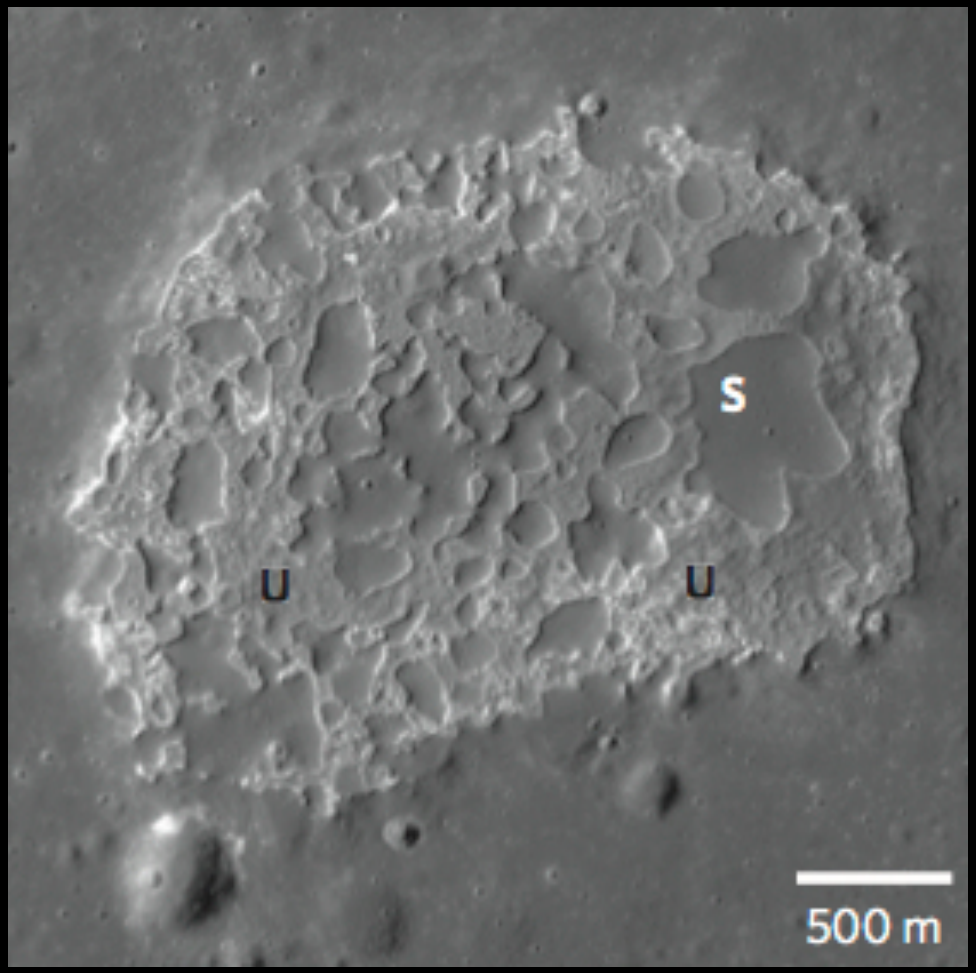
Regolith Formation on Young Lunar Volcanic Features

C. M. Elder[1], P. O. Hayne[1], R. R. Ghent[2], J. L. Bandfield[3], J.-P. Williams[4], and D. A. Paige[4]

[1]Jet Propulsion Laboratory, California Institute of Technology, [2]University of Toronto, [3]Space Science Institute, [4]University of California Los Angeles

