THE NEED TO CLASSIFY MOON SOILS: PROPOSAL FOR A FIRST STEP FOR PLANETARY PEDOLOGY

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CONTEXT

The Industrial Revolution during the 19th spurred the development of standards and methodologies in the search of mineral resources. Likewise, the first step in space resources utilization is the identification and assessment of the distribution, composition, and quantity of extra-terrestrial material, i.e. the mapping of the so-called regolith or real soil [1].

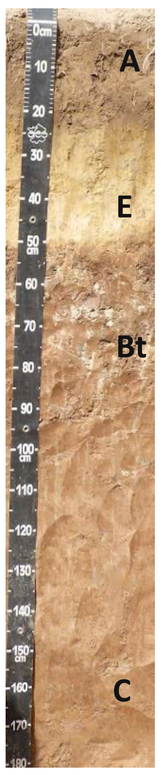
The creation of a lunar resource cartography requires to agree on a **standardized language to communicate** about the different soil layers or "horizons" of the upper regolith. This consensus is a prerequisite to ensure effective communication, accurate interpretation, proper classification and reliable mapping of the lunar soils.

This proposal provides a starting point for discussions among lunar scientists and soil scientists to establish a foundation for Moon Soil Sciences Mapping methods in the context of space resources.

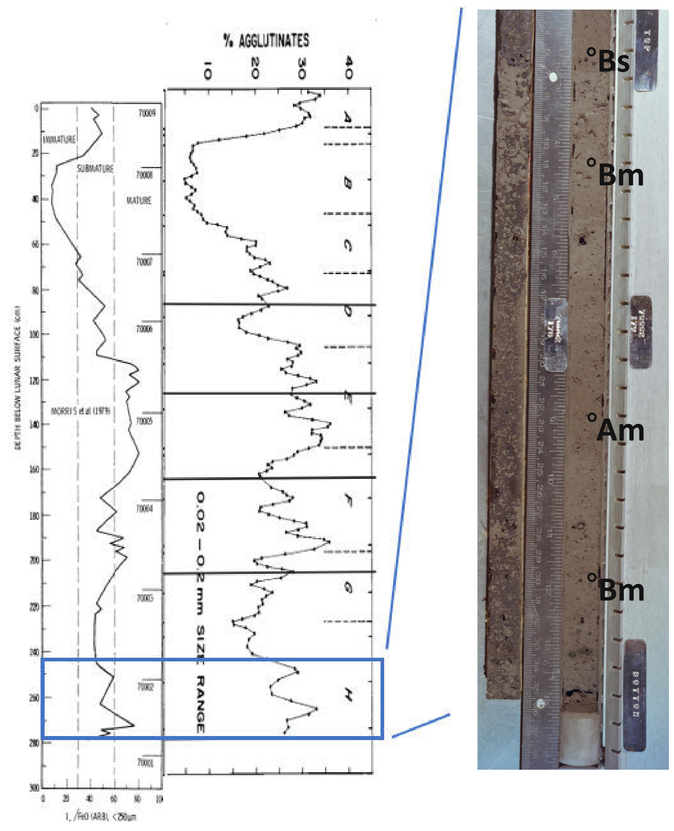
EARTH EXPERIENCE

Terrestrial pedologists have developed an international nomenclature of soil horizons based on interpretive symbols, which link soil description to properties and/or genesis of the layers [2]. This system facilitated the parallel development of pedological classification and soil mapping in the 20th century, allowing for systematic interpretation of soil properties and genesis.

For example, the World Reference Base for Soil Resources International soil classification system uses capital letters (master symbol), often followed by one or more lowercase letters (suffixes) to label soil horizons [2].



