SPACE WEATHERING OF APOLLO 16 SAMPLE 62255: LUNAR ROCKS AS WITNESS PLATES FOR DECIPHERING REGOLITH FORMATION PROCESSES. S. J. Wentworth,[1] D. S. McKay,[2] and L. P. Keller,[2]
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Introduction: Space weathering, or alteration that occurs at the surfaces of materials exposed directly to space, has been one of the primary areas of focus of lunar studies for the past several years. It is caused by processes such as micrometeorite impacts and solar wind bombardment, and effects can include microcraters, spall zones, and vapor deposits [e.g., 1, 2].

Much of the recent work on space weathering has been concentrated on nanoscale features, especially the amorphous rims commonly found on individual lunar soil grains. The rims typically contain nanophase Fe metal globules, which, along with Fe metal globules in agglutinates, have a profound effect on optical properties of lunar soils [3, 4, 5]. The nanophase metallic iron globules cause the characteristic optical changes (reddening and darkening) found in mature lunar soils.

Rock patinas: One advantage of studying patinas on lunar rocks is that the rocks may be exposed at the lunar surface for longer periods of time than single soil grains, allowing much more time for the development of detectable weathering effects. Single grains of lunar soil may only undergo a limited number of events before being buried or destroyed. Although rock and soil grain weathering features are similar, there are also apparent some differences. Weathering of rock surfaces may be dominated by direct erosional and melting processes (microcratering, glass deposition, solar wind sputtering erosion [2]). In contrast, vapor deposition (by downward injection) appears to be a dominant process affecting single soil grains [1]. Studies of rocks and soil grains should complement each other nicely.

62255: We are studying patina-bearing chips of Apollo 16 breccia 62255. This rock is a dilithologic breccia, consisting partly of anorthosite and partly of aluminous impact melt breccia. Samples consist of chips (,138 and ,148) from the anorthositic portion of the rock with a macroscopically visible darkening of the surface (patina). Earlier work on the patina [6] showed that it has the visible reddening darkening typical of lunar space weathering (Fig. 1). Microcraters and glass splashes were also present. We are currently investigating this rock in greater detail using high-resolution, low-voltage FE-SEM imaging, EDS, and BSE imaging. TEM/EDS studies using microtomed samples of the same chips are planned in order to make direct comparisons between data obtained by SEM and TEM techniques. Some current results are shown and described in Figs. 2-7.

Inferences: Results of studies thus far have primarily yielded a number of questions. Many are specific to 62255, but most could be applied to rock patinas in general. Was the 62255 patina formed by vapor deposition from impact clouds, was it formed by sputter deposition from nearby sputtered regolith, or was it formed by splash glass? If all three participated, which was the most important? Did reduced iron form at the same time as the patina? Does the patina lack significant reduced iron simply because it was formed mostly from the 62255 anorthosite substrate? Experiments [7] suggest that the small amounts of Fe present in the underlying anorthosite could be enough to account for the patina darkening (Fig. 1). It seems likely that each small, perhaps nanoscale, area of space-weathered material has its own unique history. Rock patinas may contain a record of many of processes. Only by studying a number of patinas in detail can we hope to decode the unifying processes and principles.

References: [1] Hapke (2001) *JGR* **106**, 10039-10073; [2] Wentworth et al. (1999) *MAPS* **34**, 593-603; [3] Pieters et al. (2000) *MAPS* **35**, 1101-1107; [4] Noble et al. (2001) *MAPS* **36**, 31-42; [5] Keller and McKay (1997) *GCA* **61**, 2331-2340; [6] Wentworth et al. (1997) *LPS XXVIII* 1541-1542; [7] Noble et al. (2004) this vol.

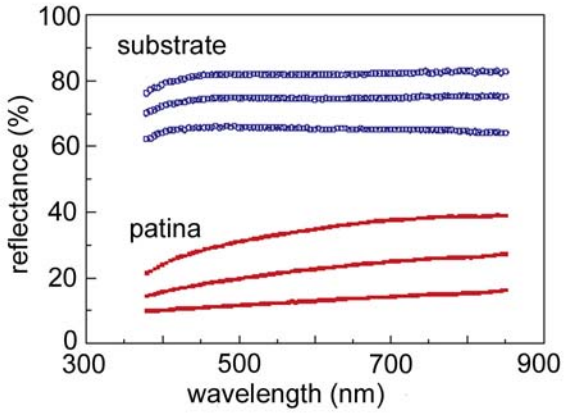

Figure 1: Reflectance spectra for 62255 anorthosite. Compared with freshly fractured portion of rock (substrate), space weathered (patina) surface shows darkening and reddening trends typical of maturing lunar soils. Graph originally in [6].

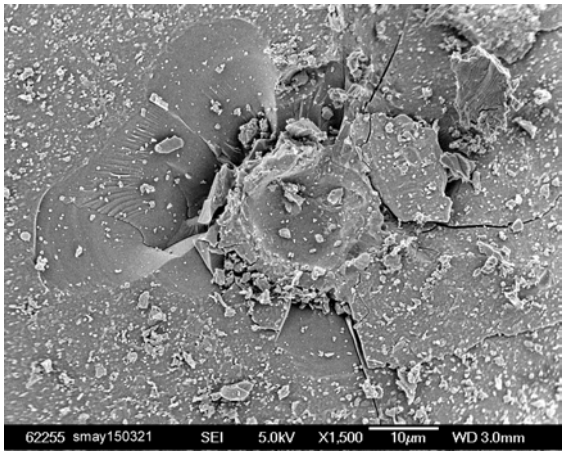

Figure 2: Hypervelocity microcrater, 62255 surface. Characteristic features: glass pit liner (bowl-shaped feature at center), radial fractures, and spall zone with conchoidal fracturing.

