Sparks on the Moon

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Mercury

Iapetus

Phobos

Vesta (asteroid)

Charon and Pluto

Moon
Space Weathering

(Pieters and Noble, 2016)
To determine surface properties via remote observations, must know how space weathering has affected surface.

To know how space weathering has affected surface, must know surface properties and all space weathering processes.
Jan. 4, 2008
Sep. 11, 2013

Before

After

LROC NAC
(NASA/GSFC/Arizona State University)
Lunar sample 61195 from Apollo 16
Impacts create regolith, including soil.
Here comes the Sun.
Solar Dynamics Observatory
Solar Dynamics Observatory
Visible light
Ultraviolet light:
Iron gas emission line (17.1 nm)
Coronal mass ejection (CME)
Coronal mass ejection (CME)
CMEs sometimes accelerate protons & electrons almost to speed of light
Lunar Reconnaissance Orbiter (LRO)

CRaTER

(NASA)
Lunar Reconnaissance Orbiter (LRO)
Cosmic Ray Telescope for the Effects of Radiation (CRaTER)
Toward the Moon

Toward space

Tissue-equivalent plastic

D1
D2
D3
D4
D5
D6
Impacts create regolith, including soil. The Sun sporadically emits energetic protons and electrons that penetrate lunar soil.
1) SEPs charge the subsurface, setting up a capacitor-like situation

2) Charging dissipates as in a capacitor

1 mm
If SEPs charge regolith faster than it can discharge...

...electric field can increase to threshold for dielectric breakdown

Budenstein [1980]
If SEPs charge regolith faster than it can discharge...

...electric field can increase to threshold for dielectric breakdown.

Combined Release and Radiation Effects Satellite (CRRES)
Time spent in sunlight during lunar day
Discharging timescale = permittivity/conductivity

Discharging timescale in PSRs: ~20 days
Breakdown may have happened recently.

![CRaTER D1 7 day fluences](image)

*Breakdown threshold*
Impacts create regolith, including soil. The Sun sporadically emits energetic protons and electrons that penetrate lunar soil. Large SEP events may cause breakdown in cold lunar soil.
Possible importance of breakdown weathering

PSRs: Very

High lat: Somewhat

Low lat: A little

PSRs: Very

High lat: Somewhat

(Jordan et al., in preparation)
Regolith

Vapor

Melt

Deposited vapor

Jordan et al. (2015)
Impacts create regolith, including soil. The Sun sporadically emits energetic protons and electrons that penetrate lunar soil. Large SEP events may cause breakdown in cold lunar soil. Breakdown weathering might be an important weathering process on the Moon.
Mercury
PSRs: <100 K (Paige et al., 2013)
Nightside: Similar to Moon
(Vasavada et al., 1999)

High-obliquity asteroids
Poles: In shadow for long time
Polar craters: Avg. temp. <100 K
(Stubbs and Wang, 2012)
Conclusions
• Breakdown weathering may have significantly affected lunar regolith
• The conditions for breakdown weathering occur elsewhere in the Solar System

Future Work
• Can remote/in situ observations + lab work show if breakdown weathering has occurred?
• Can breakdown be detected as it occurs?
• Could “sparked” material be in the Apollo samples?