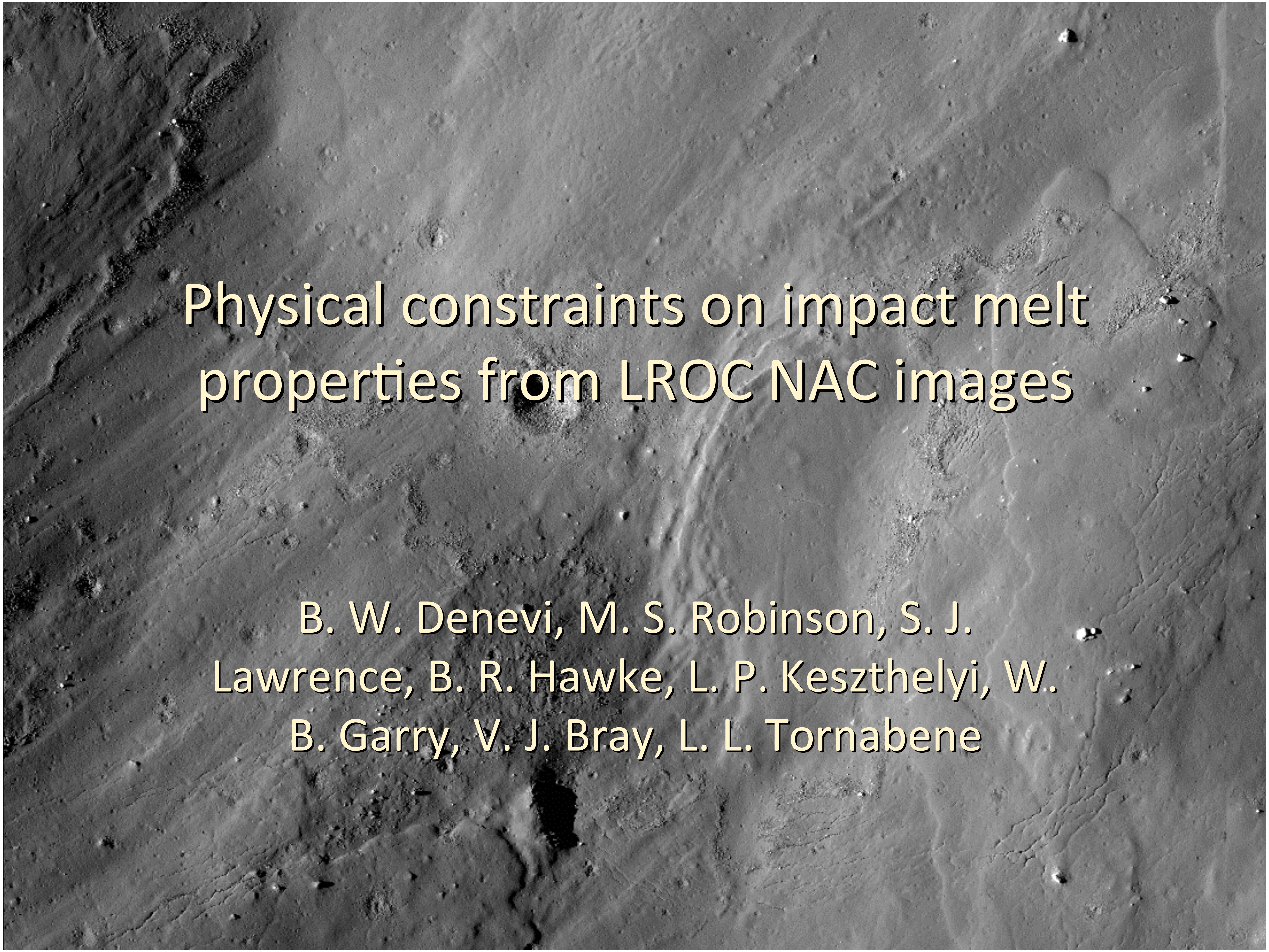
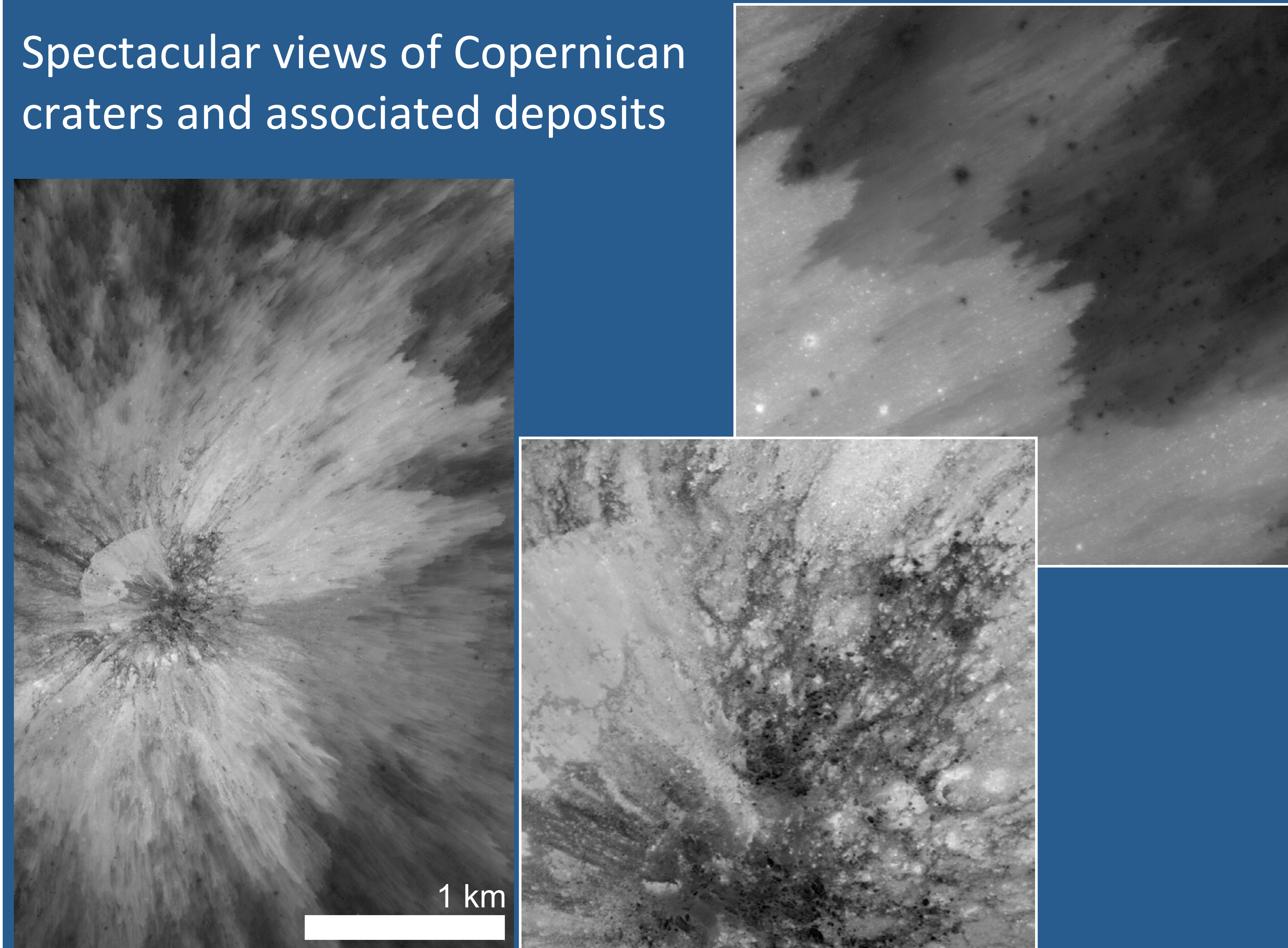
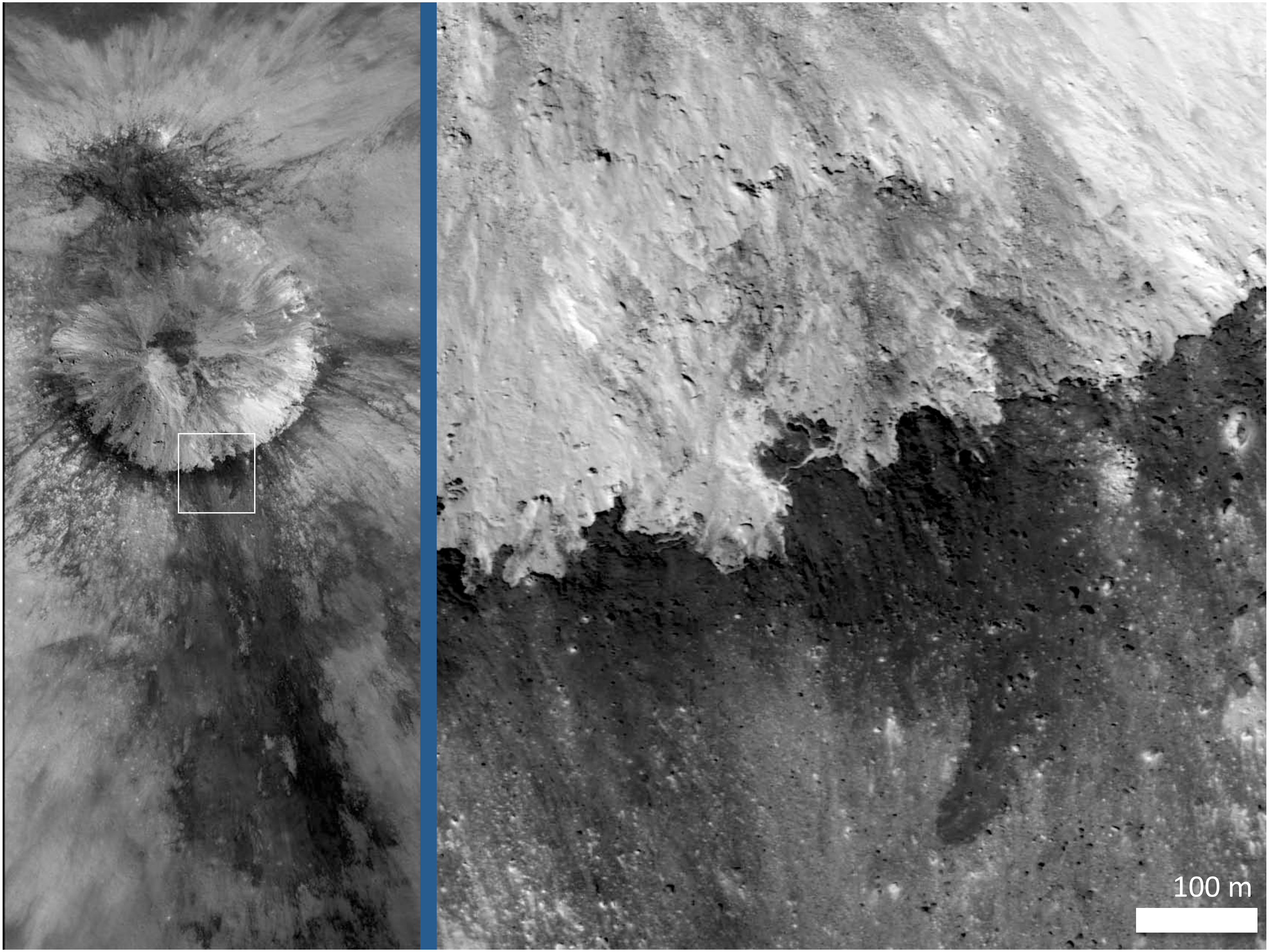


