Luna Resource / Glob Missions: Selection of landing sites

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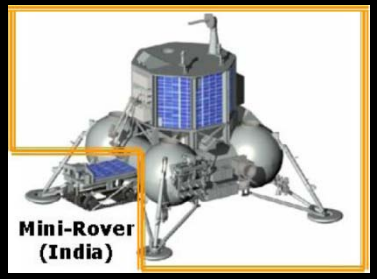


Landing Site Selection for LUNA-GLOB mission

International Workshop #2
Moscow, Institute for Space Research (IKI), May 31 – June 2, 2011

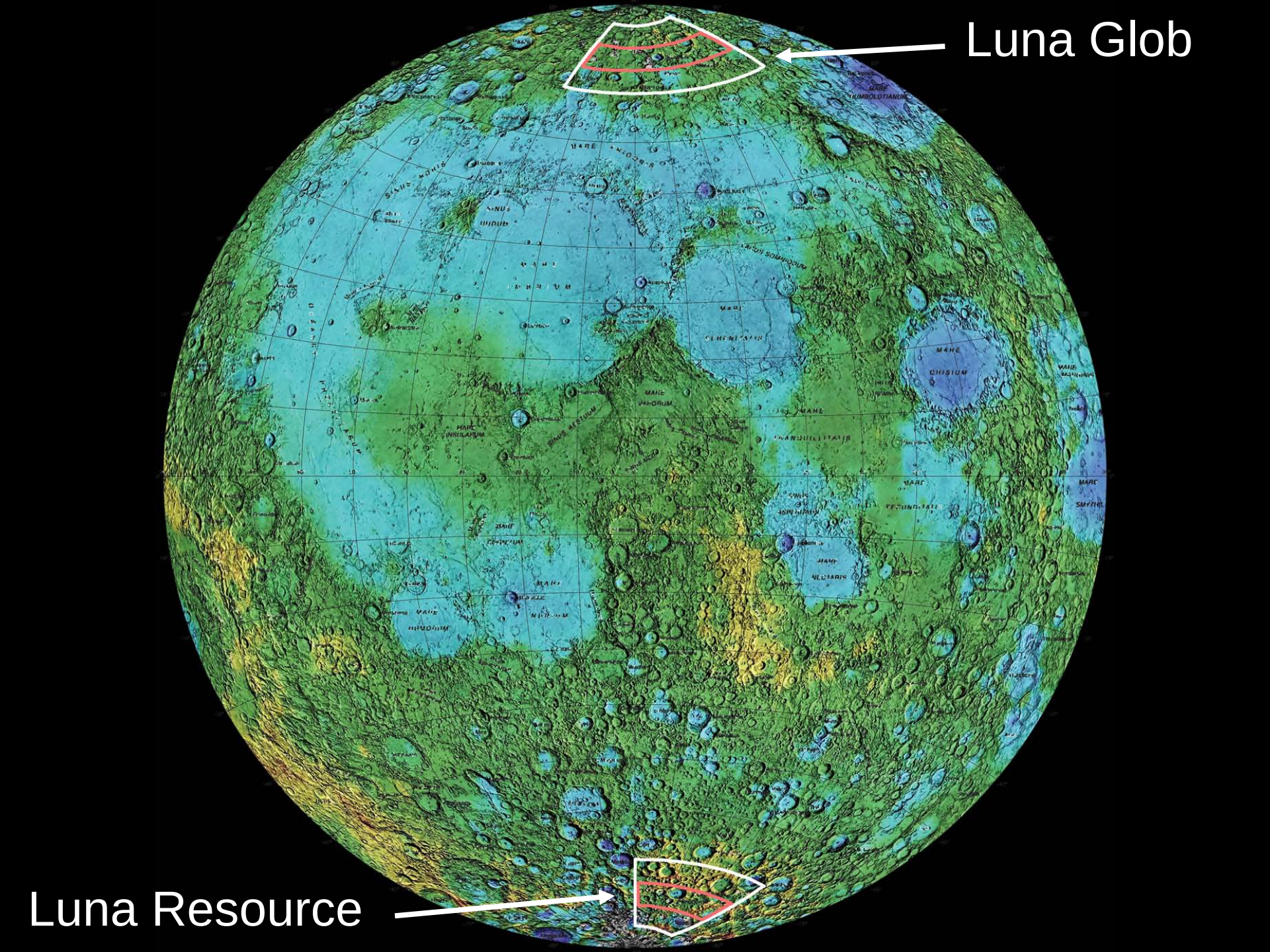
Scientific tasks of Luna Glob and Luna Resource missions (landers)

Task 1. Study of volatiles in polar areas of the Moon and understanding of mechanisms of their accumulation. This is the major task of the mission(s).

Task 2. Compositional studies of ejecta from the South Pole-Aitken basin (for Luna Resource).

Task 3. Study of internal structure of the Moon.

Task 4. Study of interaction of interplanetary plasma with lunar surface.


Luna Glob
Luna Resource

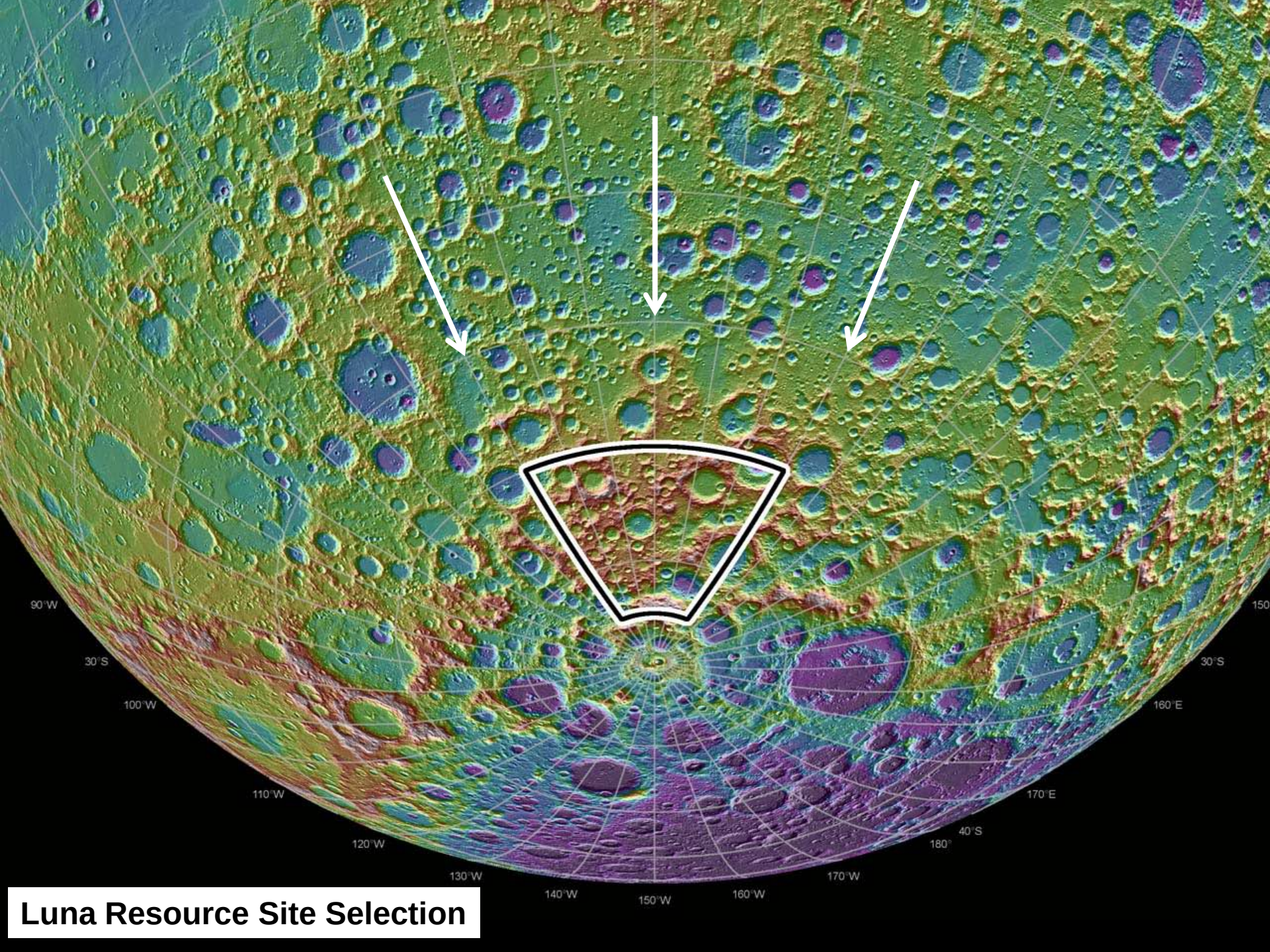
Three steps in the landing site selection