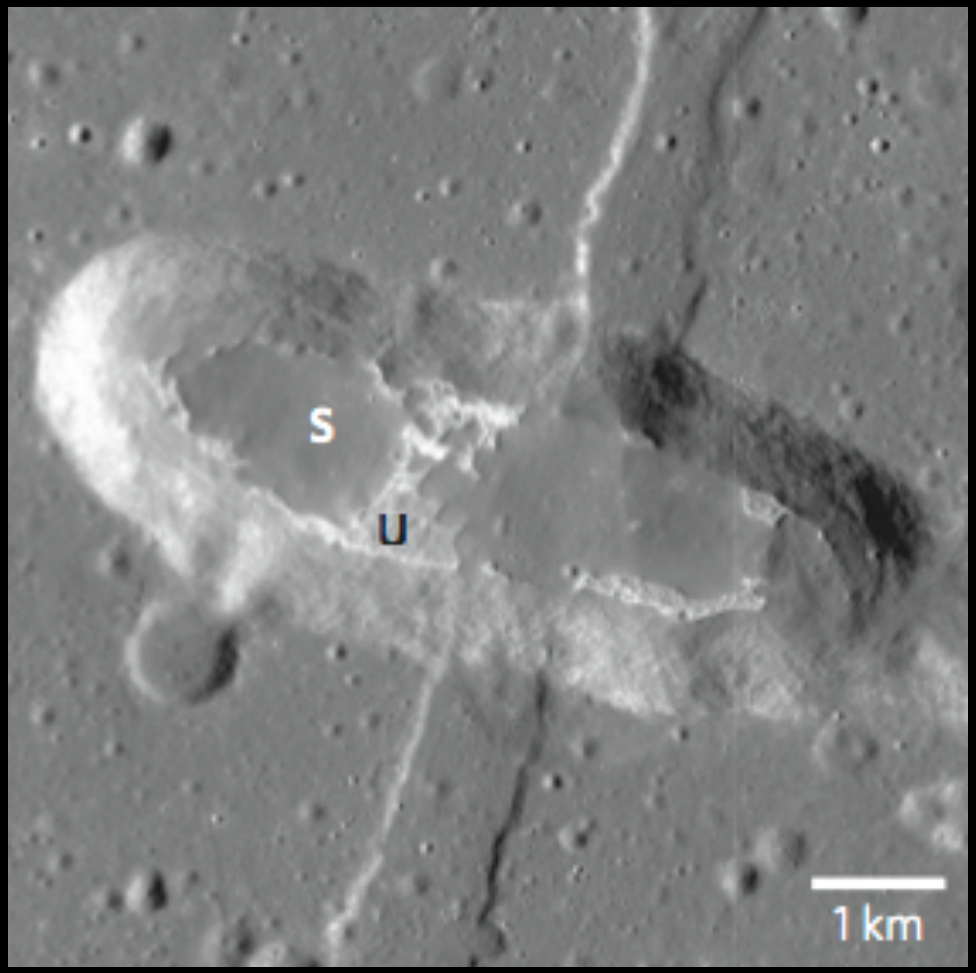
Background



Irregular mare patches:

- Small topographic anomalies with irregular morphologies and textures
- Maximum dimension: 100-5,000 m (Braden et al., 2014)

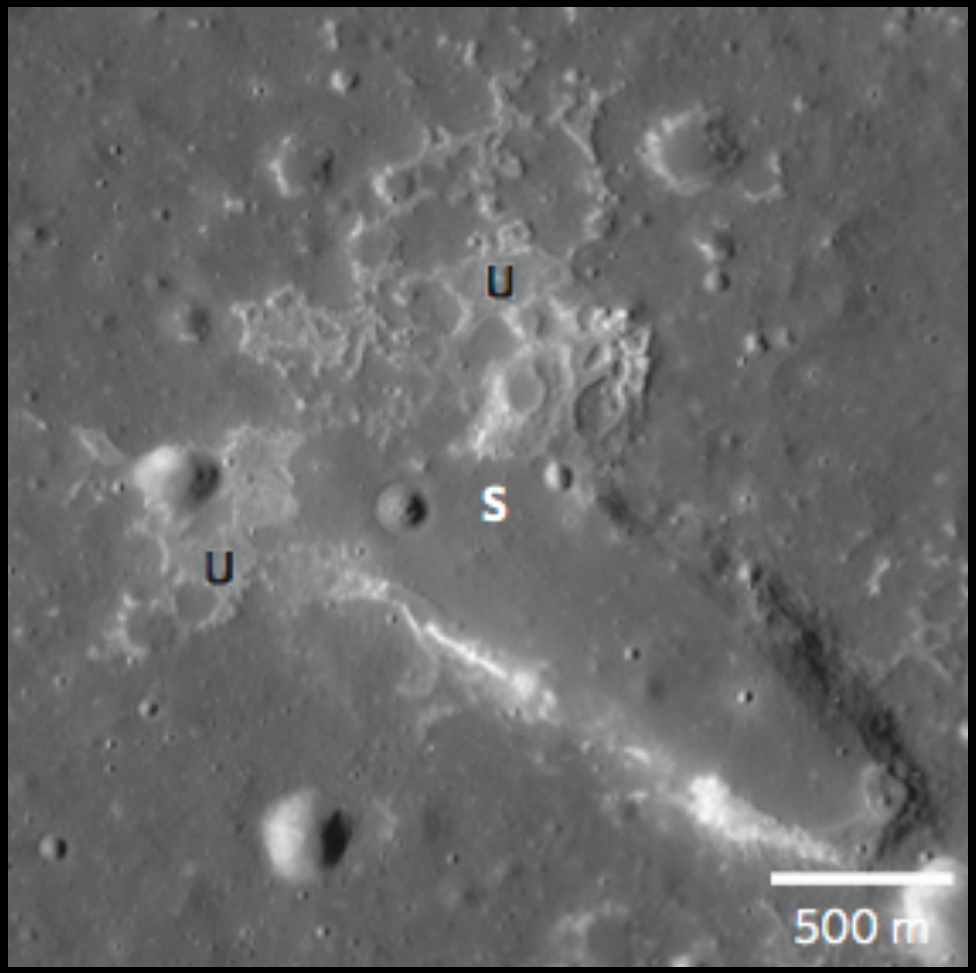
Background



Irregular mare patches:

- Braden et al, 2014 identified 70 IMPs
- Younger than 100 Myr according to crater distributions (Braden et al., 2014)
- Sosigenes possibly as young as 18 Myr (Braden et al., 2014)