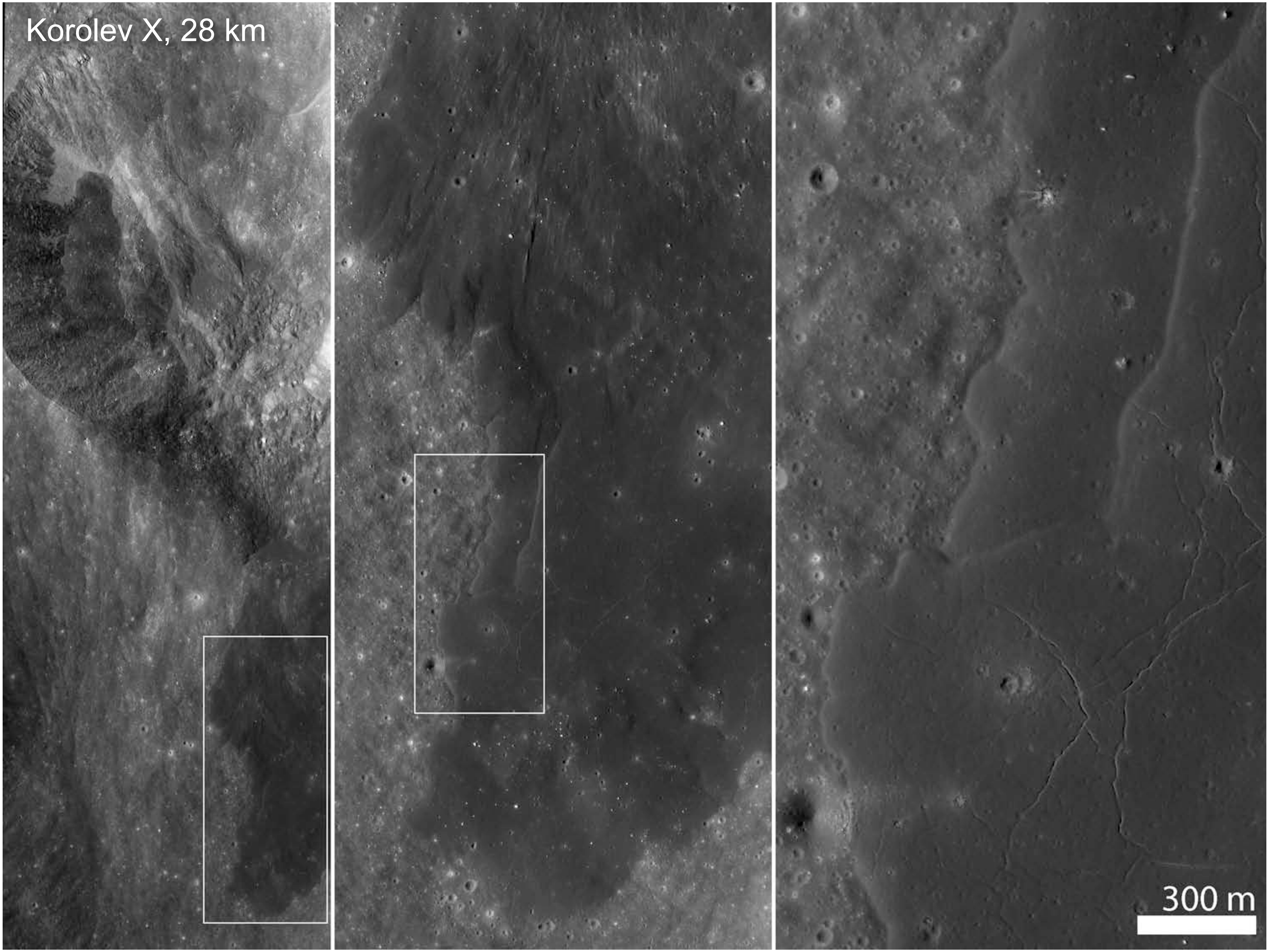
Physical constraints on impact melt properties from LROC NAC images

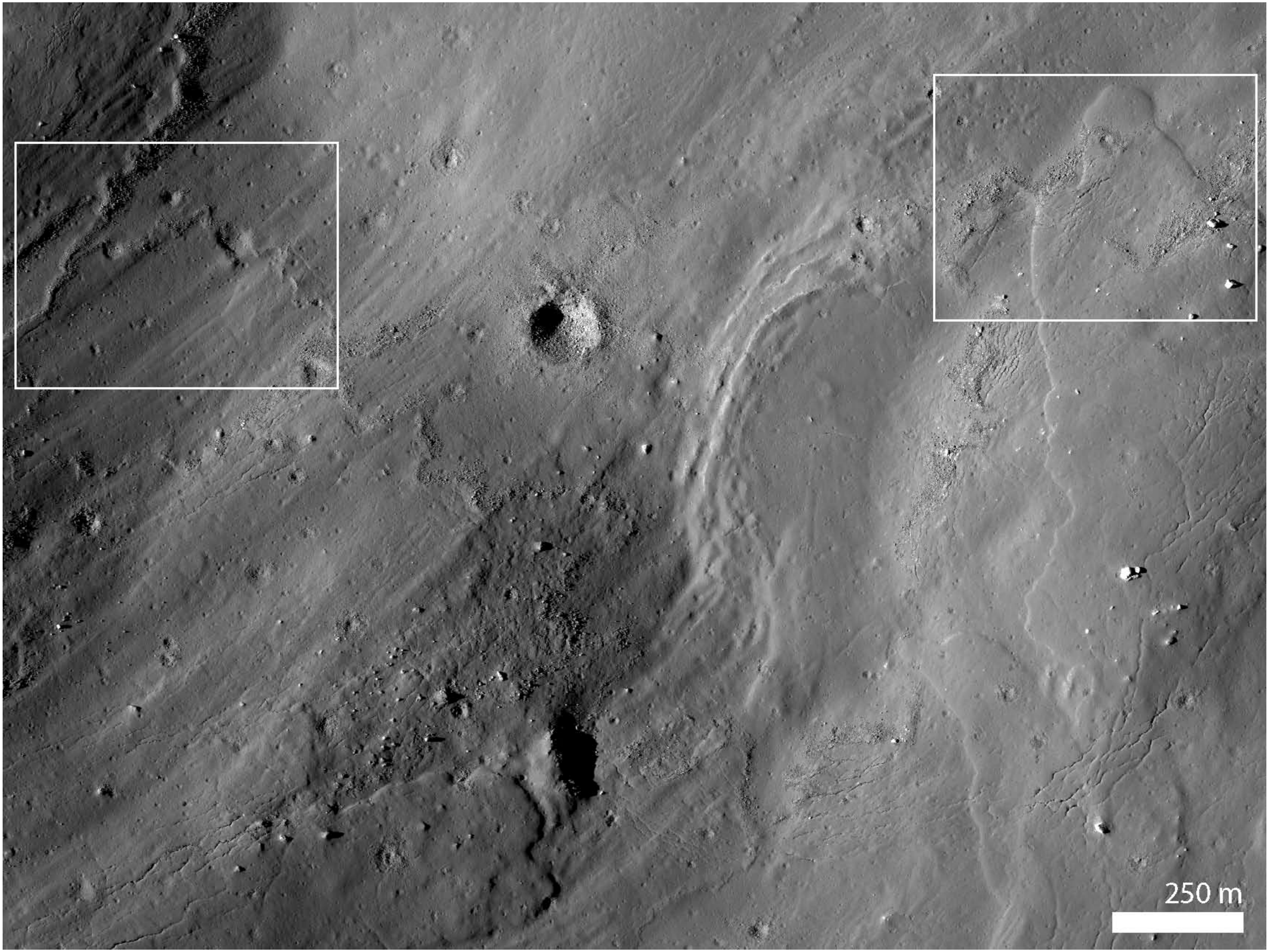
B. W. Denevi, M. S. Robinson, S. J. Lawrence, B. R. Hawke, L. P. Keszthelyi, W. B. Garry, V. J. Bray, L. L. Tornabene