Successive approach. We used it this spring:

1) Study of frozen volatiles demands landing in the area rich in volatiles (hydrogen):
   => Space Research Institute, Moscow, based on LEND data, determines positions & makes list of potential landing sites.

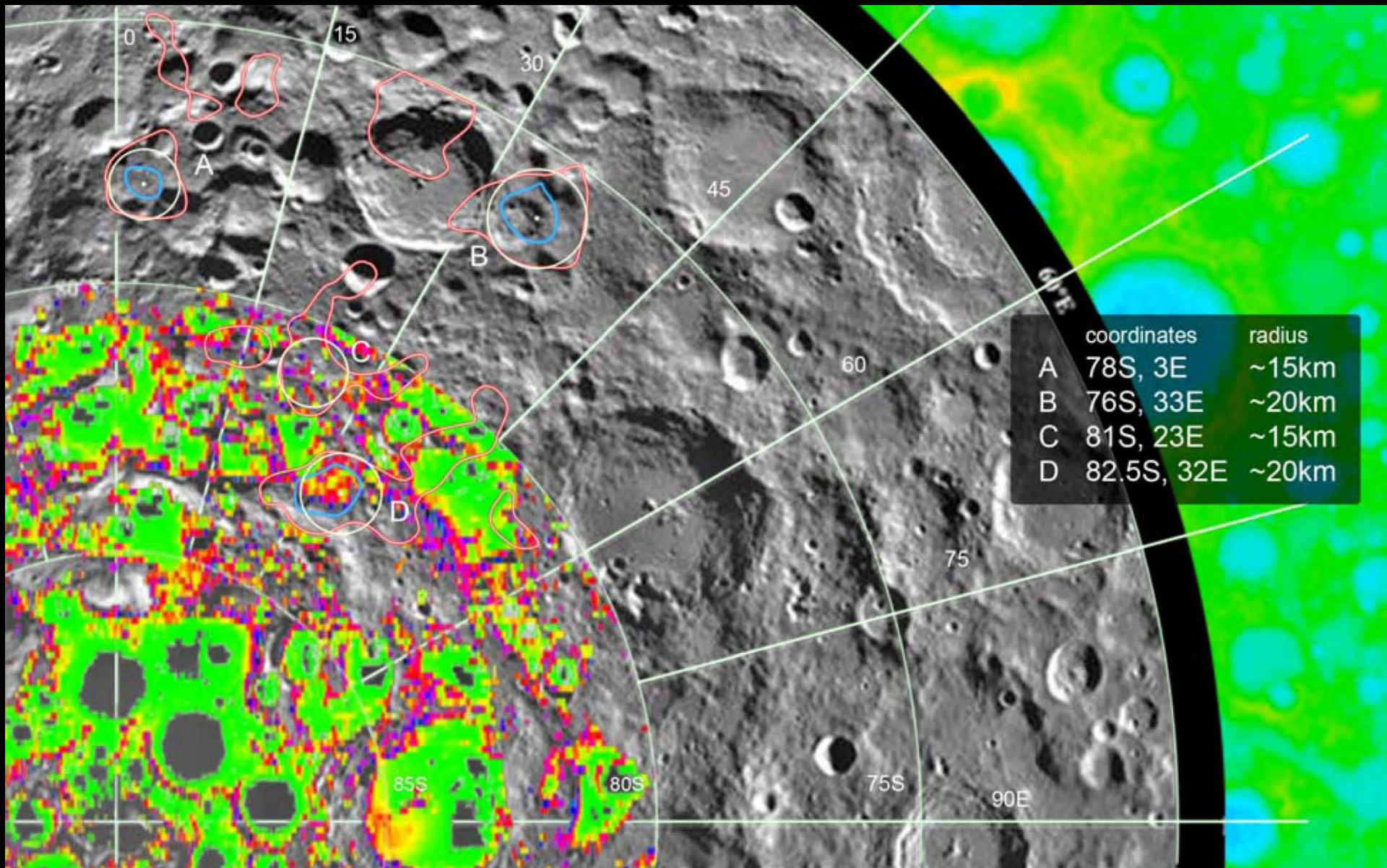
2) Landing sites should have rather smooth surface and no prominent km-scale topography along the descent track:
   => Vernadsky Institute, Moscow, based on available images and topographic data, determines positions of the landing ellipses and selects the least risky sites.

