The Spectral Characteristics of Lunar Agglutinates

Chanud N. Yasanayake[1], Brett W. Denevi[1], Bradley L. Jolliff[2], Samuel J. Lawrence[3], Rebecca R. Ghent[4,5]

[1]Johns Hopkins University Applied Physics Laboratory, [2]Washington University in St. Louis, [3]NASA Johnson Space Center, [4]University of Toronto, [5]Planetary Science Institute, (chanud.yasanayake@jhuapl.edu)

Abstract # 2159

Highlights:

- We are separating agglutinates from six Apollo soil samples.
- We will characterize the agglutinates' spectral properties and examine their rates of formation.
- These results will provide insight into the rates of the space weathering processes that produce agglutinates.

Background/Motivation:

The lunar surface is a dynamic environment, slowly but constantly evolving due to space weathering processes. We know the two dominant weathering processes are micrometeoroid bombardment and solar wind sputtering, but there is no consensus on their relative roles and rates of weathering. To better understand these processes we can look to agglutinates: irregularly shaped, vesicular grains of soil that are a product of these weathering processes and are a major component of heavily weathered soils (Figure 1a).

By characterizing the spectral properties of agglutinates we can better model agglutinate reflectance spectra, which we can use to find agglutinate formation rates at various locations across the lunar surface. These formation rates will in turn provide insight into rates of space weathering processes.

Question 1:

How do soil composition and maturity affect agglutinate reflectance spectra?

The only documented agglutinate spectra are from a single Apollo 11 soil sample (mature, high-Ti mare basalt) (Figure 1b) [1, 2]. To get a comprehensive understanding of agglutinate spectral properties, we will gather spectra from several samples of varied composition and maturity (Figure 2).

Resolved Hapke parameter maps of the lunar surface have also suggested that the highlands and maria have different forward- and back-scattering properties, possibly due to agglutinates [3]. To test this hypothesis, we will gather highland and maria agglutinate spectra at multiple geometries of incidence and emission angles.

Question 2:

What is the rate of formation of agglutinates?

We will initially determine agglutinate formation rate by modeling agglutinate abundance at lunar craters of various ages, but of similar composition and all at lower latitudes (±40°).

Recent work suggests that the latitude-dependent solar wind *flux*, rather than the total accumulated dose, is a key factor in determining soil maturity [4]. Therefore we will also look for anomalies in agglutinate abundance at higher latitudes and within lunar swirls (where solar wind flux is thought to be attenuated [e.g., 5]) to examine how solar wind flux affects agglutinate formation rate.