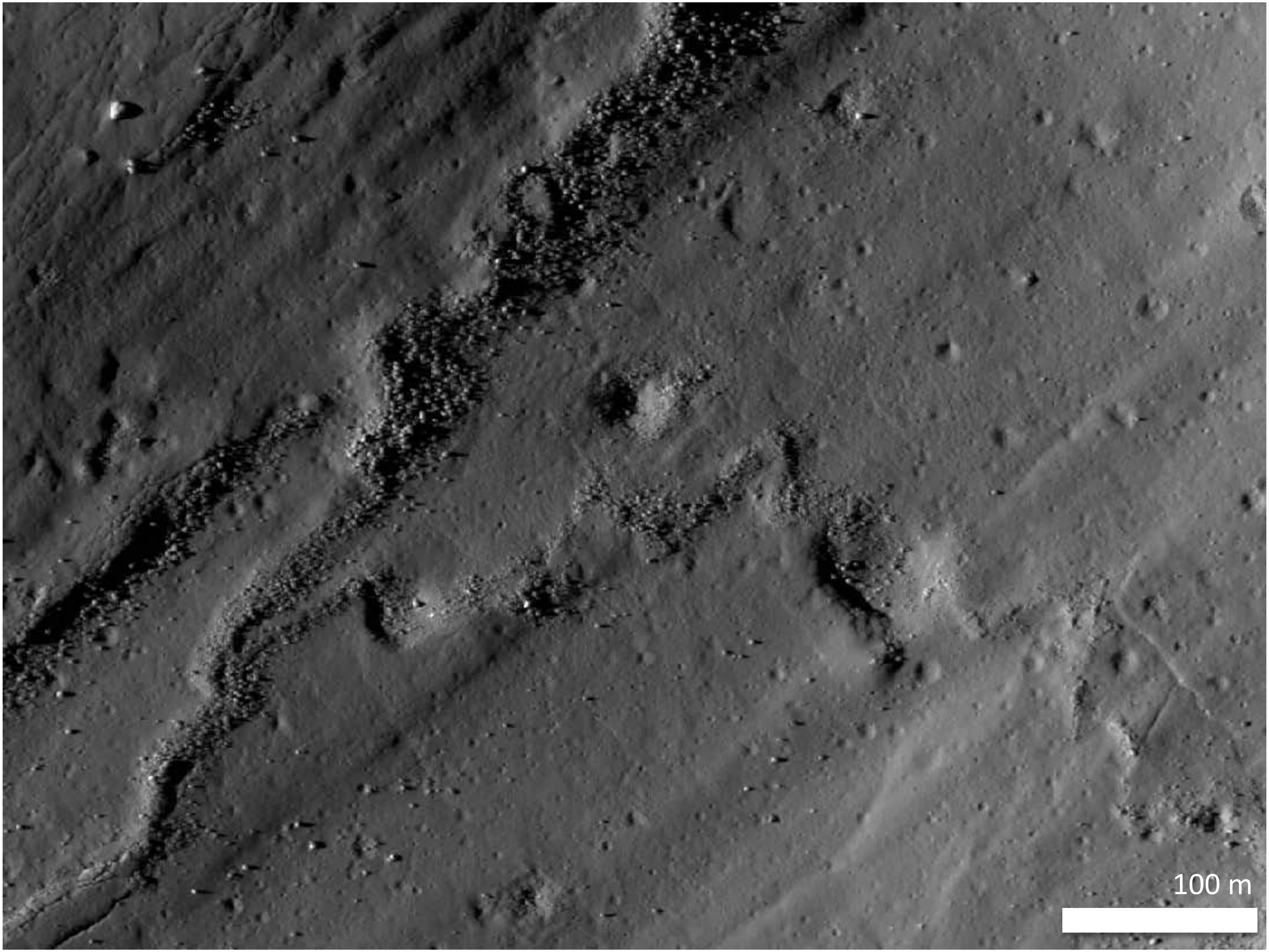
Spectacular views of Copernican craters and associated deposits