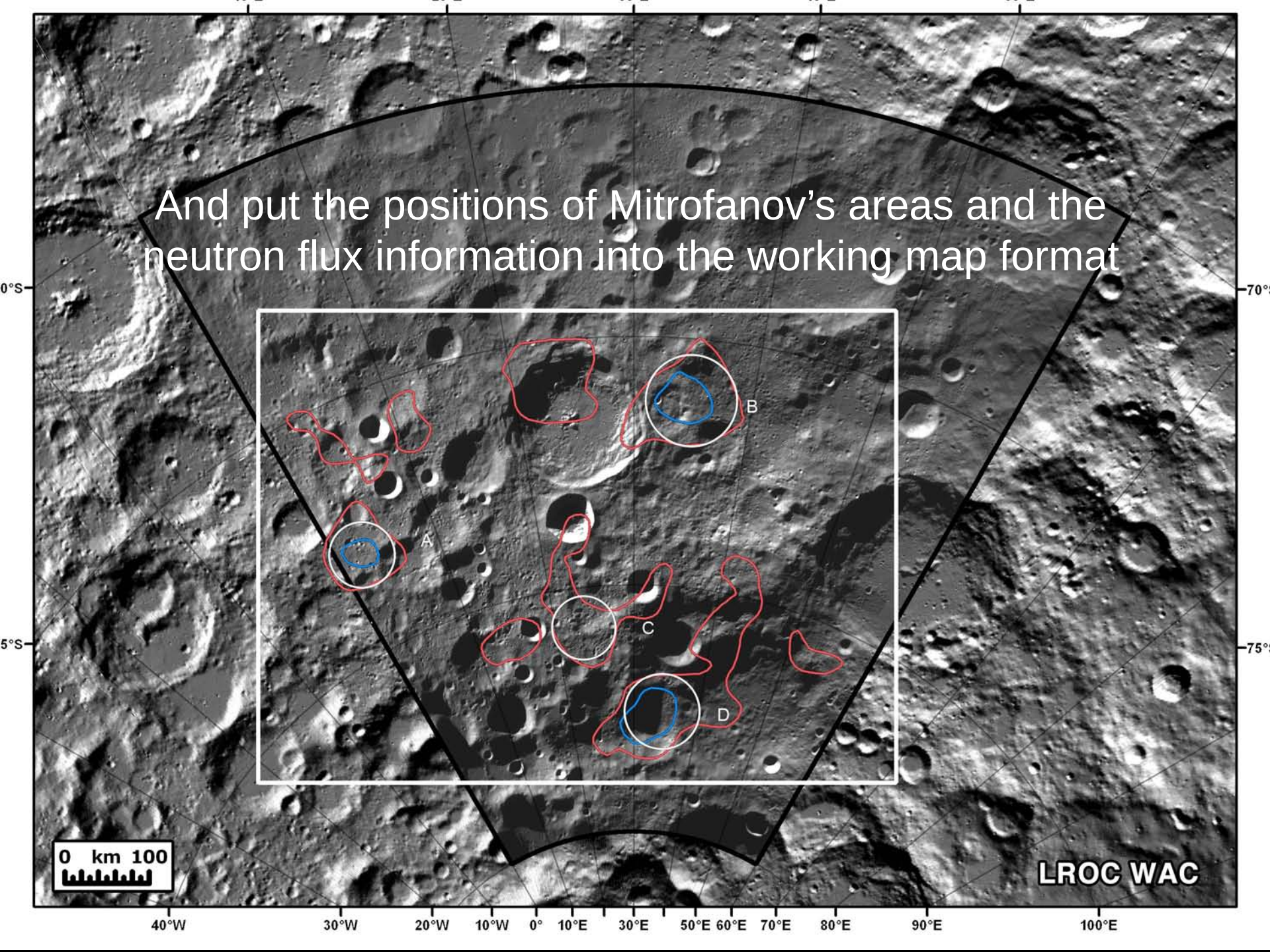
3) Landing site should be not in permanently shadowed area and be in direct visibility from Earth:
   => Sternberg Institute, Moscow, based on parameters of lunar orbit and local topography calculates solar illumination conditions and visibility from Earth within the selected sites/ellipses.

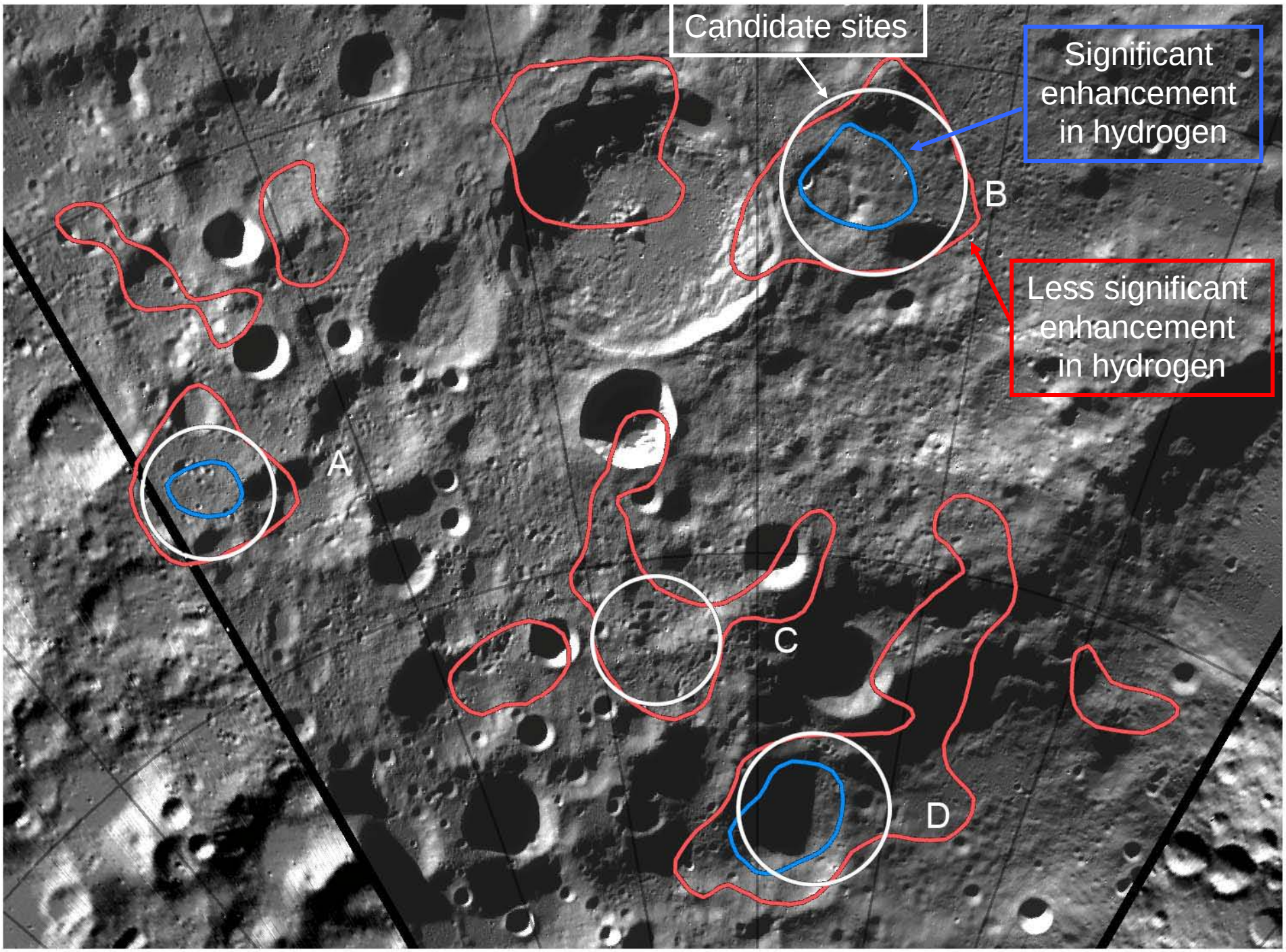


Luna Resource Site Selection

On March 29 we have received the list & positions of the landing sites from Igor Mitrofanov, Space Research Institute, Moscow