Background



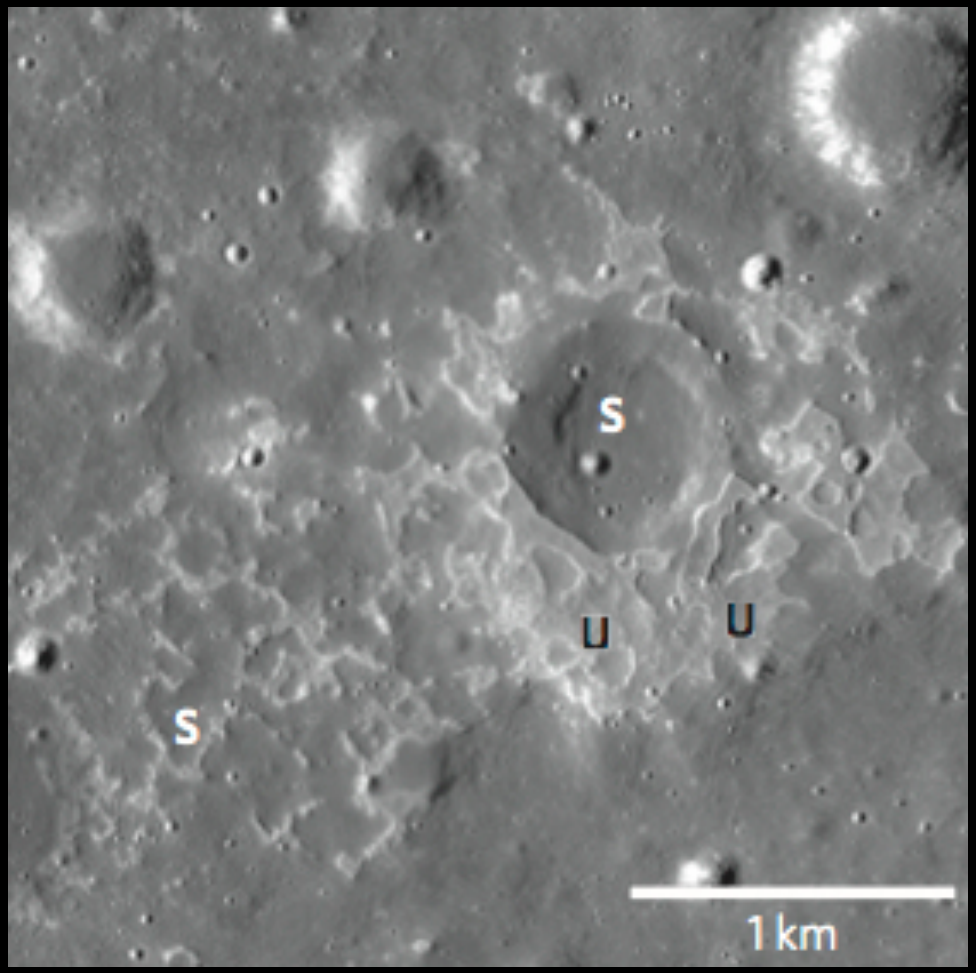
Formation Hypotheses:

- Caldera collapse and small extrusions of lava (El-Baz, 1973).
- Explosive gas release (Schultz et al. 2006)
- Basaltic lava flows (Garry et al. 2012, Braden et al. 2014)

Do IMP thermophysical properties constrain possible formation mechanisms?

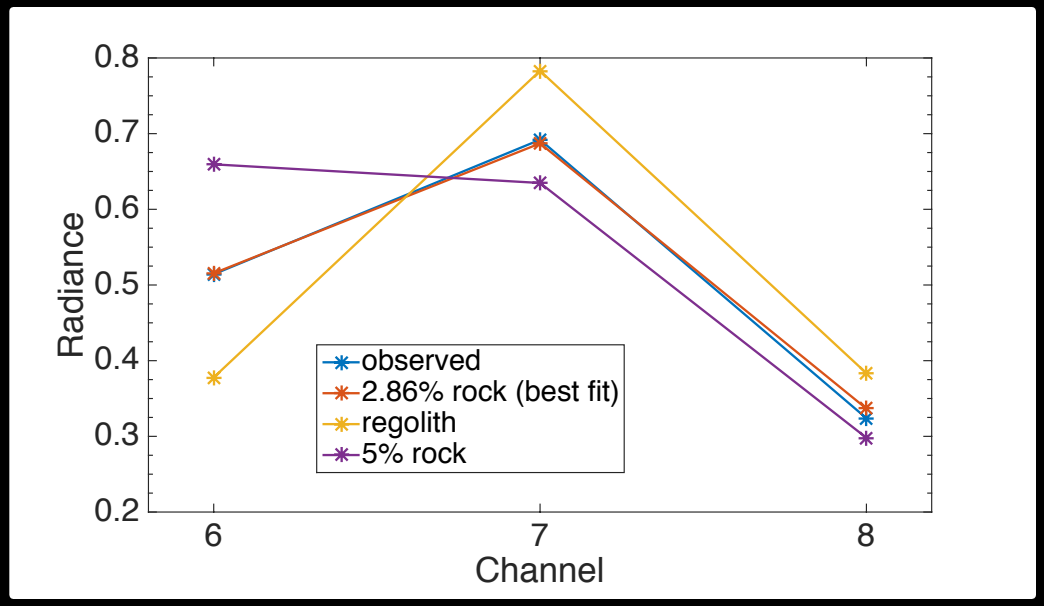
Are IMPs a laboratory for studying regolith formation?

