depletions, and wide-ranges in volatile-element stable isotope compositions reflective of a prolific devolatilization history. A particularly complex 'lithology' is lunar regolith, and components thereof, which reflect a myriad of geochemical processes through an evidently disturbed chronology [1]. Through repeated impact processing encompassing fracturing, melting, evaporation, condensation, and deposition - the geochemistry of lunar soils and their individual components are intimately associated with the geochemical evolution of planetary bodies and their surfaces.

These processes likely culminate in both volatile-depletions, and volatile-enrichments; yet their overall contribution to Moon's volatile history remains poorly resolved. A goal of this work is to build upon the collective understanding of the lunar science community to work towards deconvolving the contribution of impact processes on the primary volatile element isotope geochemistry of lunar materials.

Given the complexity involved in deconstructing the post-primary-formation processing of lunar materials, we explicitly state several foundational observations:

1. Lunar soils are comprised of local reservoirs that are physically & chemically processed by comminution - ultimately culminating in agglutinate formation from the finest fraction [2].

2. Volatile elements are generally concentrated in the finest soil fractions relating to surface area/volume effects during maturation [3], and many components in lunar soils are covered by condensates [4] which are readily removed by water leaches [5].

3. Soil maturation results in the incomplete transfer of volatiles from exterior (i.e., leachable condensates) to interior (i.e., glasses, agglutinates) reservoirs [6] relating to significant mass-loss from the Moon-system driven by surface processing.

A comparative example: We compare the adjacent Apollo 17 dominantly volcanic soil samples 74220 and 74241 as examples of how to better understand the volatile element geochemistry of the bulk-lunar soil reservoir. Thode and Rees [3] measured bulk 74220 soils finding increasing S contents from 190 to 900 ug/g and decreasing $\delta^{34}\text{S}$ values from +1.9 to 0‰ with decreasing grain size. In contrast, the adjacent soil 74241 was measured to contain 940 to 1300 ug/g S increasing with decreasing grain size - yet with significantly increasing $\delta^{34}\text{S}$ values from 2.5 to 8.0‰. It is critical to note that 74220 is comprised nearly entirely

of orange and black glasses (~65 and 30%, respectively) whereas 74241 contains basaltic fragments (30%), brown, clear, and gray glasses (~20%), and breccias (~15%) [7]. Several inferences can be made by this comparison:

1. The evaporative processes driving increases in S contents and $\delta^{34}\text{S}$ values in 74241 were insufficiently pervasive to overprint the adjacent & comparatively S-poor 74220 with high $\delta^{34}\text{S}$ -bearing vapors.

2. Assuming that the decreasing grain size fractions of the 74220 glasses were driven by soil comminution processes - the evaporative effects of soil maturation is evidently dependent on target materials (i.e., maturation of 74241 resulted in distinct evaporative trends when compared to 74220).

3. Assuming agglutinate formation results in significant modification (as indicated by the abundance of nanophase Fe in mature soils) possibly associated with evaporation, the presence of fine-fraction material during comminution may result in more extensive and/or distinct isotopic fractionation regimes of lunar regolith.

A constructive outlook: Lunar soils represent a unique and abundant sample suite for studying surface processing on primitive planetary bodies. We are in the process of identifying 'type-specimen' samples which depict the range of surface processes on individual soil components. We will use this information to guide the examination of the volatile element geochemistry of the ANGSA drive core by broadly characterizing inter-element and isotopic relationships of its individual components utilizing halogens, alkalis, and volatile metals. The Apollo 17-ANGSA workshop provides a unique opportunity to carry out this exercise aided by the knowledge of the previous generation of lunar scientists. We look forward to sharing our progress and refining sample selections in the goal of better elucidating the cryptic volatile-element processing of the lunar regolith.

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