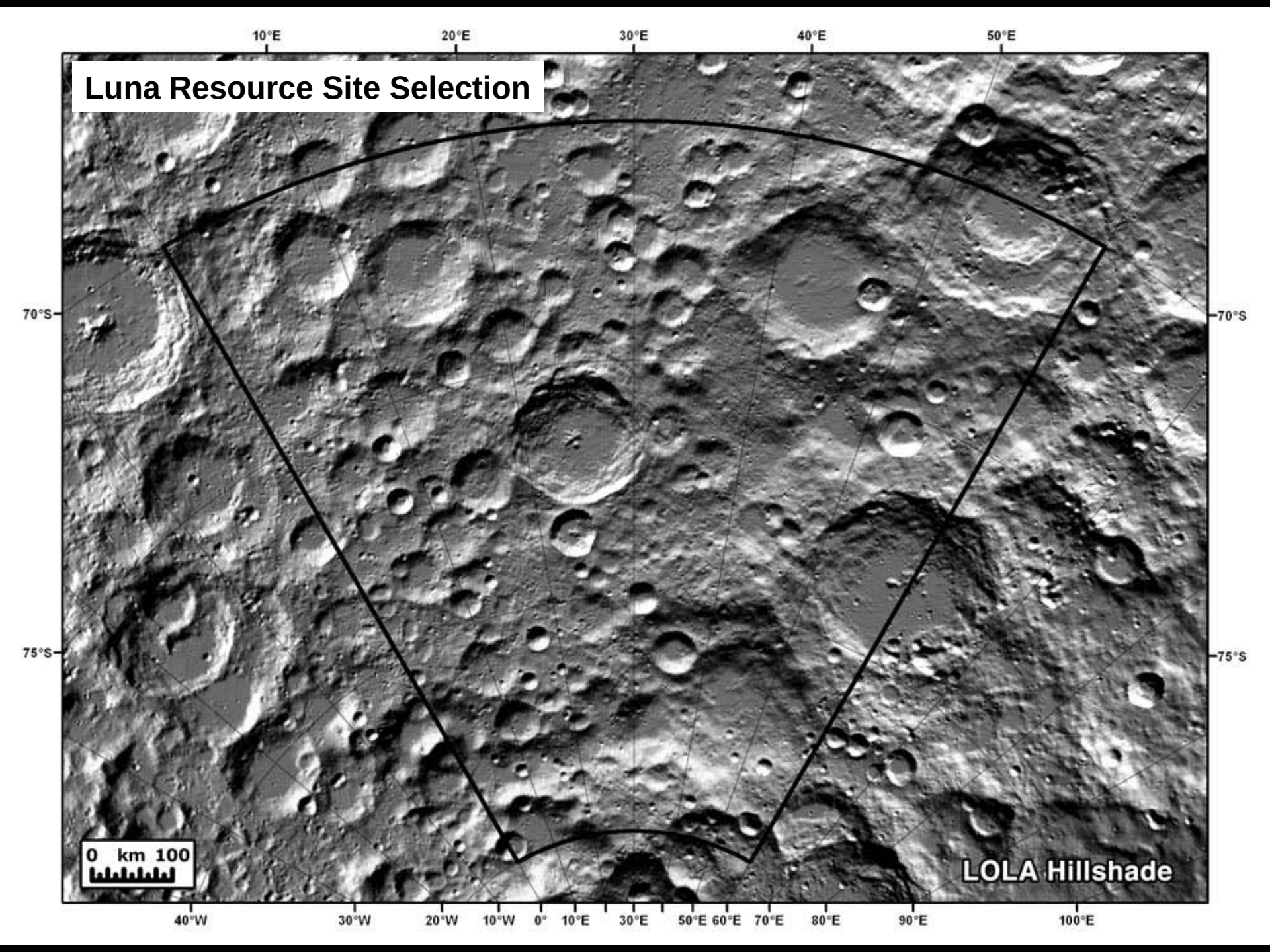

And put the positions of Mitrofanov's areas and the neutron flux information into the working map format
A
B
C
D
0 km 100
LROC WAC
0°S
5°S
70°
75°
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

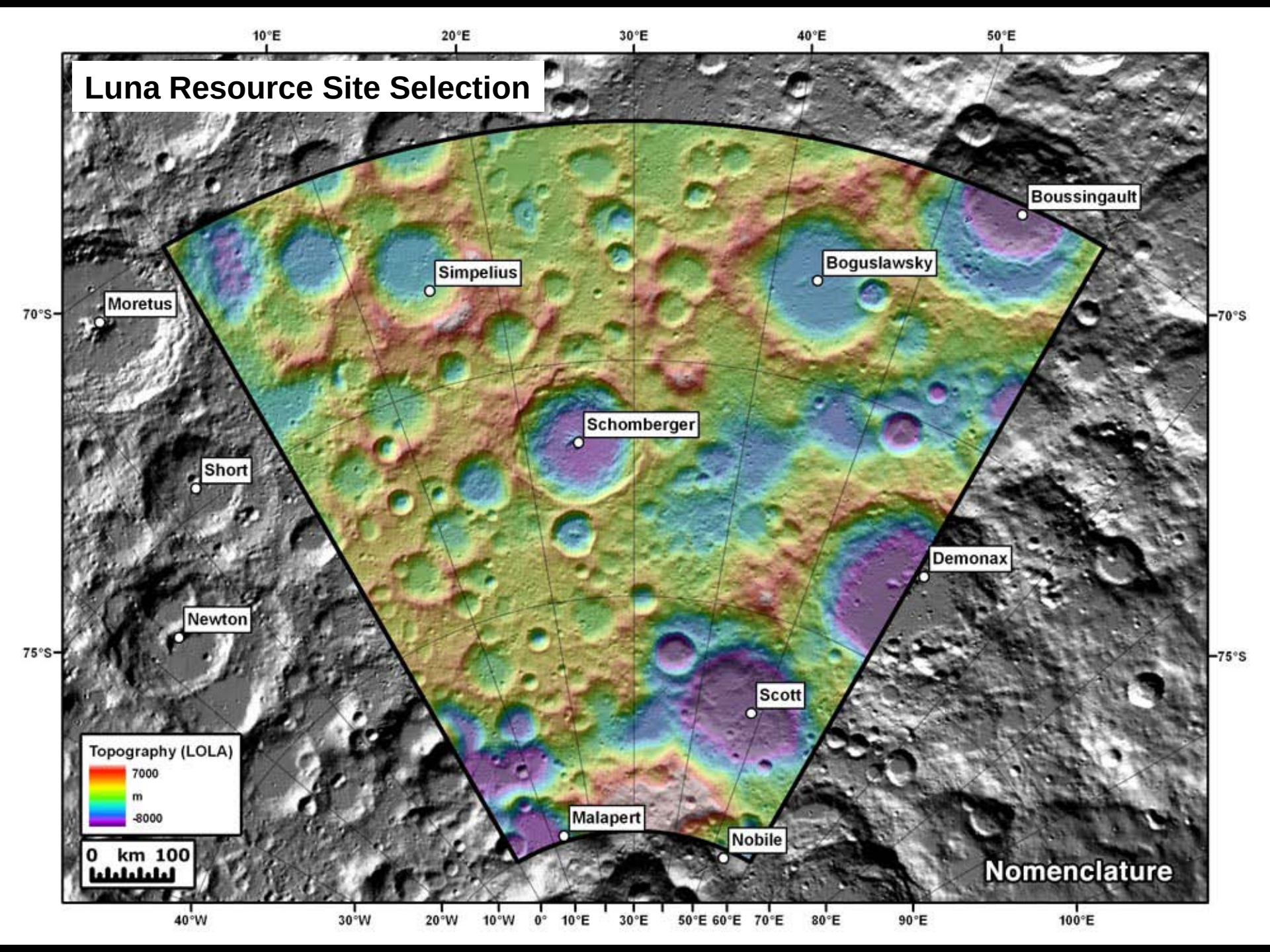

Candidate sites
Significant enhancement in hydrogen
Less significant enhancement in hydrogen
A
B
C
D