Diviner

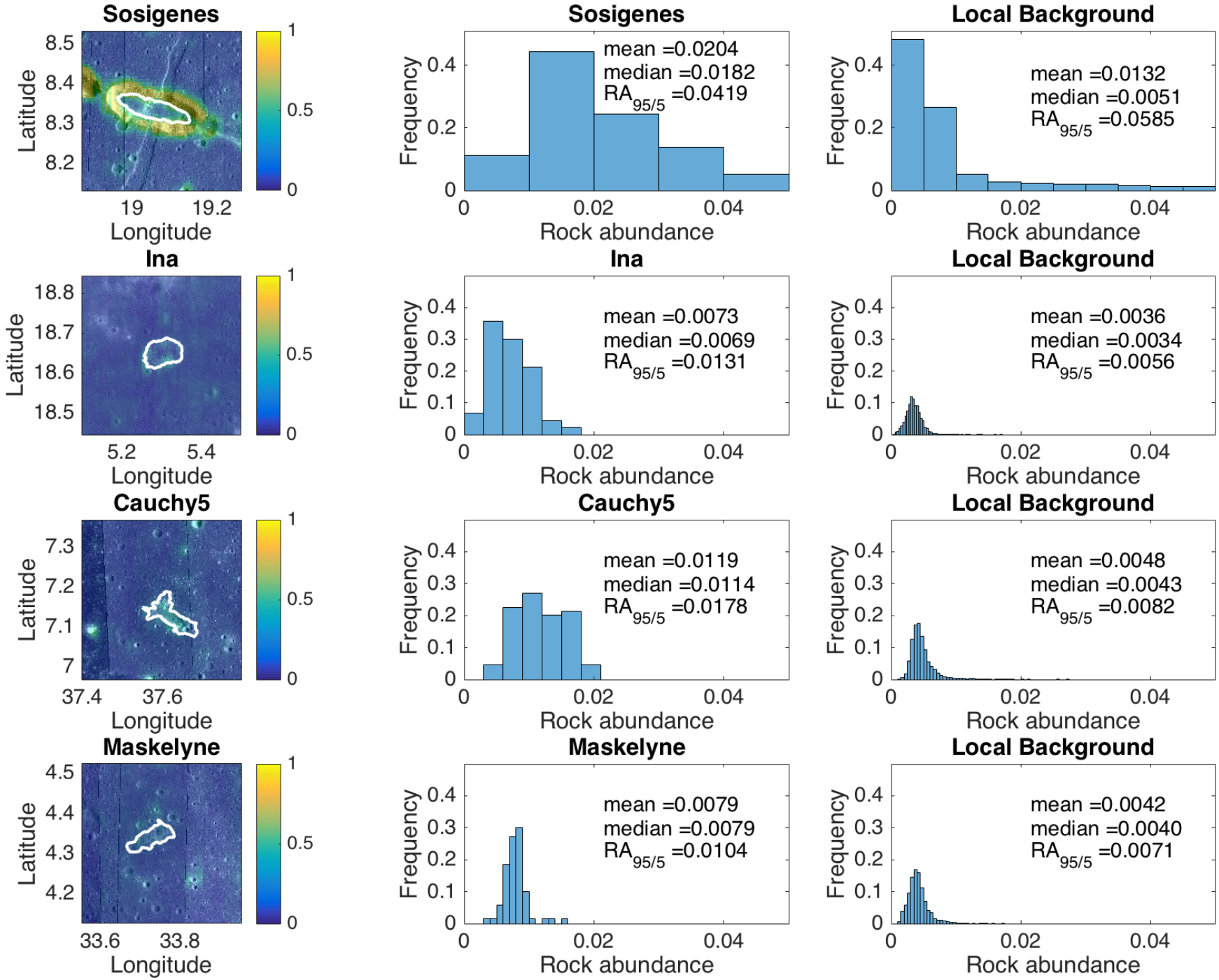


- Rock abundance
- Regolith properties
- For more info on composition, see Donaldson Hanna et al. and Grice et al. posters 2127 and 2106 on Thursday

Methods

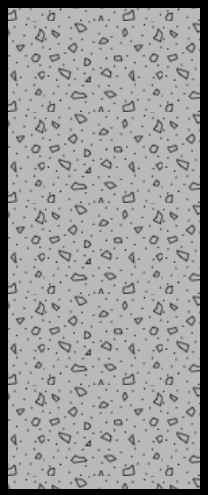


- Rock and regolith have different thermal inertias → two temperatures in field of view
- Diviner channels 6, 7, and 8 have full width half max band passes of 13-23, 25-41, and 50-100 μm
- Bandfield et al. (2011) mapped the Lunar rock abundance

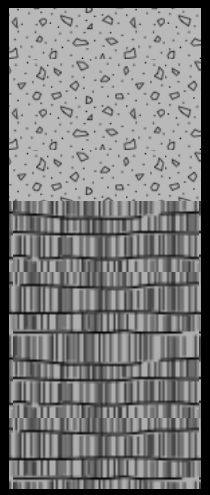

Sosigenes
Latitude
Longitude
Sosigenes
mean =0.0204
median =0.0182
RA95/5 =0.0419
Frequency
Rock abundance
Local Background
mean =0.0132
median =0.0051
RA95/5 =0.0585
Ina
mean =0.0073
median =0.0069
RA95/5 =0.0131
Local Background
mean =0.0036
median =0.0034
RA95/5 =0.0056
Cauchy5
mean =0.0119
median =0.0114
RA95/5 =0.0178
Local Background
mean =0.0048
median =0.0043
RA95/5 =0.0082
Maskelyne
mean =0.0079
median =0.0079
RA95/5 =0.0104
Local Background
mean =0.0042
median =0.0040
RA95/5 =0.0071

IMPs are covered in regolith, but how much regolith?