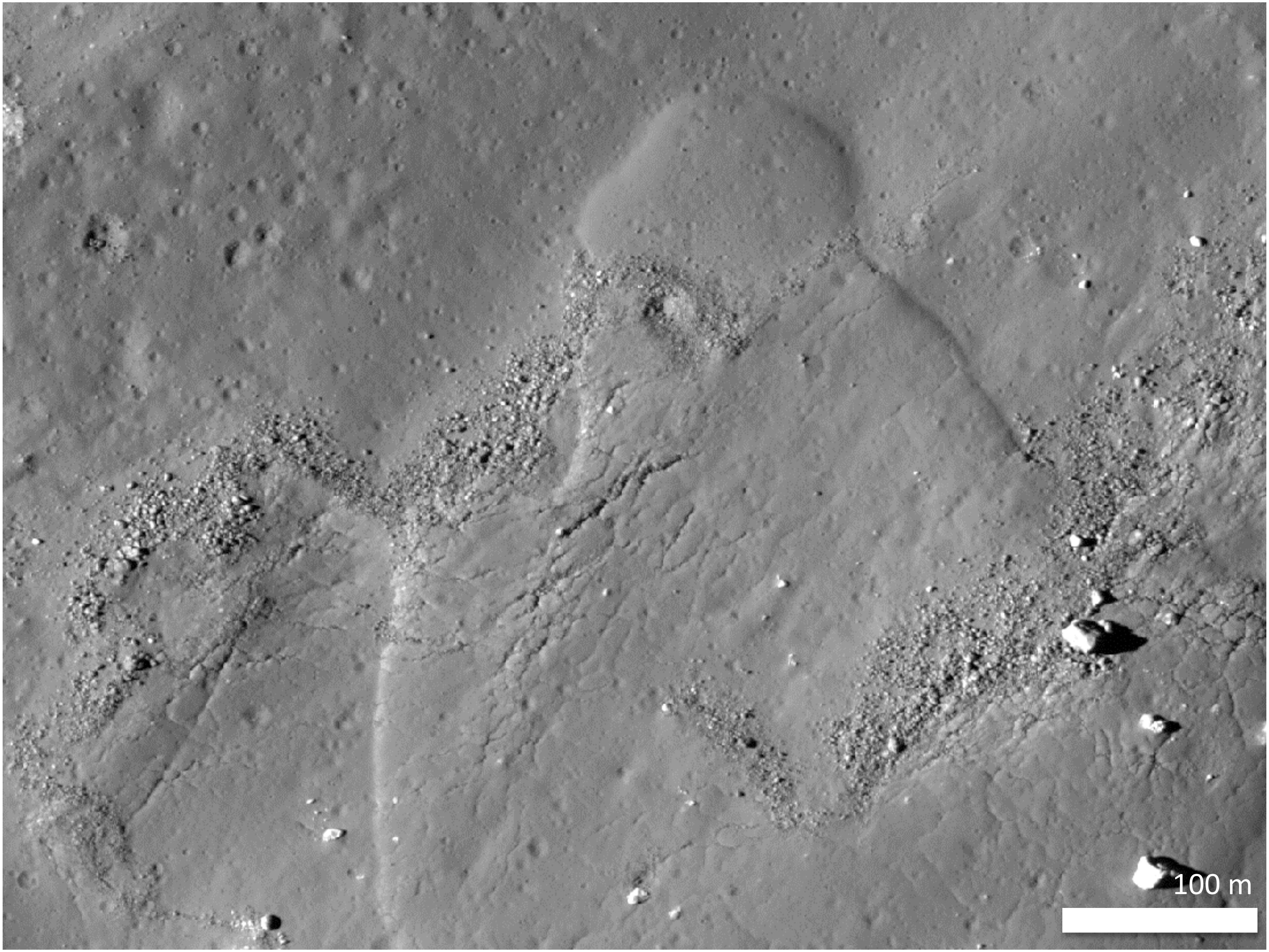


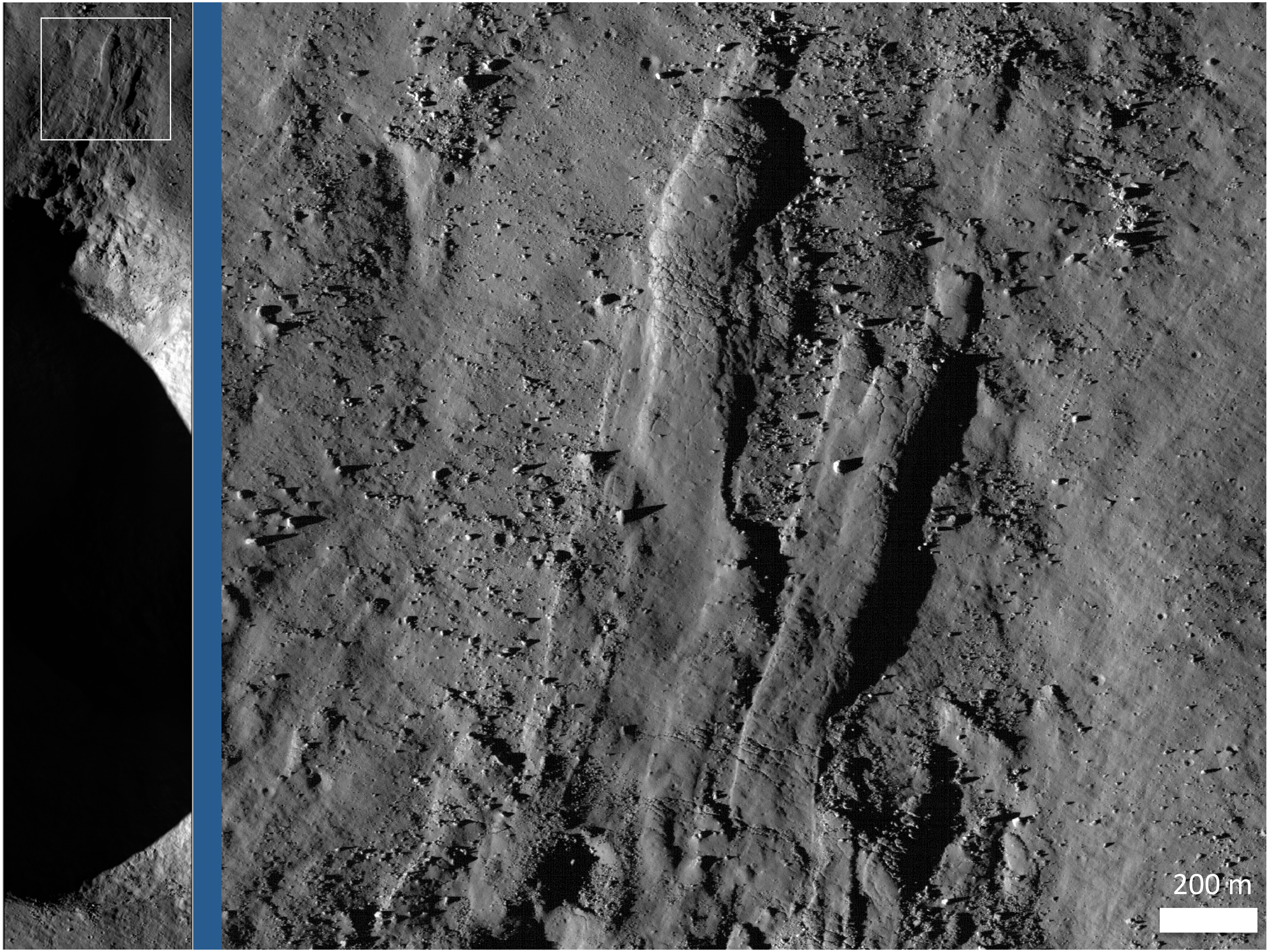

100 m

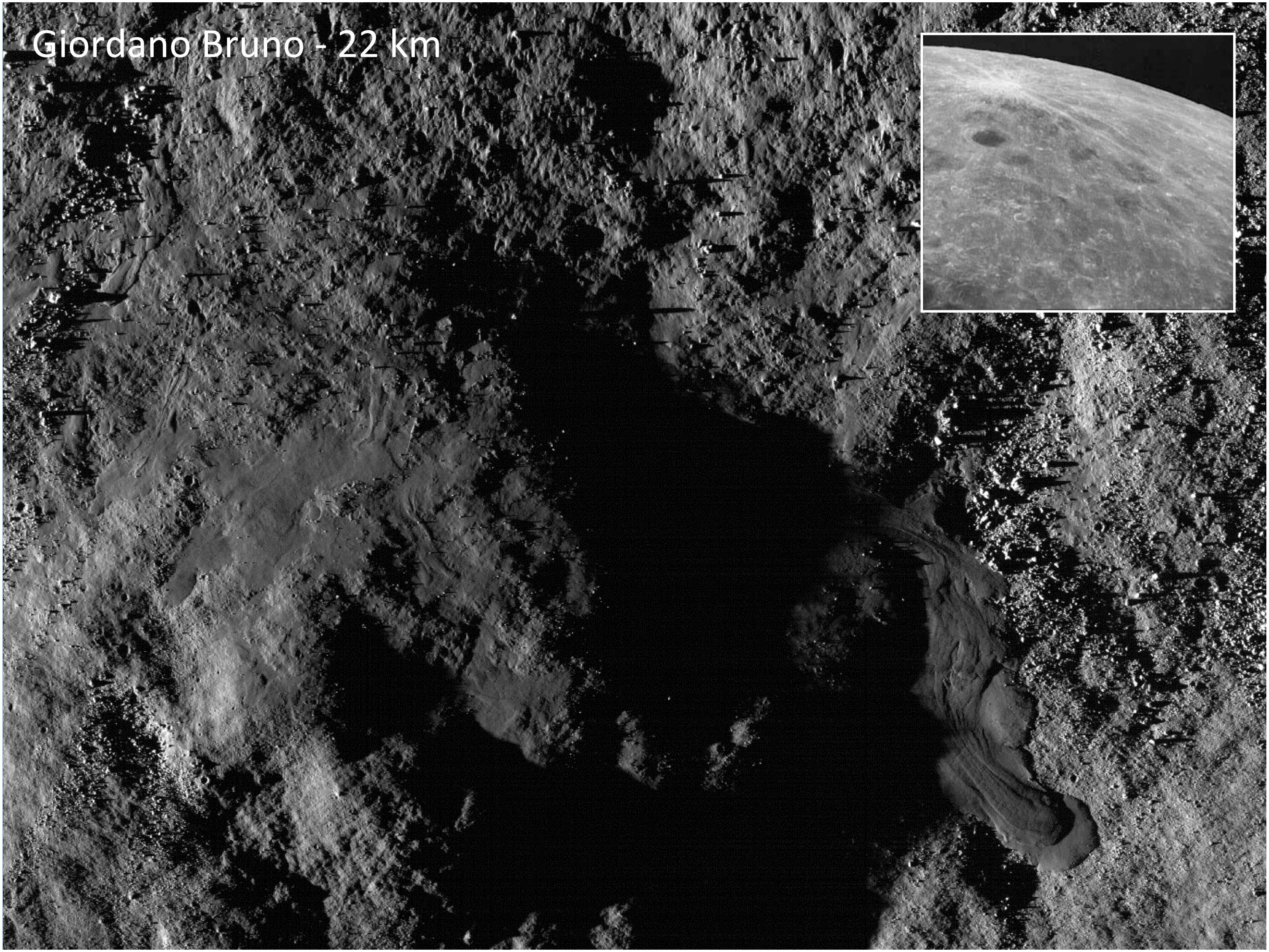

Korolev X, 28 km
300 m

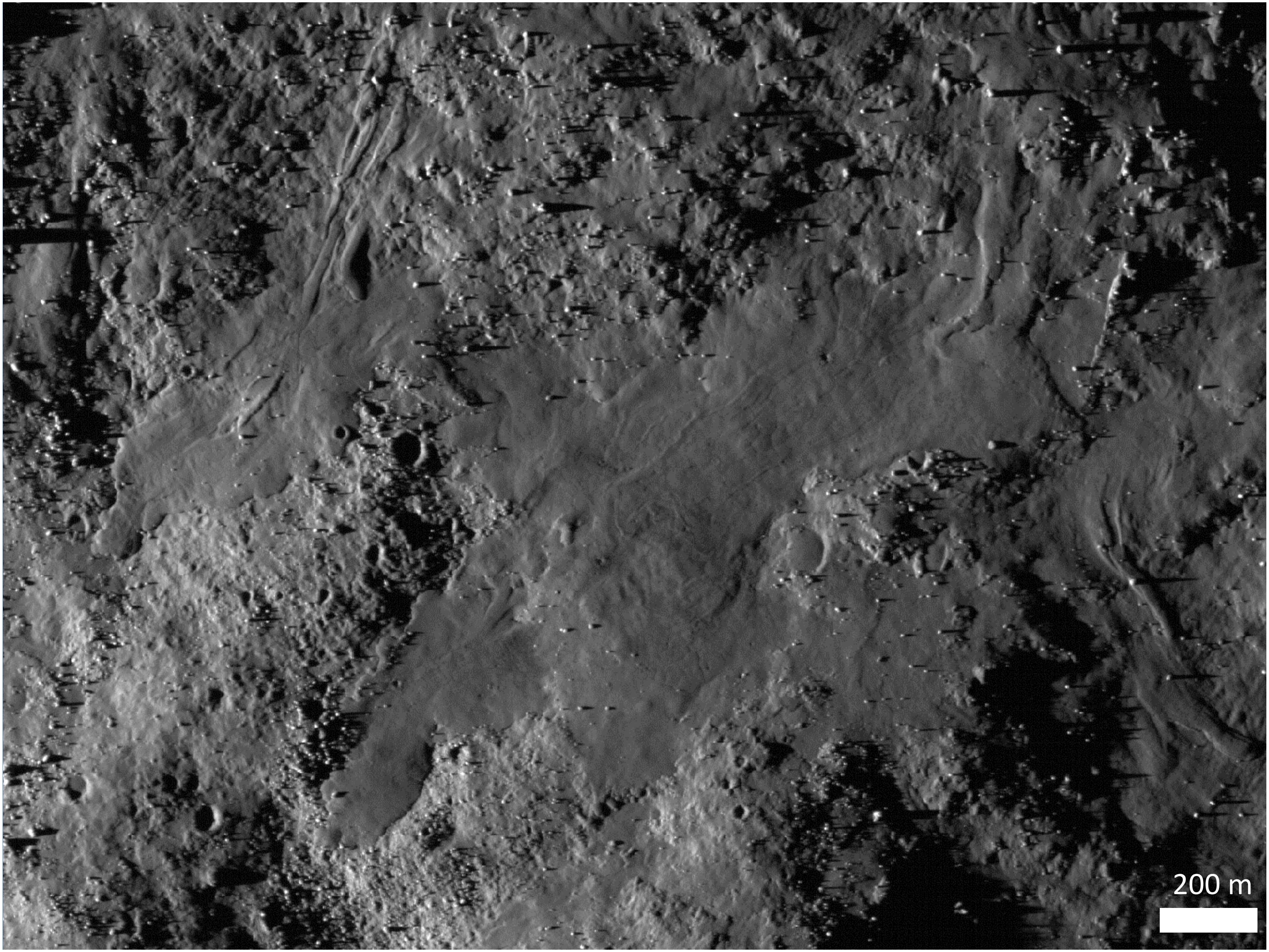

250 m

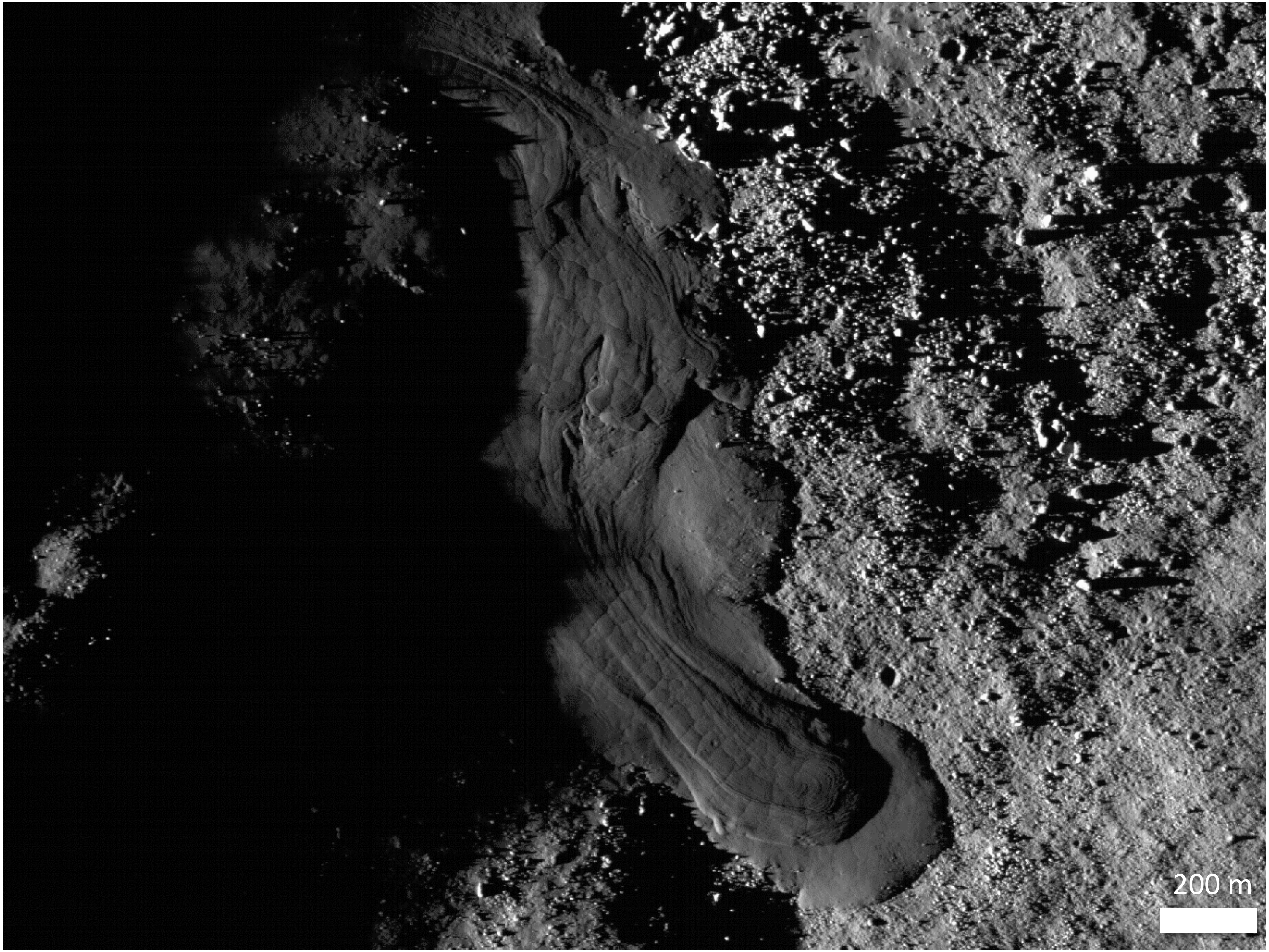

100 m


100 m

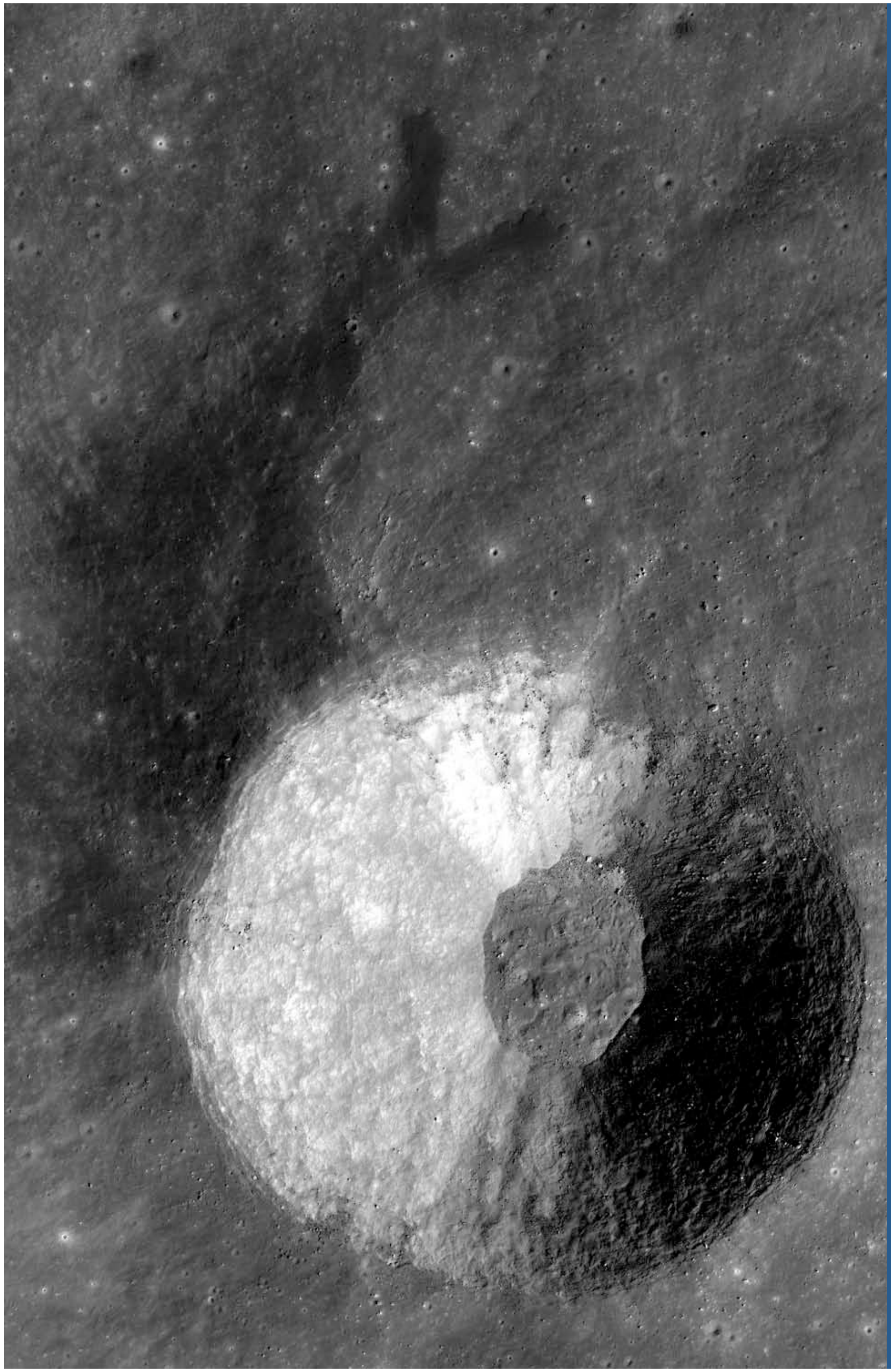

200 m