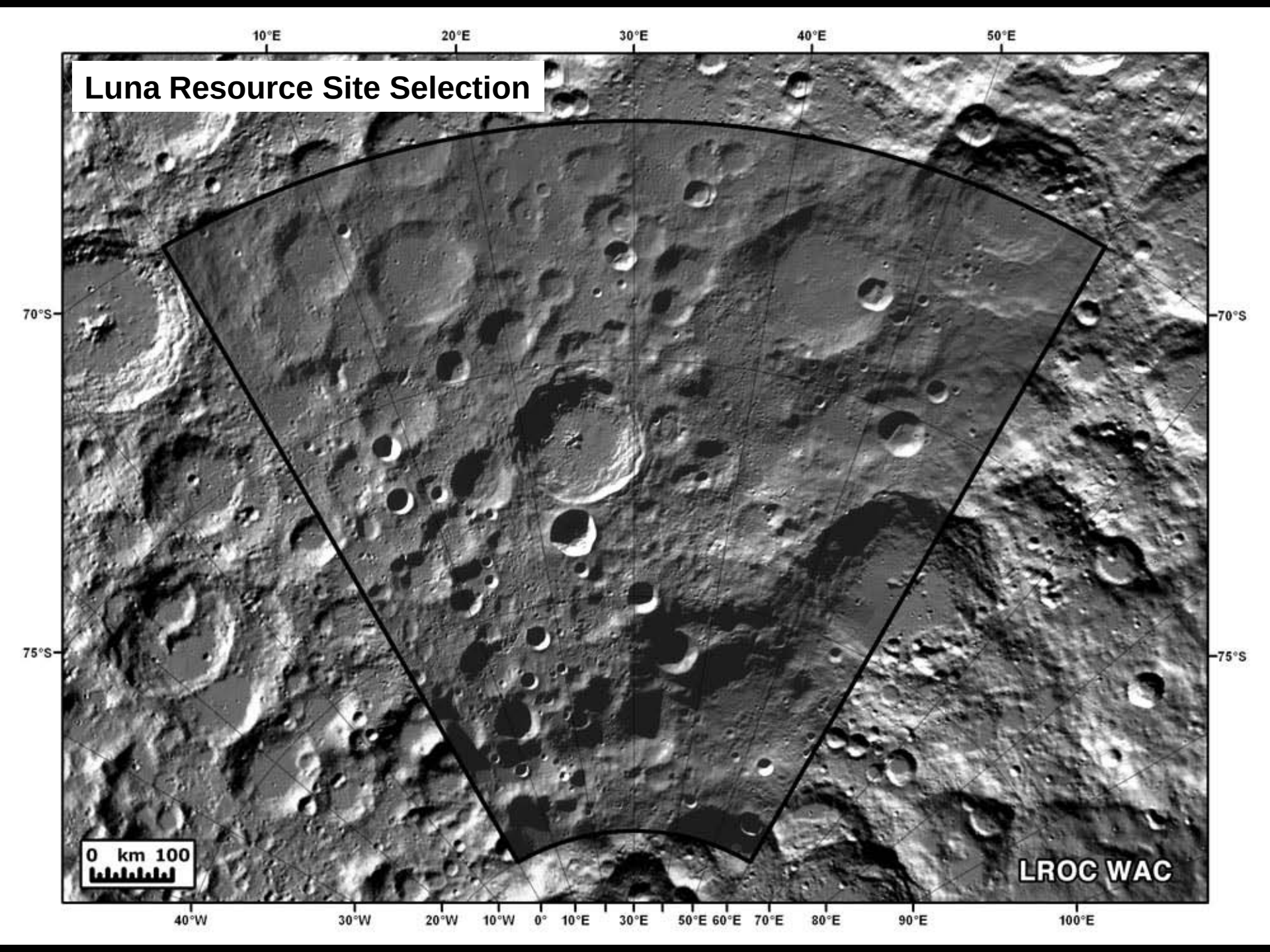
Surface characteristics in the potential landing sites

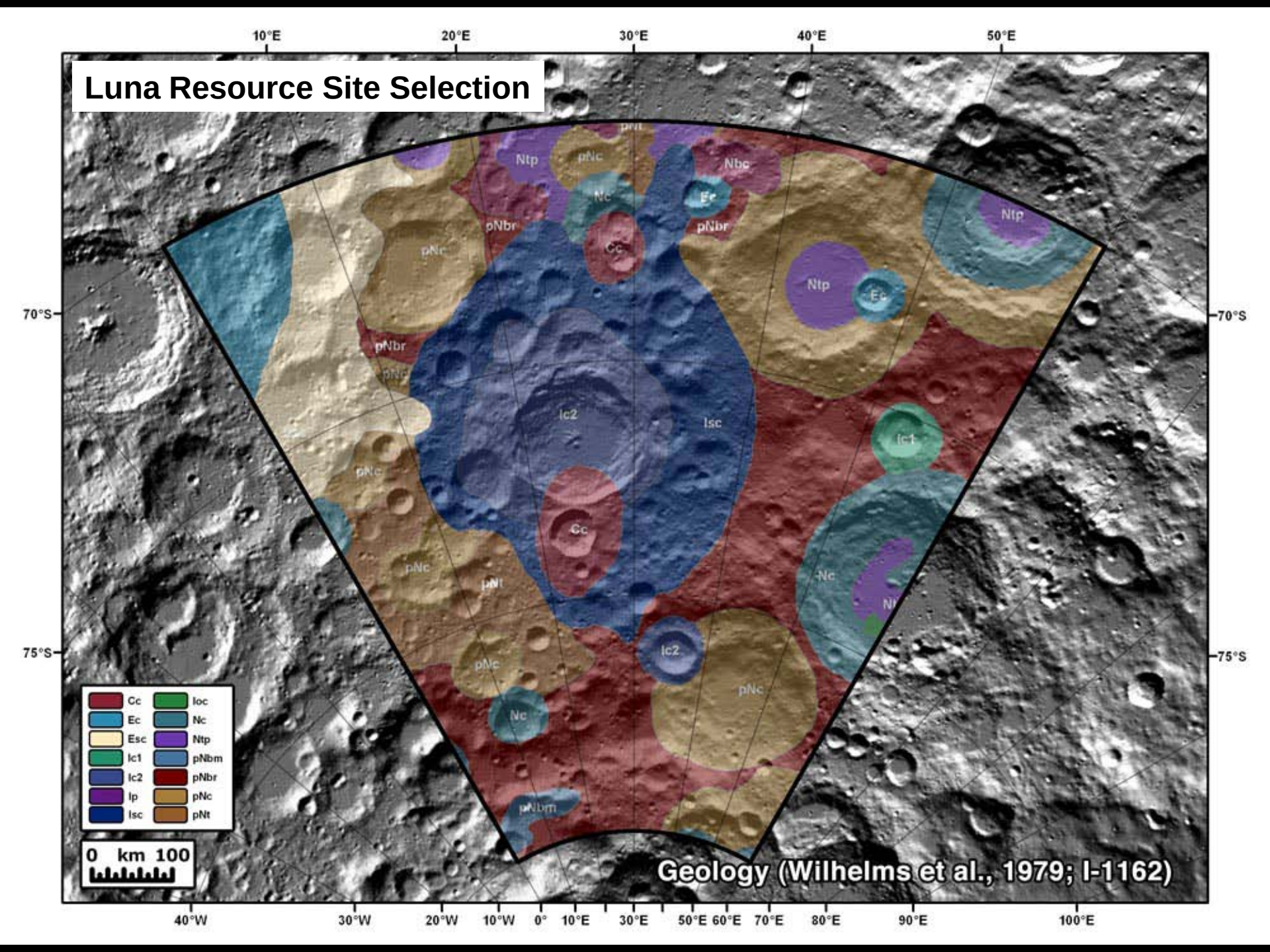
Sources of information:

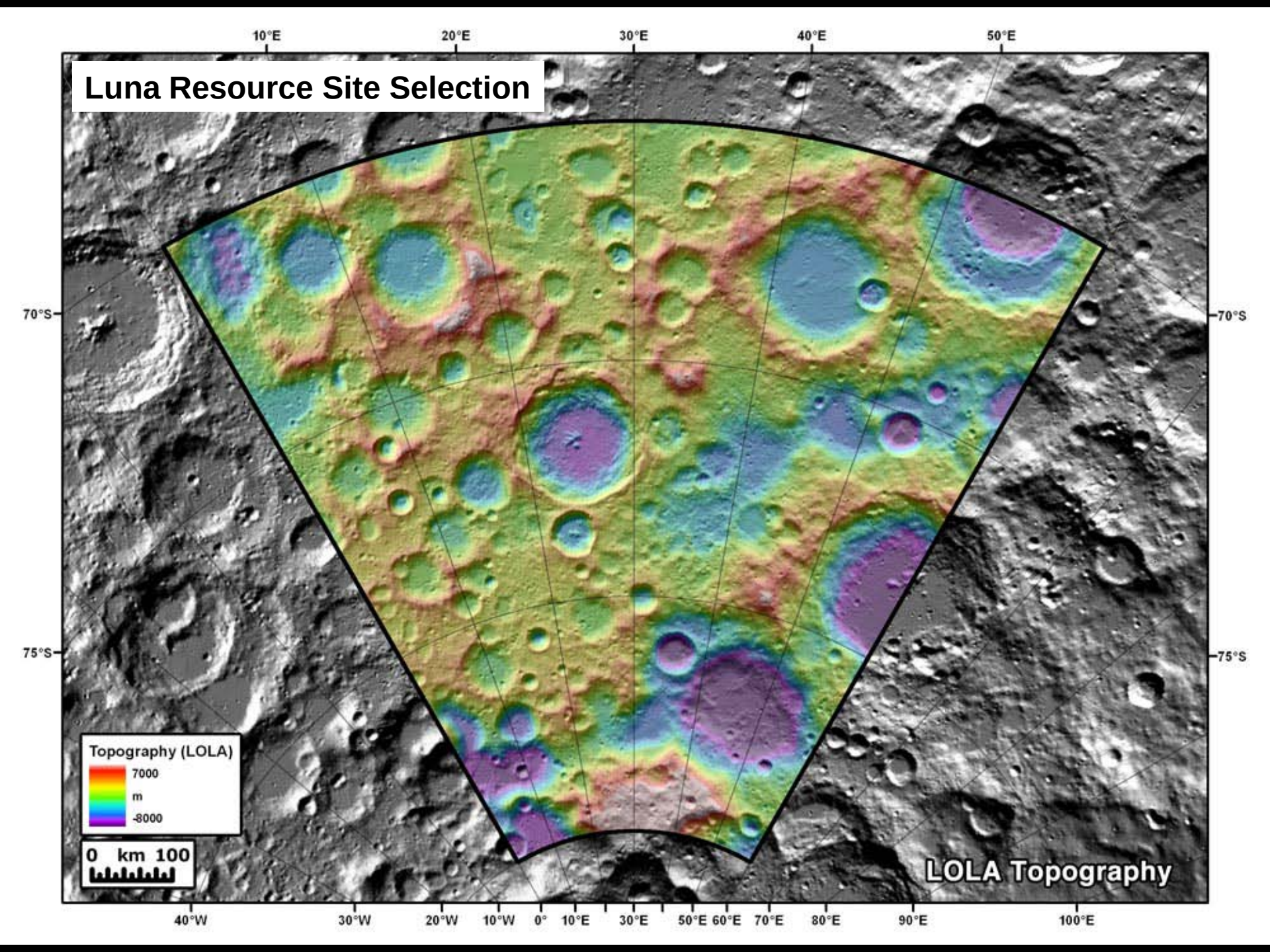
LROC WAC & NAC
LOLA
MINI-RF

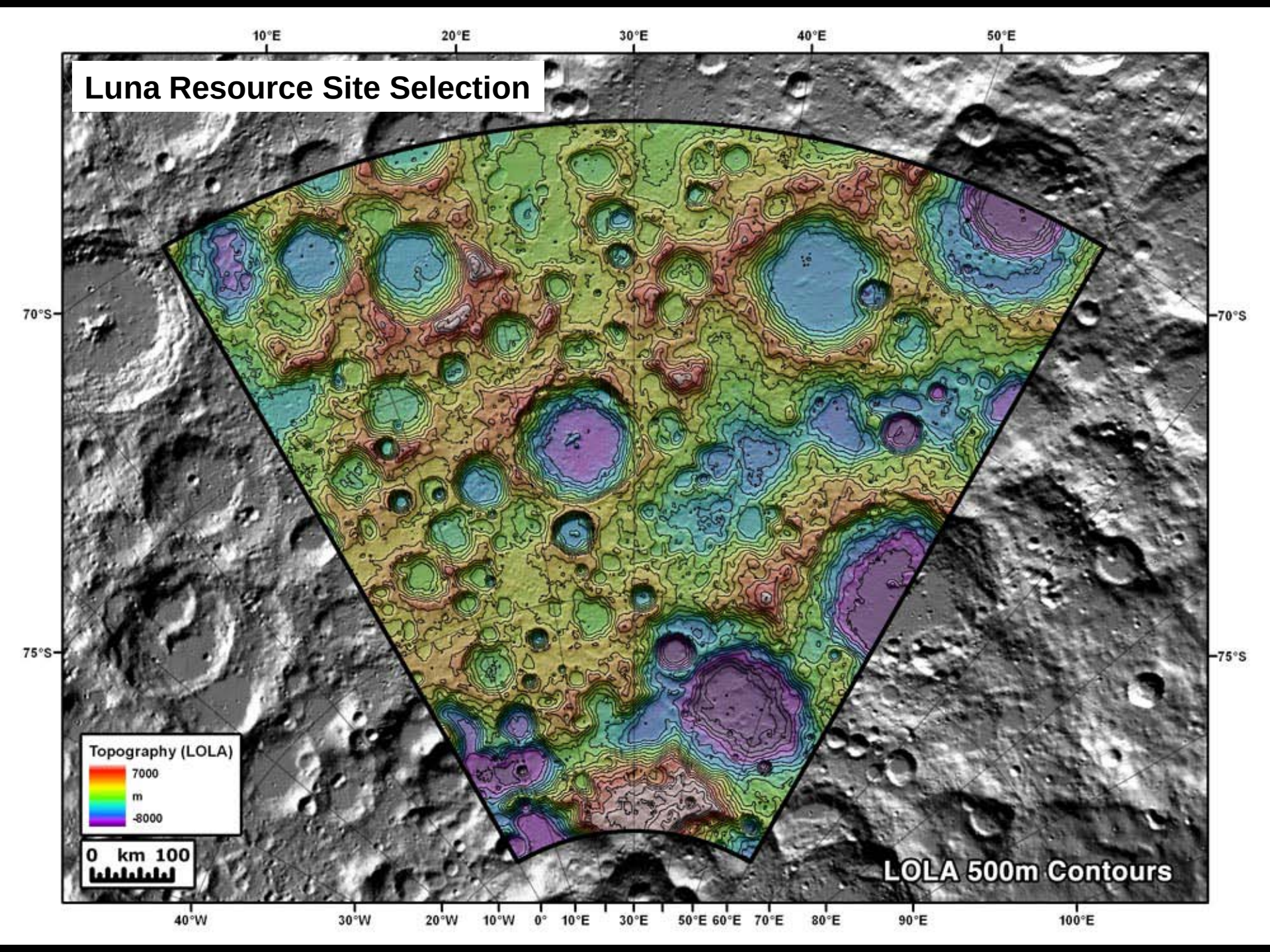

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
0 km 100
LOLA Hillshade
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

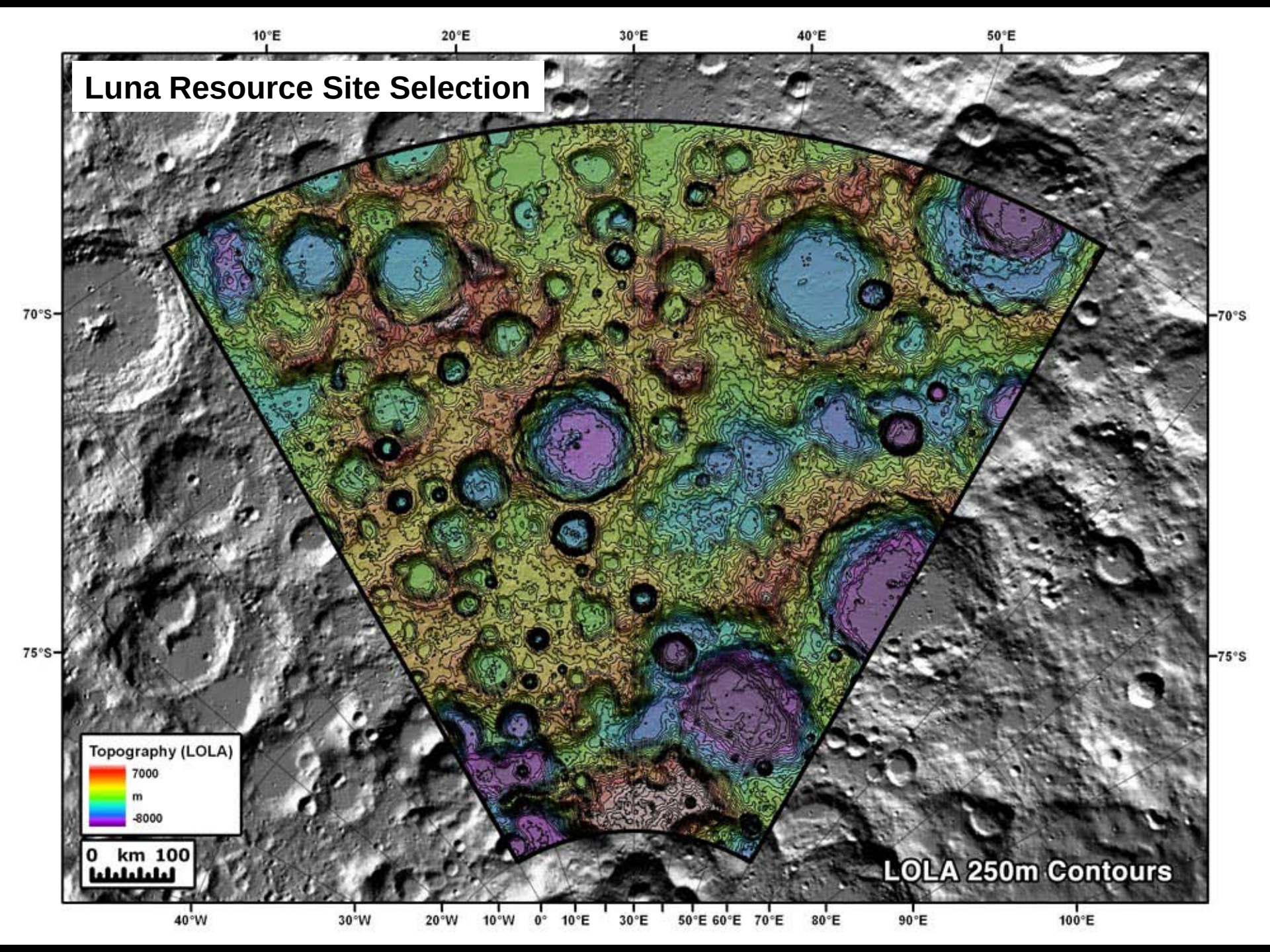

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
Boussingault
Simpelius
Boguslawsky
Moretus
Schomberger
Short
Demonax
Newton
Scott
Malapert
Nobile
Topography (LOLA)
7000
m
-8000
0 km 100
Nomenclature
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