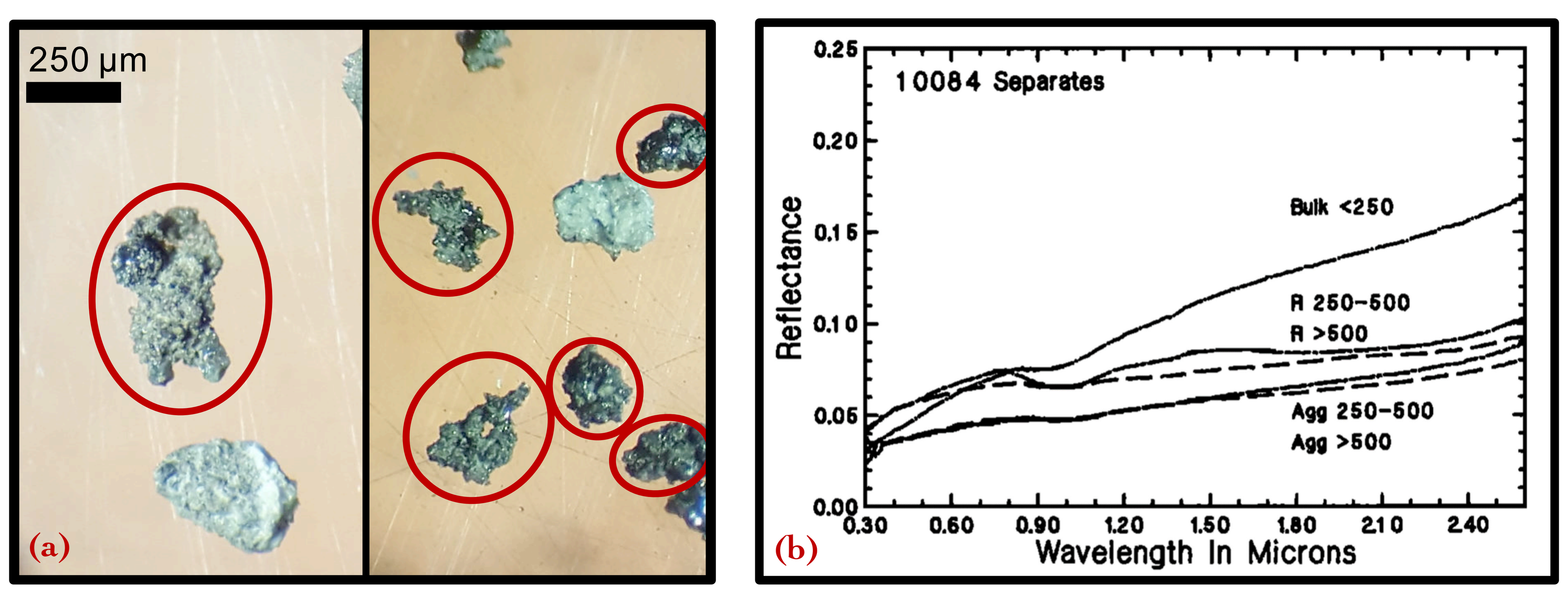


Figure 1: (a) Grains from the 125-250 µm size fraction of Apollo sample 14259, with agglutinates circled. **(b)** Reflectance spectra of Apollo 11 soil 10084 from [2]. The spectra are for three size fractions (<250 µm, 250 –500 µm, > 500 µm) and for the agglutinates (Agg), the remnant soil after picking out agglutinates (R), and the bulk soil. Pieters et al. note that the agglutinates are darker than the bulk soil and have a weaker 1 µm absorption band than the remnant soil of the same size fraction [2].

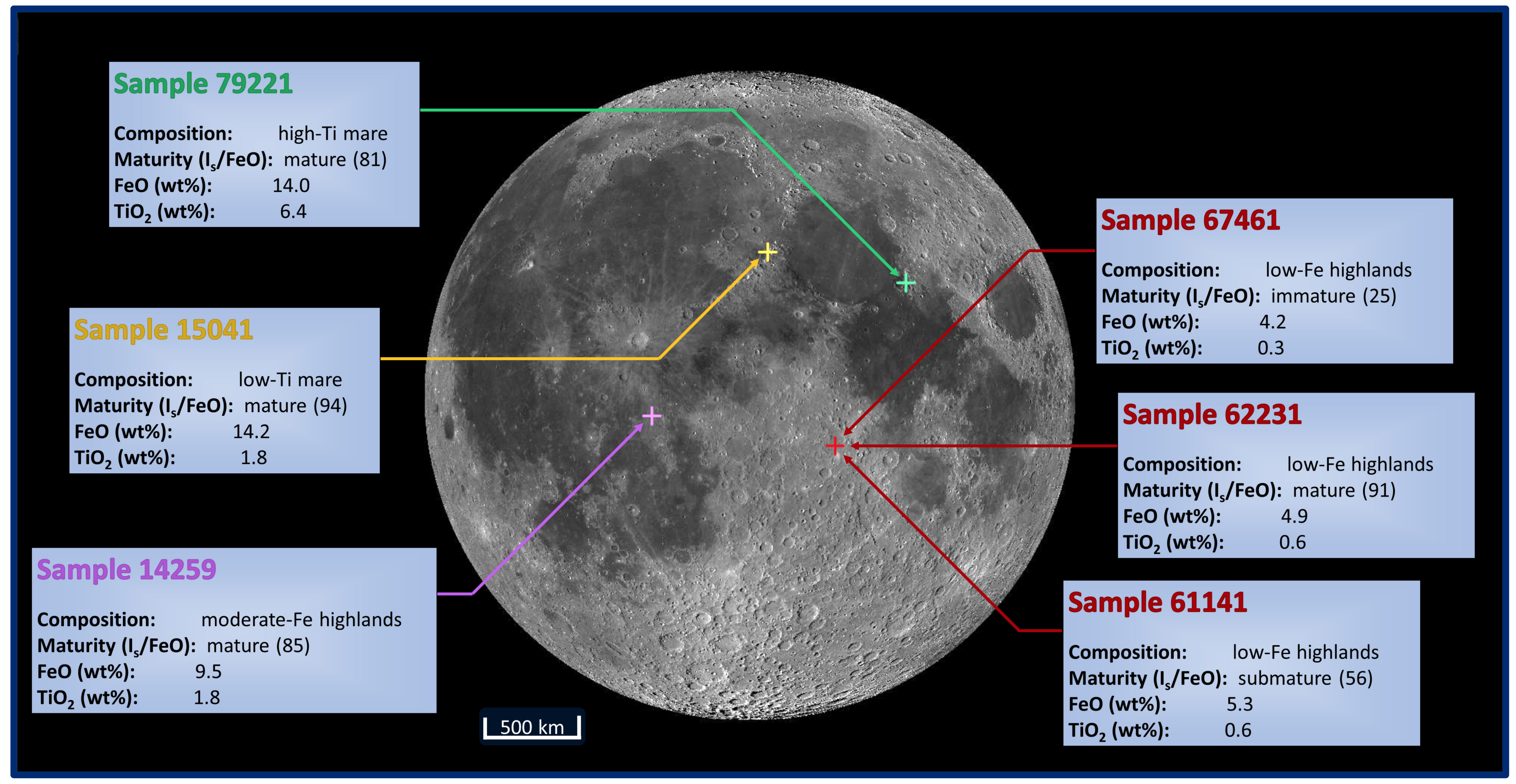
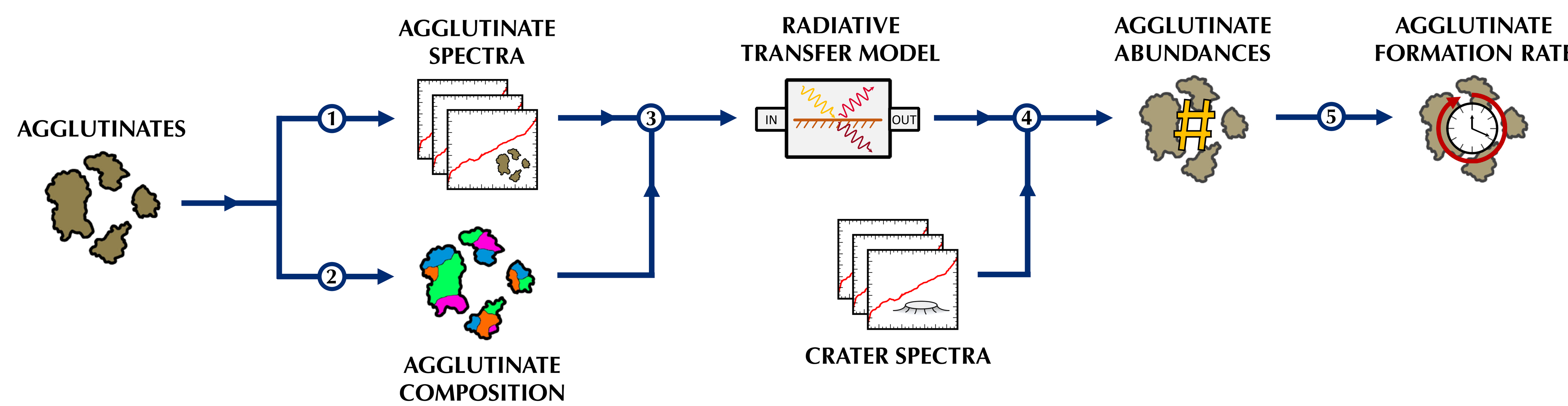


