SPACE WEATHERING OF OLIVINE IN LUNAR SOILS:
A COMPARISON TO ITOKAWA REGOLITH SAMPLES.
L. P. Keller1 and E. L. Berger 2. 1Code KR, NASA/JSC, Houston,
TX 77058. 2GeoControl Systems, Inc., Jacobs JETS contract,
NASA/JSC, Houston, TX, 77058. Lindsay.P.Keller@nasa.gov

Introduction: Regolith particles from airless bodies preserve
a record of the space weathering processes that occurred during
their surface exposure history. These processes have major im-
plications for interpreting remote-sensing data from airless bod-
ies. Solar wind irradiation effects occur in the rims of exposed
grains, and impact processes result in the accumulation of vapor-
deposited elements and other surface-adhering materials. The
grains returned from the surface of Itokawa by the Hayabusa
mission allow the space weathering “style” of a chondritic, aster-
oidal “soil” to be compared to the lunar case. Here, we present
new studies of space-weathered olivine grains from lunar soils,
and compare these results to olivine grains from Itokawa.

Samples and Methods: We analyzed microtome thin sec-
tions of olivine grains from the 20-45 µm fractions of three lunar
soils: 71061, 71501 and 10084 (immature, submature and ma-
ture, respectively). Imaging and analytical data were obtained
using a JEOL 2500SE 200kV field-emission scanning-
transmission electron microscope equipped with a thin-window
energy-dispersive x-ray spectrometer. Similar analyses were ob-
tained from three Hayabusa olivine grains [1].

Results and Discussion: We observed lunar grains showing
a range of solar flare track densities (from <10^9 to ~10^12 cm^{-2}).
The lunar olivines all show disordered, highly strained, nano-
crystalline rims up to 150-nm thick. The disordered rim thickness
is positively correlated with solar flare track density. All of the
disordered rims are overlain by a Si-rich amorphous layer, rang-
ing up to 50-nm thick, enriched in elements that are not derived
from the host olivine (e.g., Ca, Al, and Ti). The outermost layer
represents impact-generated vapor deposits typically observed on
other lunar soil grains [2].

The Hayabusa olivine grains show track densities <10^{10} cm^{-2}
and display disordered rims 50- to 100-nm thick [1]. The track
densities are intermediate to those observed in olivines in imma-
ture and submature lunar soils and indicate surface exposures of
~10^5 years [3]. The outermost few nanometers of the disordered
rims on Hayabusa olivines are more Si-rich and Mg- and Fe-
depleted relative to the cores of the grains and likely represent a
minor accumulation of impact-generated vapors or sputter depos-
ts [1]. Nanophase Fe metal particles are less abundant in the
Hayabusa rims compared to the rims on lunar grains.

Conclusions: The Hayabusa and lunar olivine grain rims
have widths and microstructures consistent with formation from
atomic displacement damage from solar wind ions. The space
weathering features in the Hayabusa grains are similar to those
observed in olivines from immature to submature lunar soils. A
major difference, however, is that the Hayabusa grains appear to
lack the hypervelocity impact products (melt spherules, thick va-
por deposits, and abundant nanophase Fe metal particles) that are
common in lunar soil grains with a similar exposure history.

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