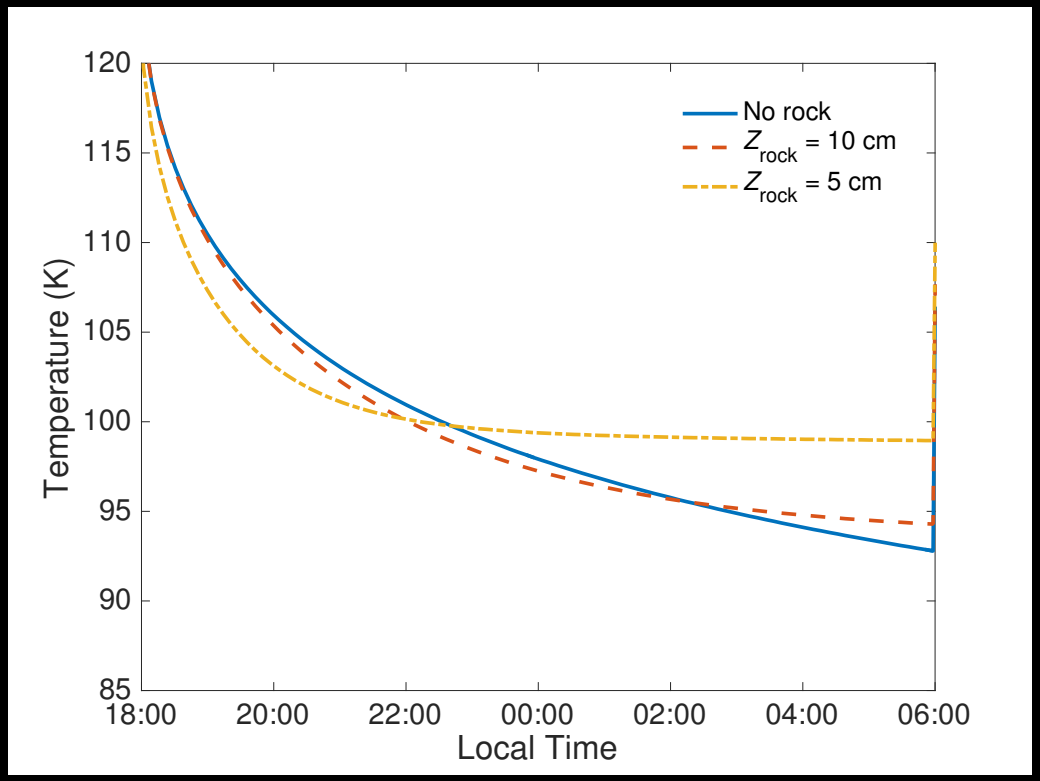
Layering?