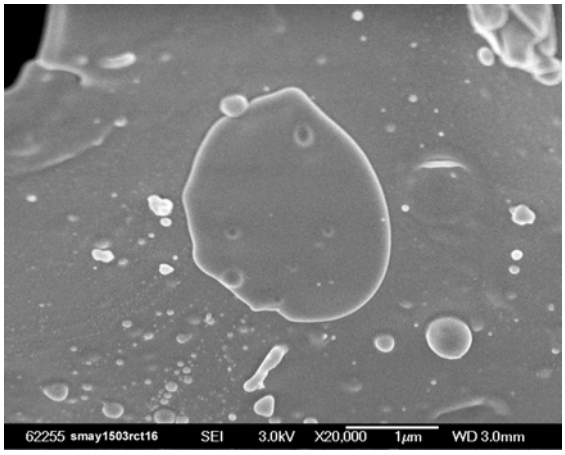

Figure 3: Impact-produced glass "pancake" (splash glass) on 62255 patina surface. Like microcraters, pancakes are distinctive of surfaces exposed directly to space.

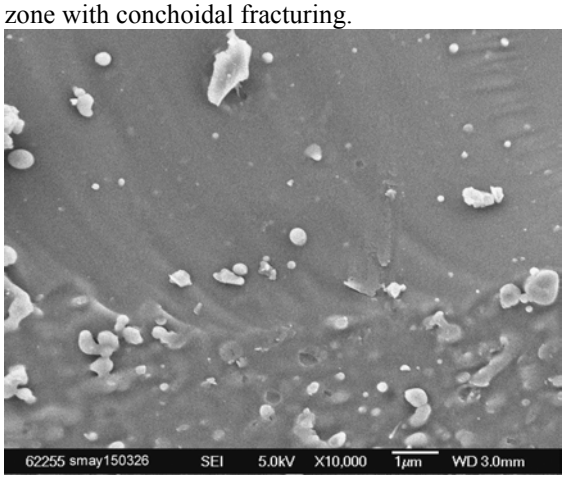

Figure 4: Edge of microcrater spall zone in Fig. 2, showing contrast between freshly spalled material 5 patina (towards bottom). Important notes: patina is very thin (<<1 μm) and contains numerous clasts.

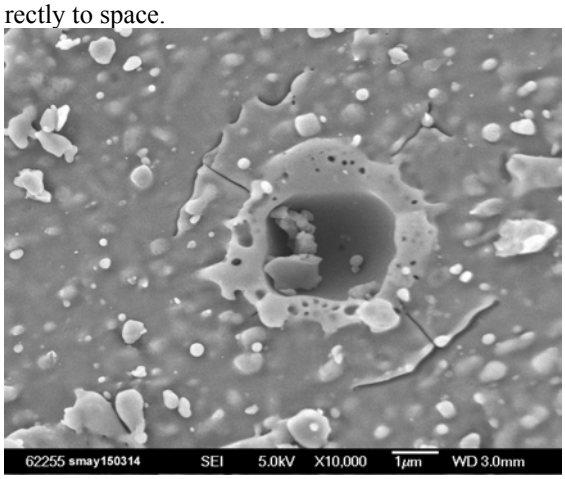

Figure 5: Small hypervelocity crater in 62255 patina; note incipient spall zone. Important question: why are some rims vesicular like this while others (e.g., Fig. 2) are not?

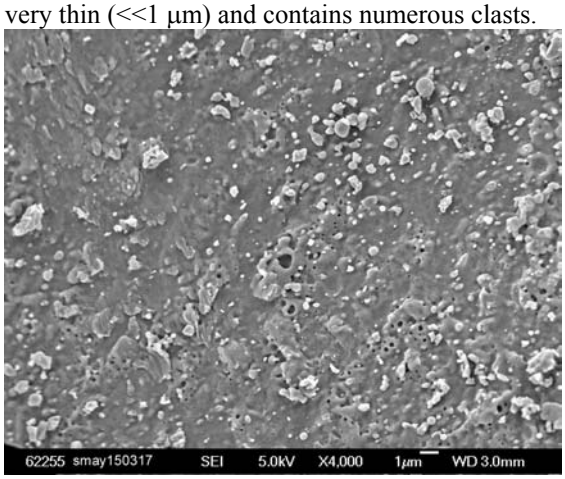

Figure 6: Layer of heterogeneous ropy/vesicular splash glass on 62255 patina surface.

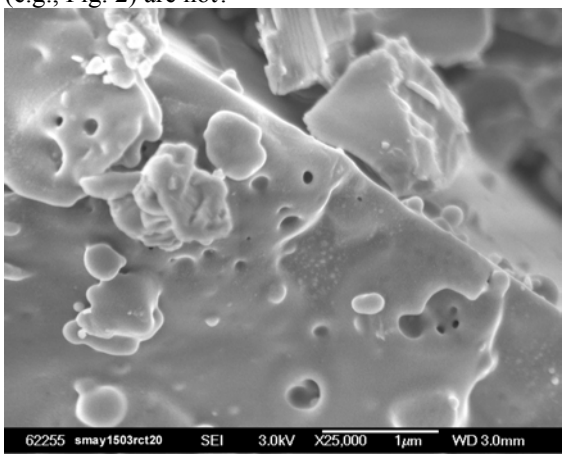

Figure 7: Agglutinitic(?) area of 62255 patina surface; texture very different from that of the dominant patina (Figs. 4, 5).