Earth soil with the labelled master horizons



Apollo 17 Moon soil core 70002 with the labelled reference horizons according to maturity index [4] (left) and agglutinates content (right) [5].
Image Source: Lunar Planetary Institute

PROPOSAL FOR THE MOON

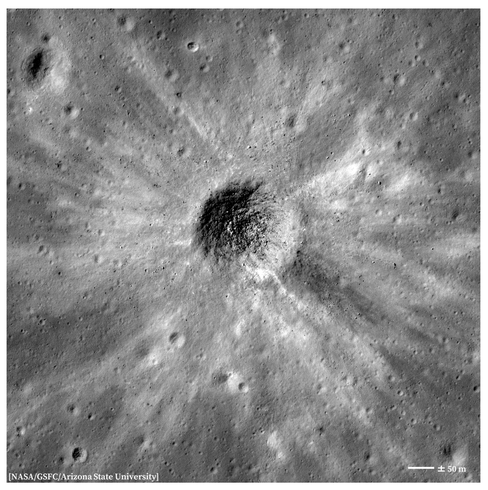
We propose to use a combination of the Is/FeO maturity index of Morris [3] **(*i.e.*, the amount of single-domain and nanophase Fe^0 (Is) normalized for total FeO content), and the agglutinate content to differentiate soil reference horizons, as these variables reflect the surface exposure time of lunar soils to weathering.**

In addition, we suggest using a labelling system inspired by Earth's pedology concept but adapted to the Moon context. To avoid confusion with terrestrial soils horizons, we have chosen to use the degree symbol ° (Unicode U+00B0) as a prefix to the master horizon designation. **We have defined 4 master horizons (°A,°B, °C, °D)** based on the agglutinates content, and these, combined with the Is/ FeO maturity index, allow us to define 12 reference soil horizons (see Table below). **We suggest naming the °A horizon the Agglutinic Master Horizon, as it has the highest content of agglutinates.**

Finally, we recommend integrating rock fragment cover, texture and other important features for in-situ resource utilization (ISRU) as diagnostic properties.

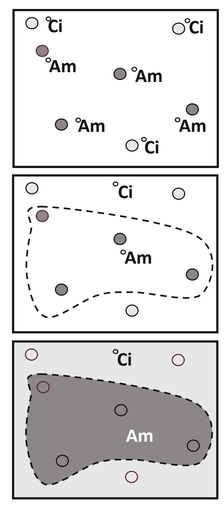
Agglutinates (%)	Master Horizon	Is/Fe (%)	Reference Horizons	Comments
> 30	°A	> 60	°Am	Mature °A
		30 - 60	°As	Submature °A
		< 30	°Ai	Immature °A
15 - 30	°B	> 60	°Bm	Mature °B
		30 - 60	°Bs	Submature °B
		< 30	°Bi	Immature °B
5 - 15	°C	> 60	°Cm	Mature °C
		30 - 60	°Cs	Submature °C
		< 30	°Ci	Immature °C
< 15	°D	> 60	°Dm	Mature °D
		30 – 60	°Ds	Submature °D
		< 30	°Di	Immature °D

APPLICATION IN SOIL MAPPING



Remote-sensing data of the zone of interest

Soil sampling and reference horizons identification in cores



Identification of the mapping unit based on the upper reference horizons

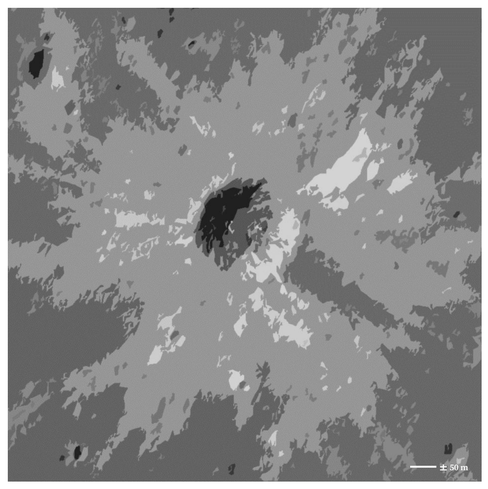


Illustration of what a soil map of the Moon surface can be (not real data)

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