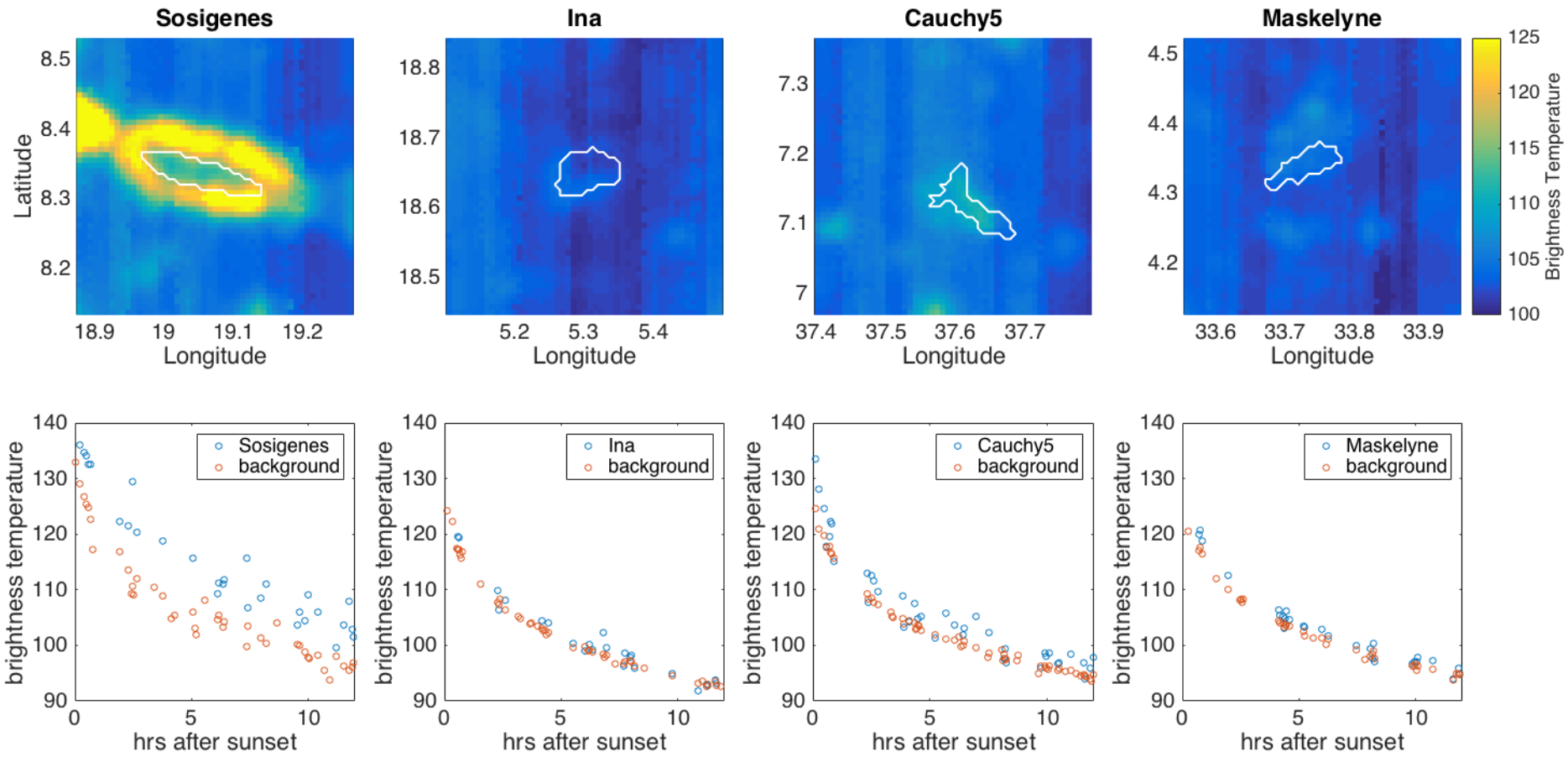
Regolith

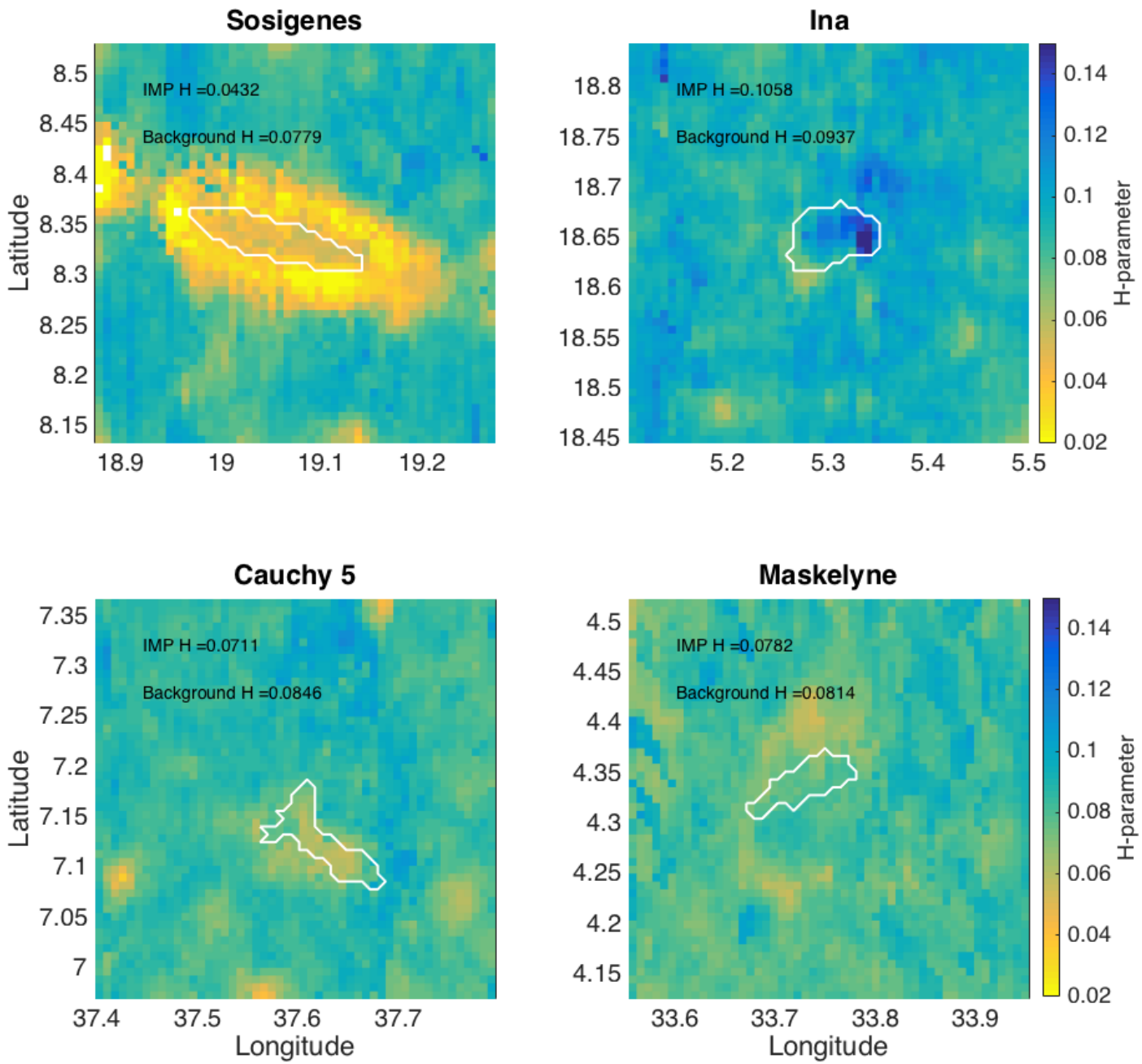


Regolith above rock



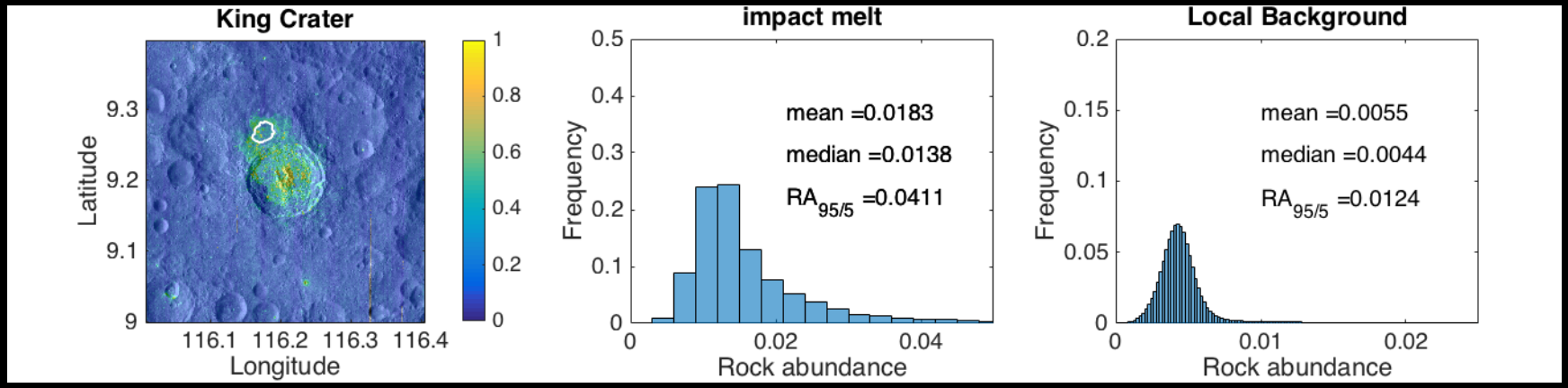
Layering?