Giordano Bruno - 22 km


200 m


200 m

Large range in melt volumes

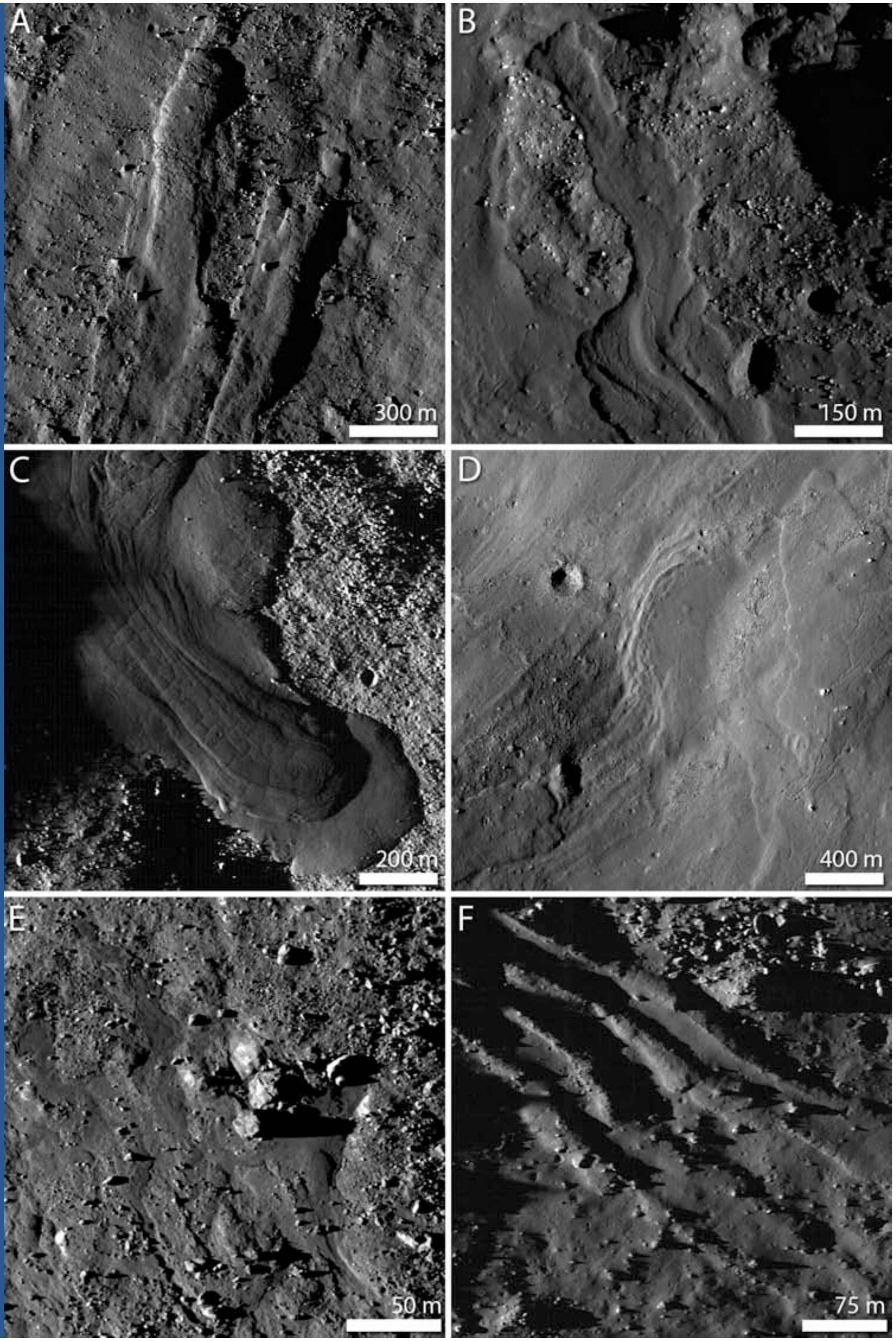


Unnamed crater, 3 km in diameter
30°N, 161°E

Impact melt flows

Emplacement setting, morphology, flow dimensions can provide clues to physical properties of the melt immediately after formation:

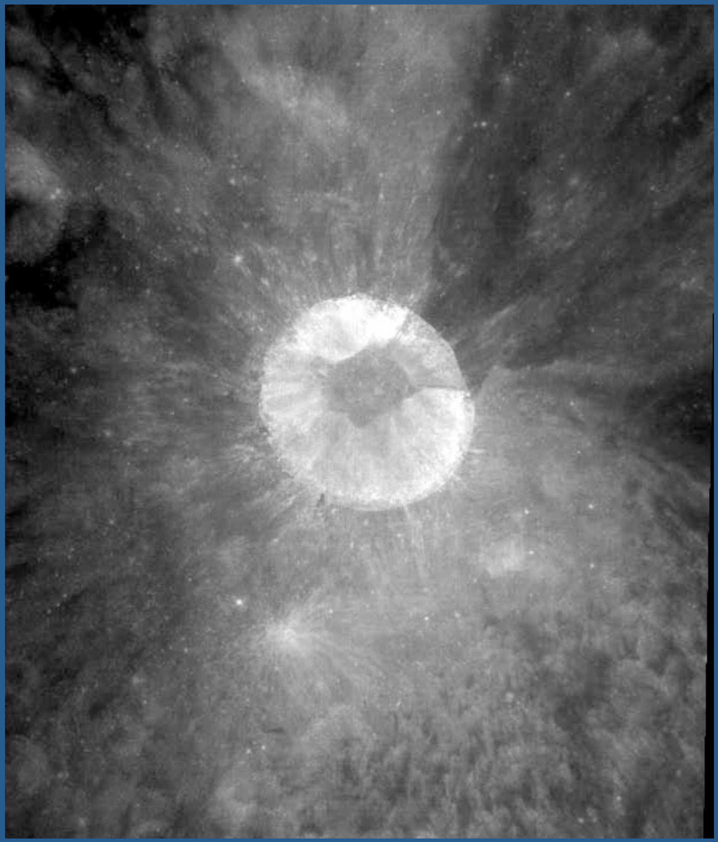
- Yield Strength
- Viscosity
- Temperature



General Observations

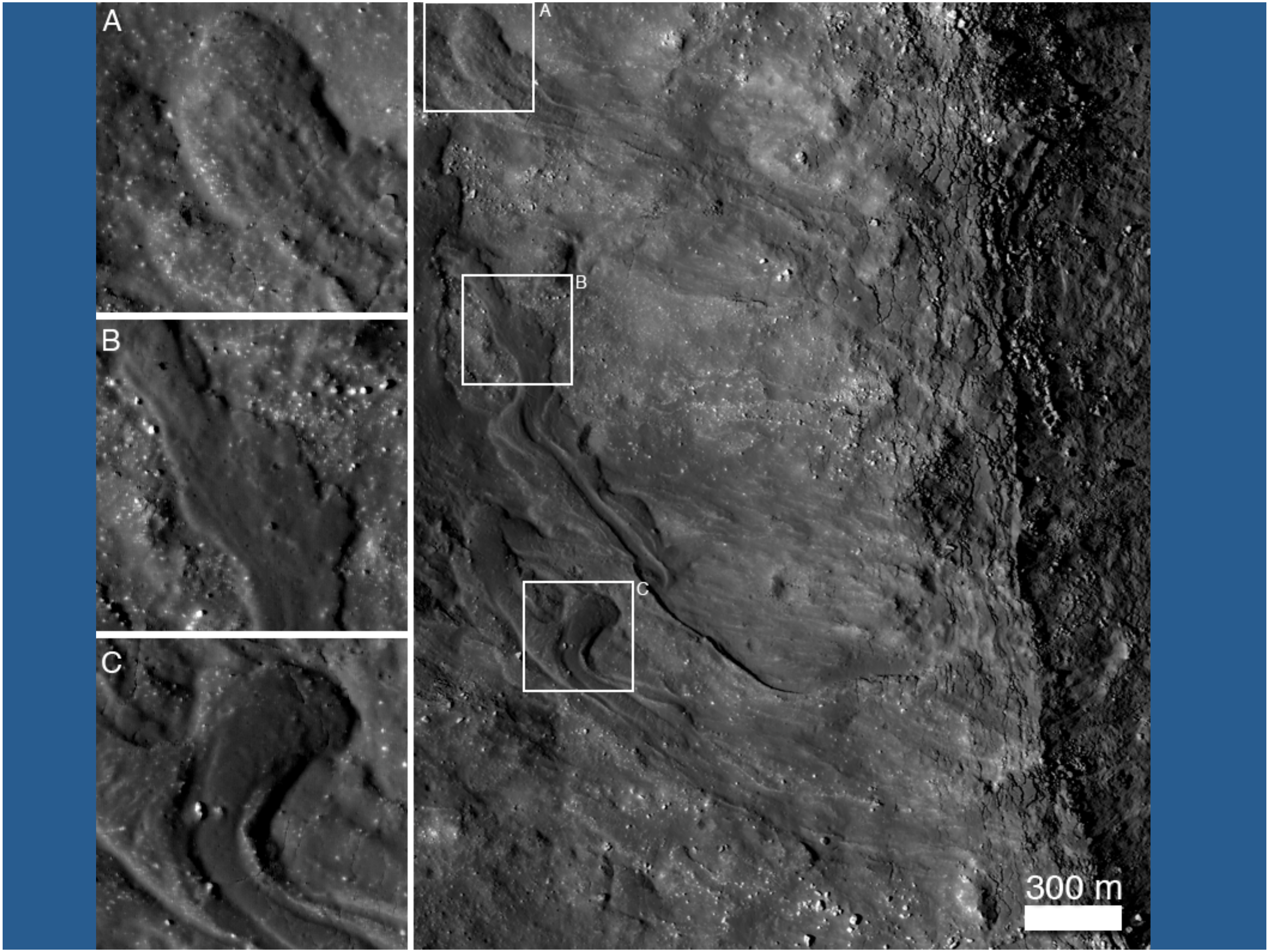
- Flows start at rim or 1000s of m away
- Overlie blocky ejecta
- Ejected at very end of excavation stage of crater formation
- Large volumes of melt ejected at relatively low velocity
  - Horizontal velocity component often small
- Morphologies often similar to terrestrial basaltic flows

Mandel'shtam F



17 km in diameter
Farside highlands (5.2° N, 166.2° E)

M108148884CE
M103424431ME


A
B
C
A
B
C
300 m

Digital Terrain Model

Targeted off-nadir observations (M115231170 and M115224385)

