LUNAR METEORITES AND THE GLOBAL ABUNDANCE OF "PAN" (PUREST ANORTHOSITE): INCONVENIENT TRUTHS ABOUT REMOTE SENSING FOR PLANET-SURFACE COMPOSITION

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I have tested various remote-sensing lunar surface composition data sets for consistency with one another, and with the ground truth provided by the populational statistics of lunar highland meteorites. The approach here emphasizes comparing the data as compositional-frequency populations, with less concern paid to pixel-by-pixel (region-by-region) comparison. Data sets tested are based on gamma-ray spectrometry (GRS) [1, 2; cf. 3]; x-ray spectrometry (XRS) [4−6], with global data only from Chang'e 2's "CE2GRS" [5]; and visible to near-visible spectrometry, mainly from Kaguya Spectral Profiler, "KSP" [7]. For GRS, only the Lunar Prospector [1] data set "LPGRS" seems fully published, although a few data read off a chart in [2] suggest fairly close agreement with the LPGRS data.

Results (Fig. 1) show dreadfully unsatisfactory agreement for Al/Si (or plagioclase, or Al_2O_3; these 3 parameters are fairly easily translatable) in the surface regolith of the feldspathic highlands, defined here for convenience as that 50% of the global surface with the most plagioclase-rich, mafic-mineral-poor, composition (most but not all of this 50% is on the far side). In terms of implied average mafic minerals content of the thusly-defined feldspathic highlands, the results from the visible to near-infrared spectrometry (KSP) and XRS (CE2XRS) techniques ***disagree with the LPGRS result by factors of 0.4 and 1.3***, respectively. The LPGRS results do show relatively close agreement with the highland meteorites [8]. (A slight caveat: diagrams of this format tend to manifest artificial complexities at the compositional extremes [stemming from statistical effects of analytical errors], such as upturn at the left end of the Fig 1 *x*-axis [but not the right end, because that is a cut-off in the middle of the full global distribution]. Otherwise, however, Fig. 1 is an easily interpretable manifestation of very real disparities among the various data sets.)

These disparities do not appear to stem from differences in sampling depths among the various techniques. XRS and KSP similarly sample the very top (<< 1 mm) of the regolith. The GRS technique, which yields the intermediate results, is the one technique that samples relatively deep (~ 1−2 m) into the regolith. The KSP application of visible-to-near-IR spectral reflectance was claimed [7] to have a "± 1 vol% absolute mafic mineral abundance error". ***Remote sensing techniques for regolith composition are evidently not as easy to calibrate, and their results not so easy to interpret, as we would like to think***. Ground truth, lunar sample, data are thus extremely important.

For lunar geology, the implication from lending credence mainly to the GRS and highland-meteorite data is that the feldspathic highland regolith (and underlying feldspathic highland crust) appears to contain on average about 28 wt% Al_2O_3, in the form of 82 vol% plagioclase along with 18 vol% mafic minerals. The crustal complement of "purest anorthosite" (or PAN, defined to contain 98+ vol% plagioclase) appears to have been greatly overestimated in some recent studies [7, 9−11]. Only about 7%, and with high confidence no more than 12%, of the feldspathic highland regolith (in other words, at most 6% of the global regolith) appears to contain less than 10 vol% mafic minerals. The lunar magma ocean hypothesis [12, 13] is quite consistent with the final feldspathic highland crust having 28 wt% Al_2O_3 and 18 vol% mafic minerals.

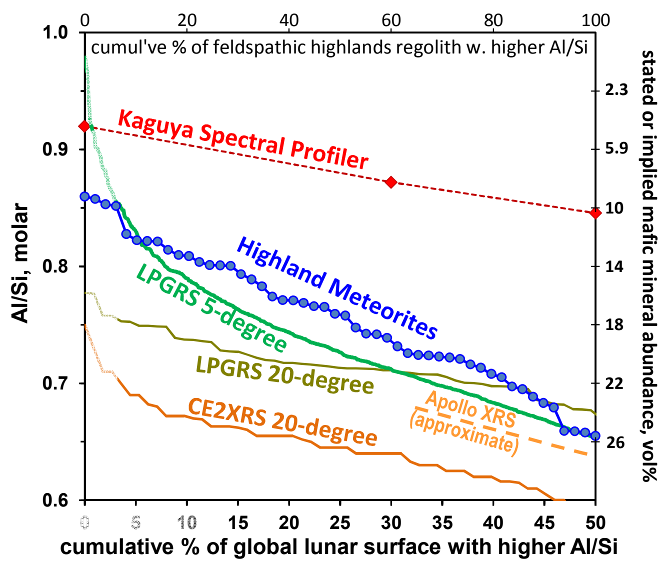

Fig. 1. Disparate Al/Si distributions implied by various analytical approaches for the feldspathic highlands half (i.e., the highest-Al/Si half) of the lunar global regolith.

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