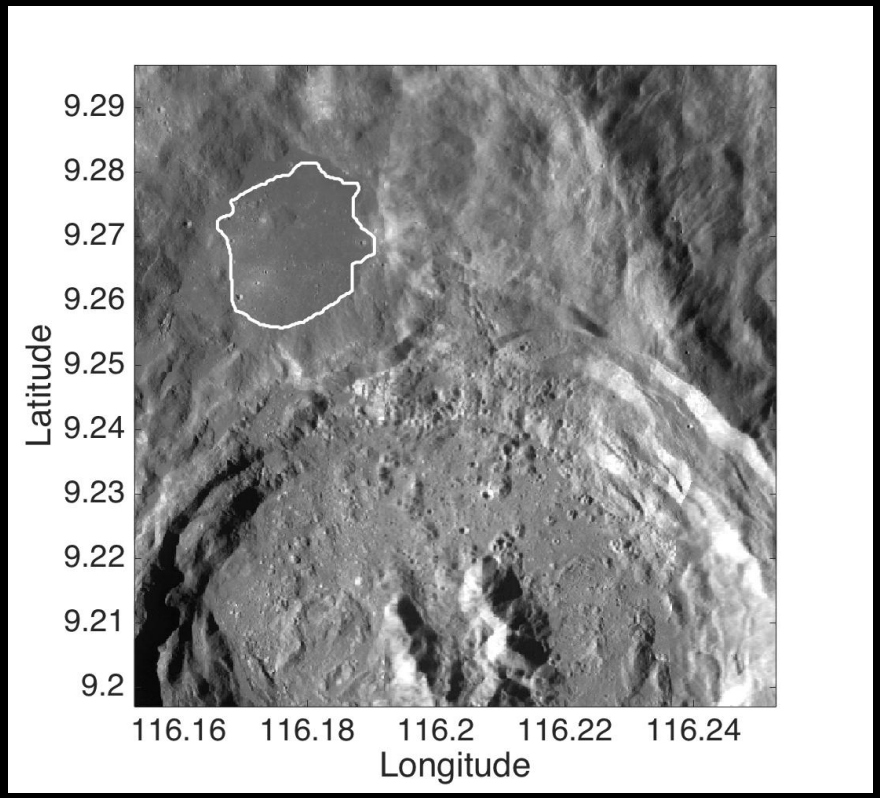

Sosigenes
Ina
Cauchy5
Maskelyne
Latitude
Longitude
Brightness Temperature
brightness temperature
hrs after sunset
Sosigenes
background
Ina
background
Cauchy5
background
Maskelyne
background


Sosigenes
IMP H =0.0432
Background H =0.0779
Latitude
8.5
8.45
8.4
8.35
8.3
8.25
8.2
8.15
18.9
19
19.1
19.2
Ina
IMP H =0.1058
Background H =0.0937
18.8
18.75
18.7
18.65
18.6
18.55
18.5
18.45
5.2
5.3
5.4
5.5
0.14
0.12
0.1
0.08
0.06
0.04
0.02
H-parameter
Cauchy 5
IMP H =0.0711
Background H =0.0846
Latitude
7.35
7.3
7.25
7.2
7.15
7.1
7.05
7
37.4
37.5
37.6
37.7
Longitude
Maskelyne
IMP H =0.0782
Background H =0.0814
4.5
4.45
4.4
4.35
4.3
4.25
4.2
4.15
33.6
33.7
33.8
33.9
Longitude
0.14
0.12
0.1
0.08
0.06
0.04
0.02
H-parameter