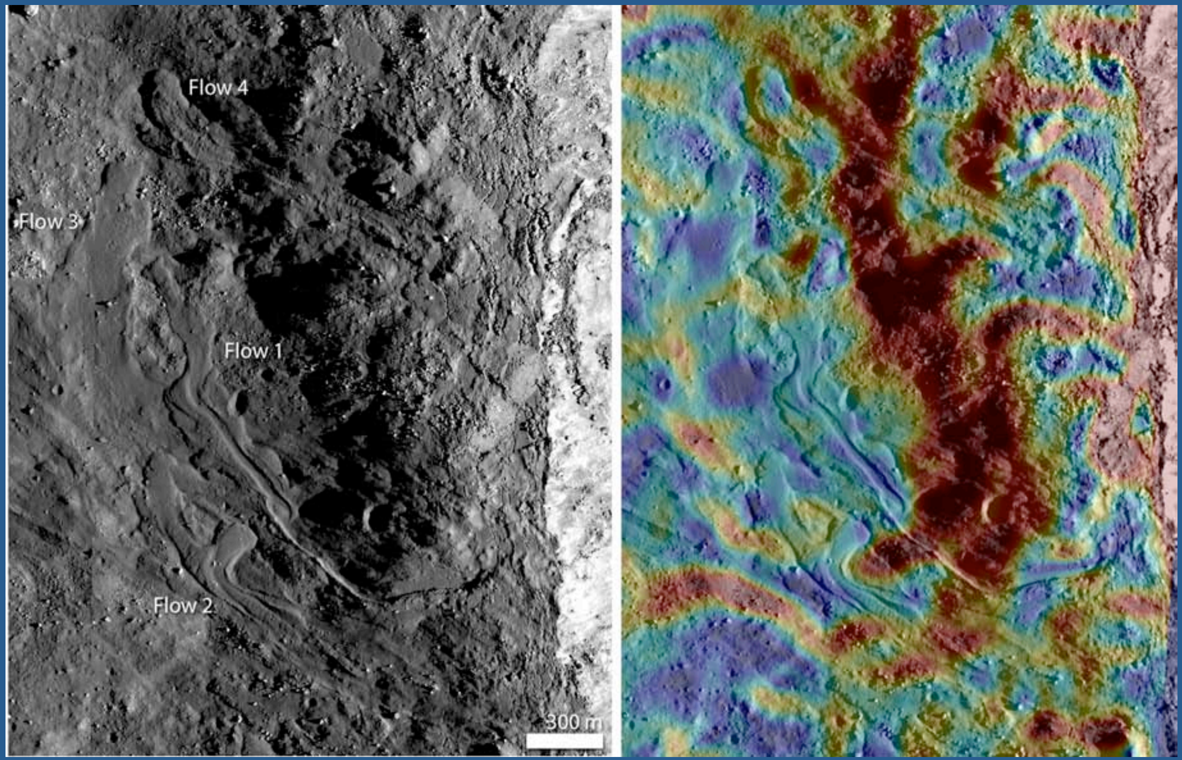
Convergence angle = 28.8°

Incidence angle 71°

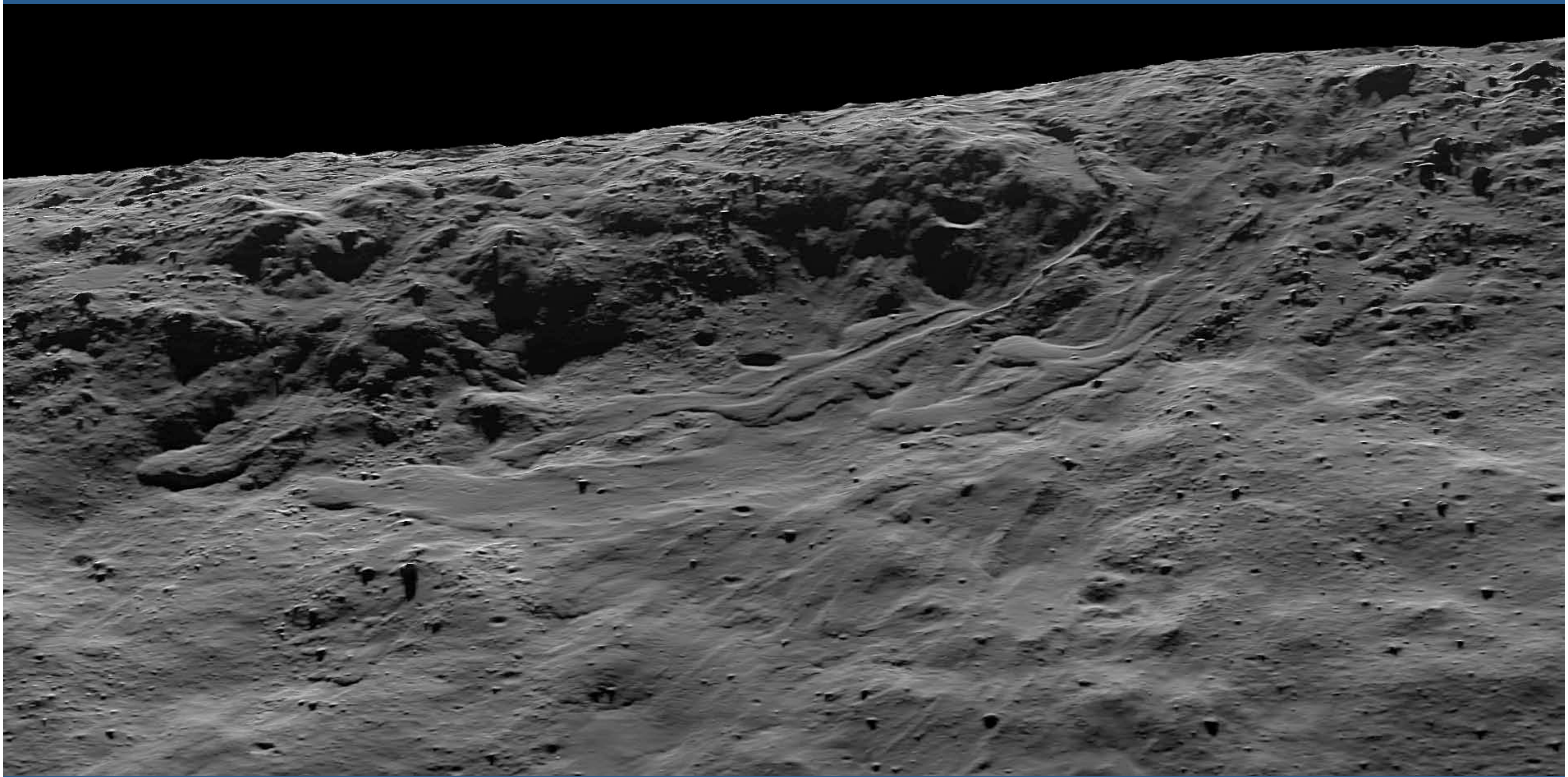
Resolution 0.99 m/pixel (summed mode)

SOCET SET Toolkit used to create DTM at 3 m/pixel

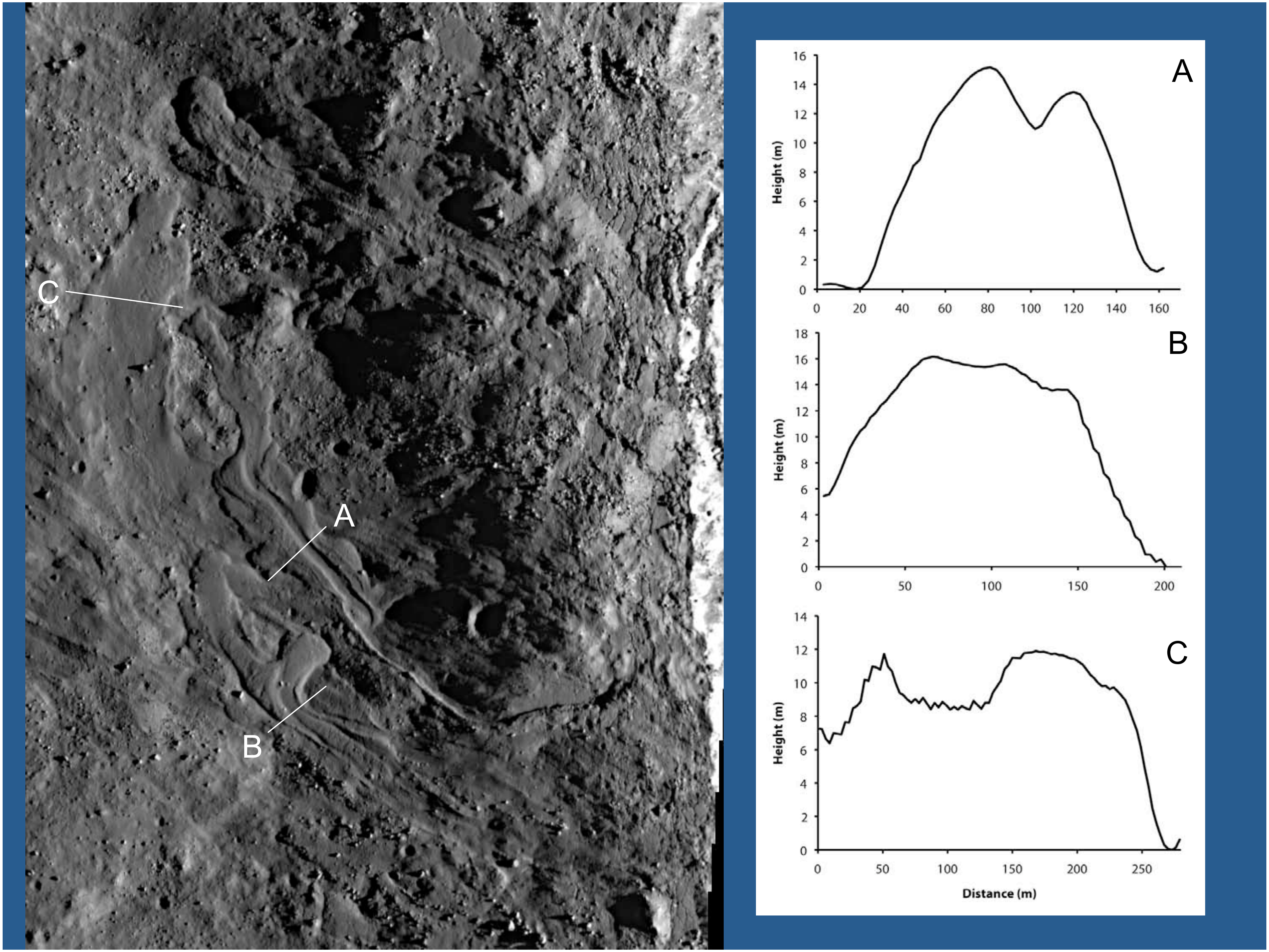
Tied to LOLA



Slope map
Red: 19° - Blue: 1°



15x vertical exaggeration



C
A
B
A
Height (m)
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
120
140
160
B
Height (m)
0
2
4
6
8
10
12
14
16
18
0
50
100
150
200
C
Height (m)
0
2
4
6
8
10
12
14
0
50
100
150
200
250
Distance (m)

Yield strength

$$\tau_y = \rho g d \sin(\theta)$$

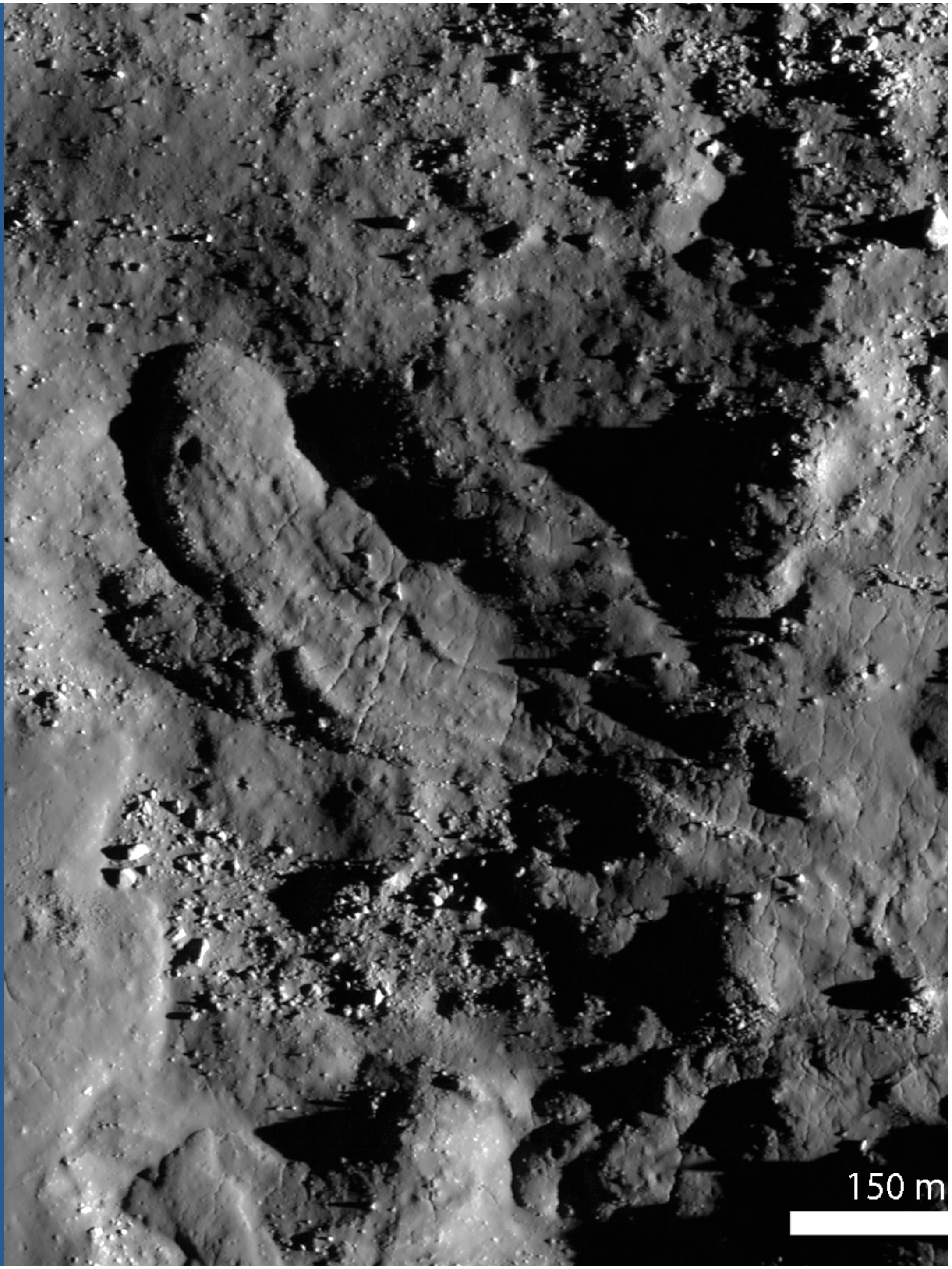
$$\tau_y = \rho g \frac{d^2}{w}$$

Resistance that must be overcome before material can flow

Input parameters: density, gravity, thickness, width, slope

Mean yield strength estimates range from $10^3 - 10^4$ Pa

Typical terrestrial basaltic values are an order of magnitude higher ($10^4 - 10^5$ Pa)
(Fink and Zimbleman, 1986; Moore et al. 1978)



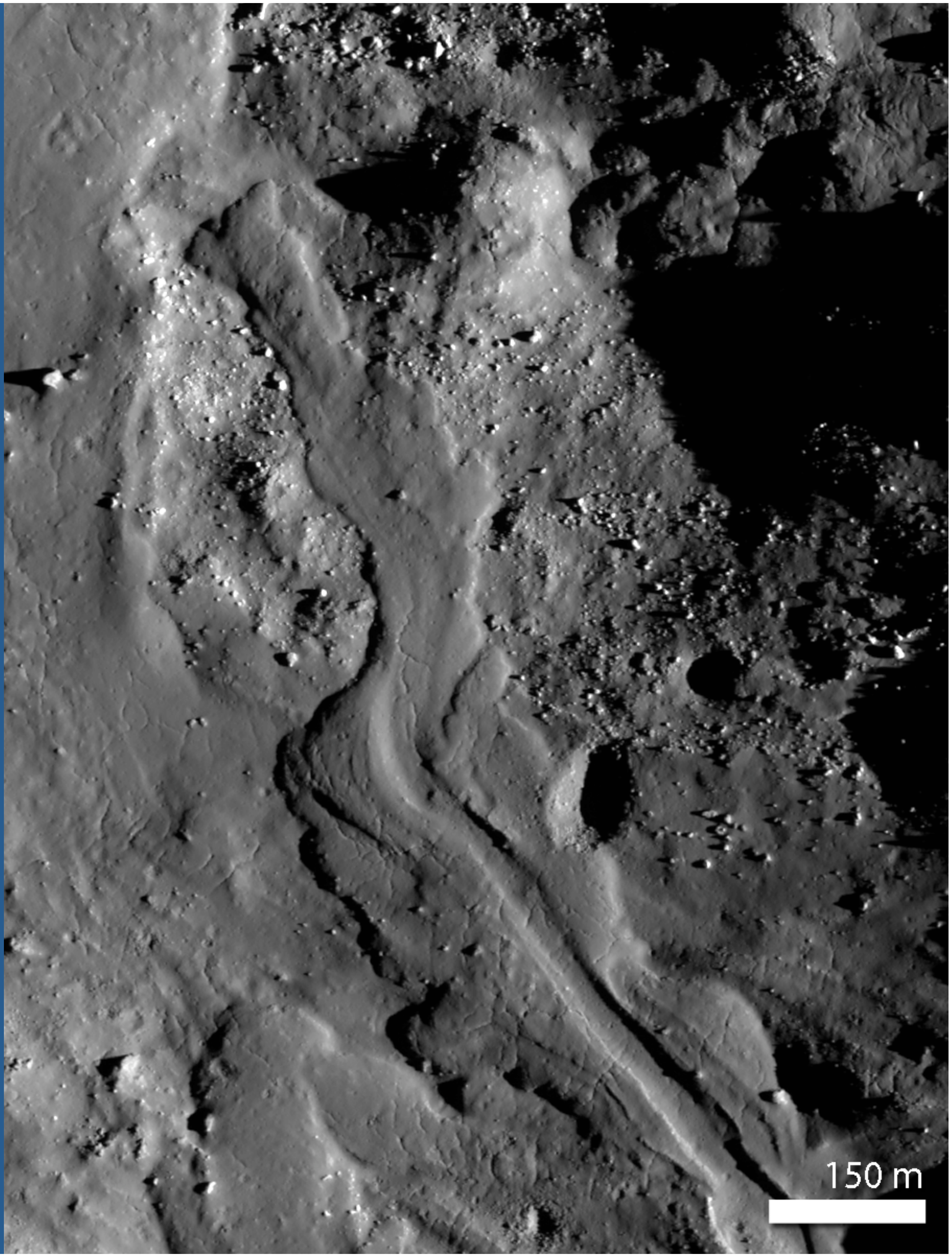
Viscosity

Viscosity related to yield strength
$(\tau_y/\eta)^{1/3}$ = 0.2-0.6 $s^{-1/3}$

Mean effective viscosities also low compared to terrestrial basalts
~10^5 Pa s (impact melt) vs. ~10^6 Pa s (basalt)

Compositional differences would lead to higher viscosity for feldspathic material, compared to basalt at same temperature

Much higher temperatures for impact melt (>1400°C)

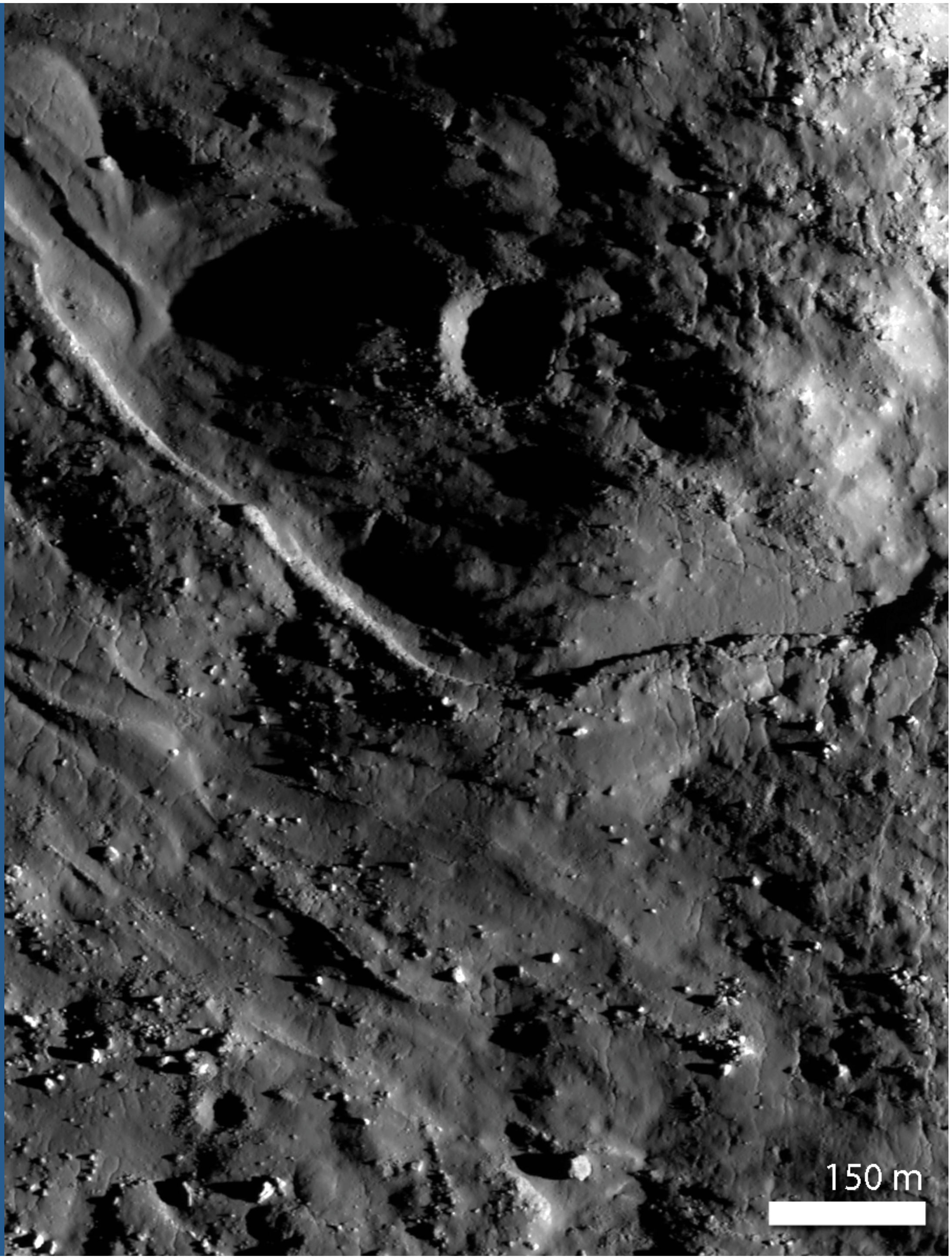


Flow duration

Flows appear to be volume-limited

Ceased flowing because exhausted their source rather than because of cooling

Flow duration 10s of minutes



Summary

- NAC observations commonly reveal well-preserved impact melts associated with Copernican craters
- Precise DTMs enable detailed rheologic modeling of impact melt properties
- Modeling suggests low viscosities, high temperatures
- Current modeling technique very basic, large error bars
- High temperatures in spite of potentially high clast content
- Image data consistent with sample inference and impact modeling that impact melts have high temperature
- Large range in volume of melt produced?