Figure 2: A map of the sites from which the six lunar samples were collected (map and site locations from [6], sample information from [7, 8, 9]). Samples are from Apollo 17 (79221), Apollo 15 (15041), Apollo 14 (14259), and Apollo 16 (67461, 62231, 61141). These samples were chosen because they show varied composition and maturity and have also been extensively characterized in terms of mineralogy, chemistry, maturity, and spectral properties by previous studies [7, 8, 9, 10, 11].

Methods:



1. Gather agglutinate reflectance spectra
The spectra will be (a) ultraviolet to near-infrared (0.3 – 2.55 µm) at multiple geometries (incidence at 5° to 70°, emission at -70° to 60°) and (b) infrared (2 – 25 µm) at a fixed geometry [12].

2. Determine agglutinate composition
Electron microprobe analysis of agglutinate grain mounts will yield the elemental composition of the agglutinates' glass and mineral fragments.

3. Incorporate agglutinates into radiative transfer model
This requires agglutinate single scattering albedo, and we will test whether this is better derived from (a) reflectance spectra at multiple geometries or (b) optical constants of agglutinates' individual mineral and glass components [13].

4. Model agglutinate abundances from crater spectra
Using the radiative transfer model that now incorporates agglutinates, we will model reflectance spectra of lunar crater ejecta of differing maturity. This will yield the agglutinate abundance at each crater.

5. Determine agglutinate formation rates based on crater age
We can estimate crater absolute age based on rock abundance in crater ejecta [14]. By comparing crater ages to agglutinate abundances, we can estimate agglutinate formation rate.

References/Acknowledgements:

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