Implications of low rock fraction

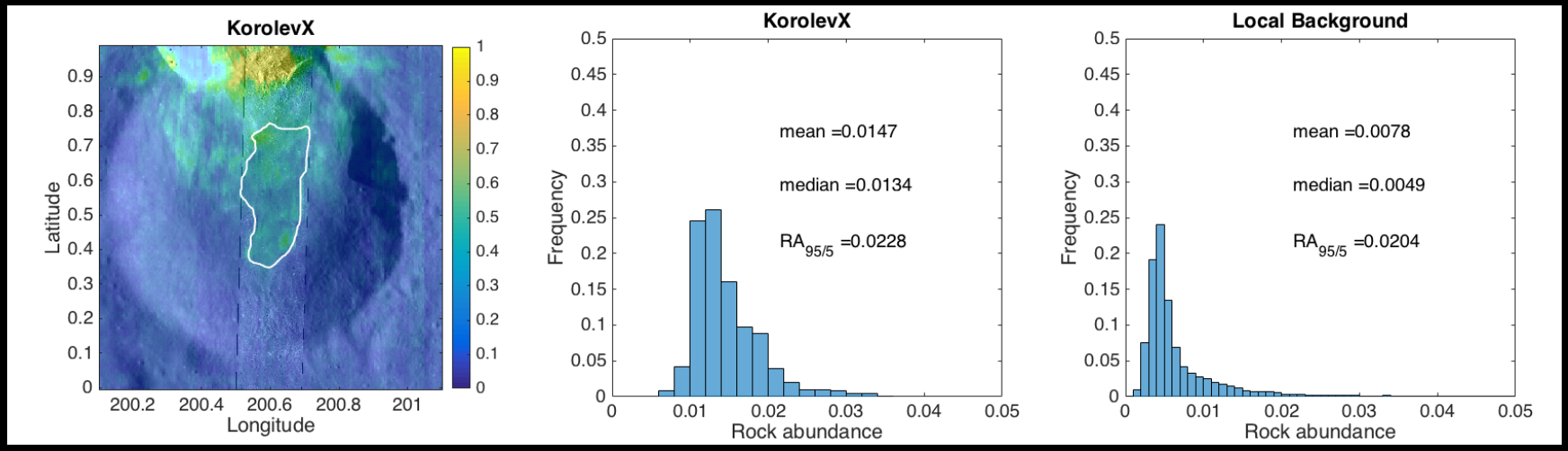
- IMPs are covered in a layer of regolith at least 10 cm thick
- Slightly thicker than Arnold (1975) model would predict for an 18 Myr surface
- What was the initial rock abundance and topography? Can 10 cm of regolith really reduce the rock abundance to ~1%?
- How quickly does regolith form on smooth rocky surfaces?
  - Compare to impact melt

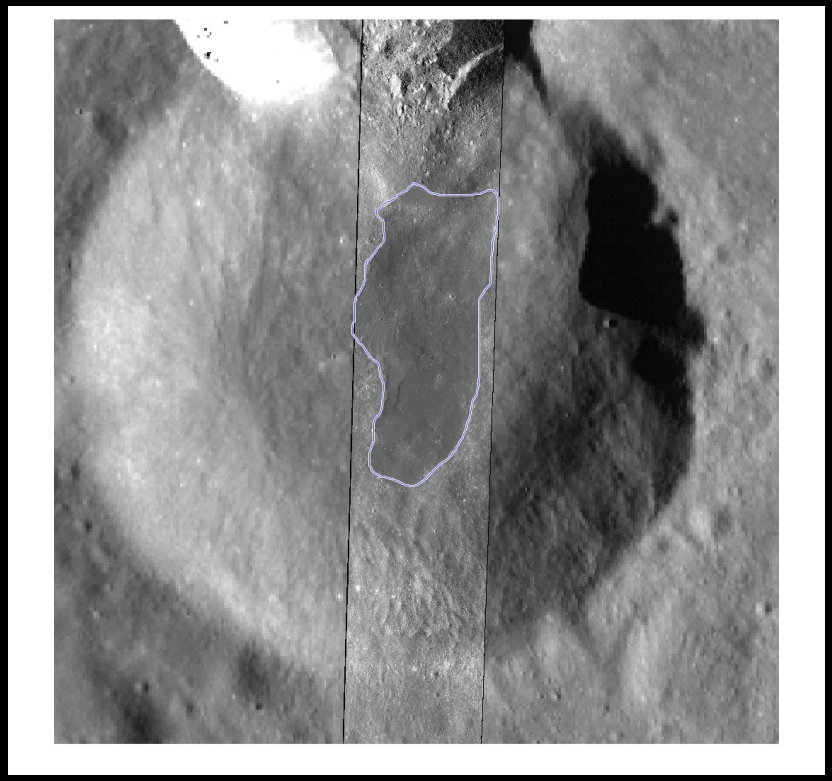




King crater: 992 Ma

	mean	median	$RA_{95/5}$
Sosigenes	0.0204	0.0182	0.0419
Ina	0.0073	0.0069	0.0131
Cauchy 5	0.0119	0.0114	0.0178
Maskelyne	0.0079	0.0079	0.0104
King ejecta (Ghent et al.)	0.006	0.006	0.0103





	mean	median	$RA_{95/5}$
Sosigenes	0.0204	0.0182	0.0419
Ina	0.0073	0.0069	0.0131
Cauchy 5	0.0119	0.0114	0.0178
Maskelyne	0.0079	0.0079	0.0104

Results

- IMPs are covered in a layer of regolith at least 10 cm thick
- Impact melt patches at King Crater and Korolev X Crater have a higher rock fraction than all IMPs except for Sosigenes (mass-wasting from the steep slopes might add boulders to Sosigenes)
- Ina is fluffier than surrounding materials; Sosigenes, Maskelyne, and Cauchy 5 are more consolidated

Conclusions

- IMPS are not regolith-free inflated flows

Conclusions and Interpretations

- IMPS are not regolith-free inflated flows
  - IMPs were initially very smooth. 10 cm of regolith covers 99% of rocks.

    – or –
  - IMPs are much older than Braden et al. claimed and have built up a thick regolith layer. Their low rock fraction suggests they're older than King crater.

    – or –
  - IMPs are lava flows covered in regolith. They started very rocky, have since built up a layer of regolith, and in the future, impacts will punch through this regolith and raise the rock fraction towards something more similar to impact melt at King and Korolev X.

IMPs are covered in a layer of regolith at least 10 cm thick. They may be telling us something about the early stages of regolith formation.

Part of this work was performed at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration.