# THE SHOCKING GROUND TRUTH OF LUNAR SAMPLES.

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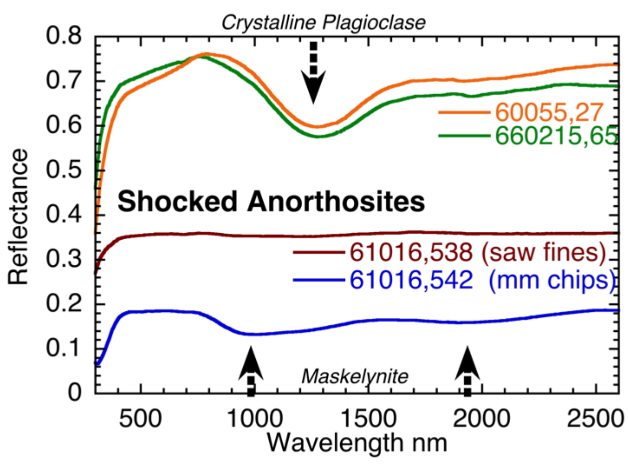
**Introduction:** Spectroscopic measurement of the Moon with remote sensors have been key in constraining the global properties of the lunar crust. Samples of lunar anorthosite returned during Apollo exhibit a well-defined diagnostic absorption near 1.25 µm due to trace amounts of ferrous iron in the crystal structure. It wasn't until spectroscopic instruments were flown to the Moon onboard Kaguya and Chandrayaan-1 that lunar surface areas of pure anorthosite were identified using this diagnostic signature. Previously, high albedo lunar areas that exhibit no absorptions from mafic minerals were interpreted to be anorthositic. The logic was that highly shocked feldspar loses its crystal structure becoming isotropic or so-called diiaplectic glass. This solid state non-crystalline form of plagioclase, called maskelynite, would thus not exhibit the crystalline plagioclase ferrous feature near 1.25 µm (and would of course also exhibit no absorption features from mafic minerals). This hypothesis describing 'featureless plagioclase' could unfortunately not be confirmed with samples. Only one clean sample of lunar maskelynite was obtained from a mineral separate of the highly shocked lunar gabbroic meteorite A881757. This natural maskelynite sample was not featureless; it exhibited distinct ferrous glass absorptions near 1 and 1.9 µm. Since 'featureless' lunar spectra acquired remotely from orbit exhibit a red-sloped continuum, other models that involve space weathering products were also proposed as possibe explanations (Lucey 2002, GRL; Yamamoto et al., 2015, JGRP).

Laboratory spectra of lunar anorthosite samples that exhibit extensive shock features petrographicaly (along with abundant maskelynite) were nevertheless shown to exhibit a clear crystalline 1.25 µm anorthosite diagnostic feature in the near-infrared (see examples in Figure 1). The one possible exception (61016,538) turned out to be a possible mixture (saw fines) from 61016, the large 'Big Muley' aluminous impact melt rock with a 'cap' of shocked anorthosite (e.g., Pieters et al., 2018, LPSC49 #1698). Additional samples of *only* the anorthositic cap of 61016 were requested and a new spectrum of coarse (1-3 mm) vitreous chips (61016,538) is also shown in Figure 1. Although the presence of trace amounts of pyroxene cannot be excluded yet, our initial interpretation is that this specific lunar sample is essentially pure maskelynite, which would make it only the second one recognized.

**Work underway.** We were allocated a special sample (,546) from the upper surface of the 61016 anorthosite cap (Figure 2). The small chip (443 mg) includes part of the exposed surface (exhibiting a patina) on one side and unexposed (shocked) anorthosite on the other. This sample is currently being measured in the RELAB. We have also obtained grain mounts coordinated with the particulate samples of Figure 1 to petrographically document and provide insight into their shock history in order to integrate and (we hope) clarify the shocked anorthosite story, and what it can tell us about lunar crustal evolution.



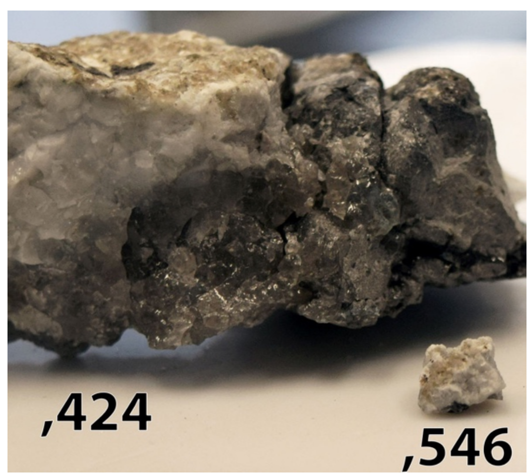




**Figure 1 (left)** Bidirectional reflectance spectra of particulate samples of lunar anorthosites that have been described as exhibiting extensive shock features. Diagnostic absorption bands of crystalline plagioclase (~1.25µm) and maskelynite (~1 and 1.9 µm) are indicated.

**Figure 2 (right)** Image of the 6 mm chip 61016,546 obtained from the upper surface of the anorthositic 'cap' of the large 61016 'Big-Muley' Apollo 16 sample.

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