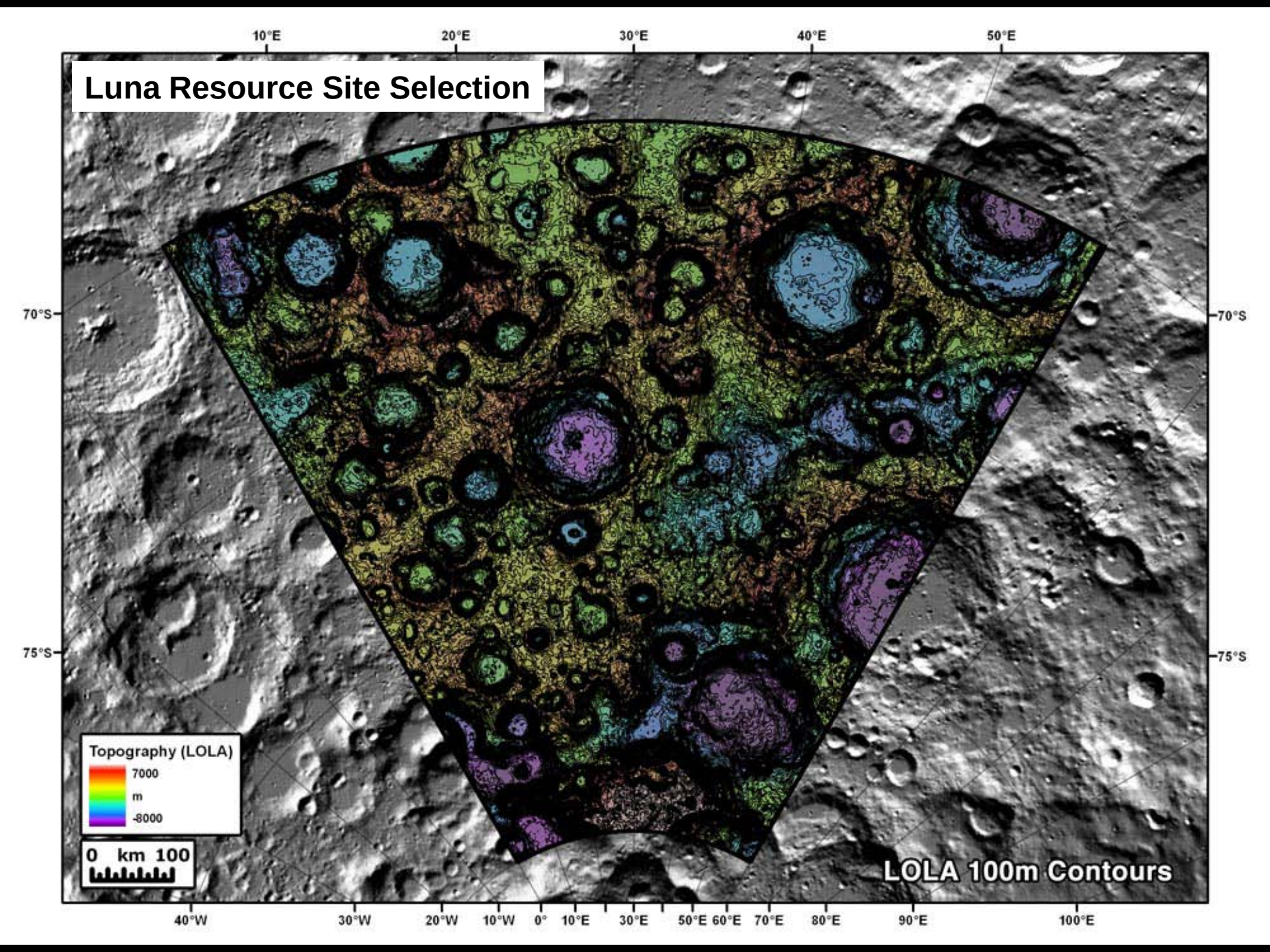

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
0 km 100
LROC WAC
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

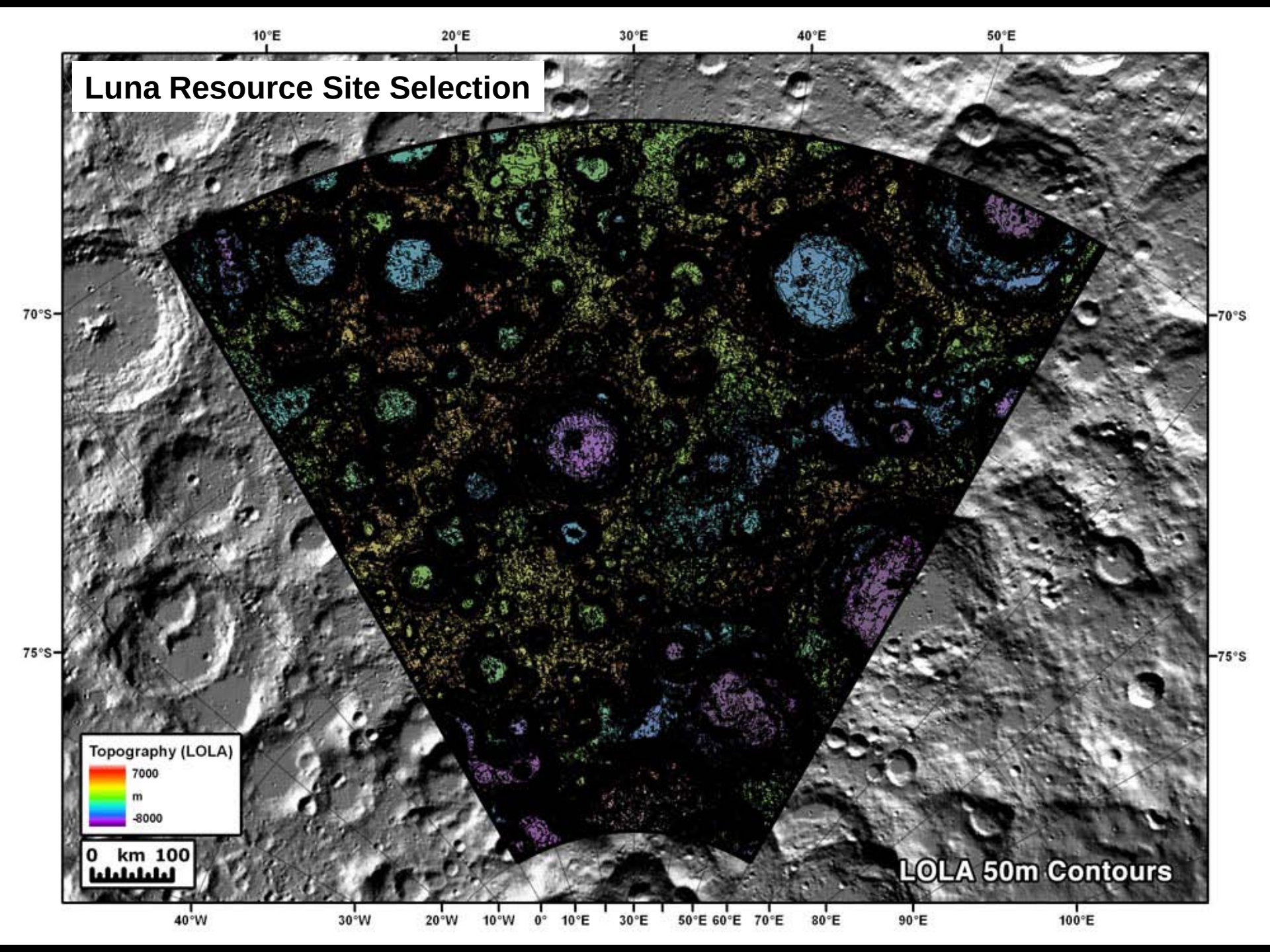

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
Ntp
pNc
Nbc
Nc
Ec
pNbr
Cc
Esc
Ntp
Ec
pNbr
pNc
Ic2
Isc
Ic1
Cc
pNc
pNt
Nc
Ic2
pNc
Nc
pNbm
Cc
Ec
Esc
Ic1
Ic2
Ip
Isc
Ioc
Nc
Ntp
pNbm
pNbr
pNc
pNt
0 km 100
Geology (Wilhelms et al., 1979; I-1162)
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

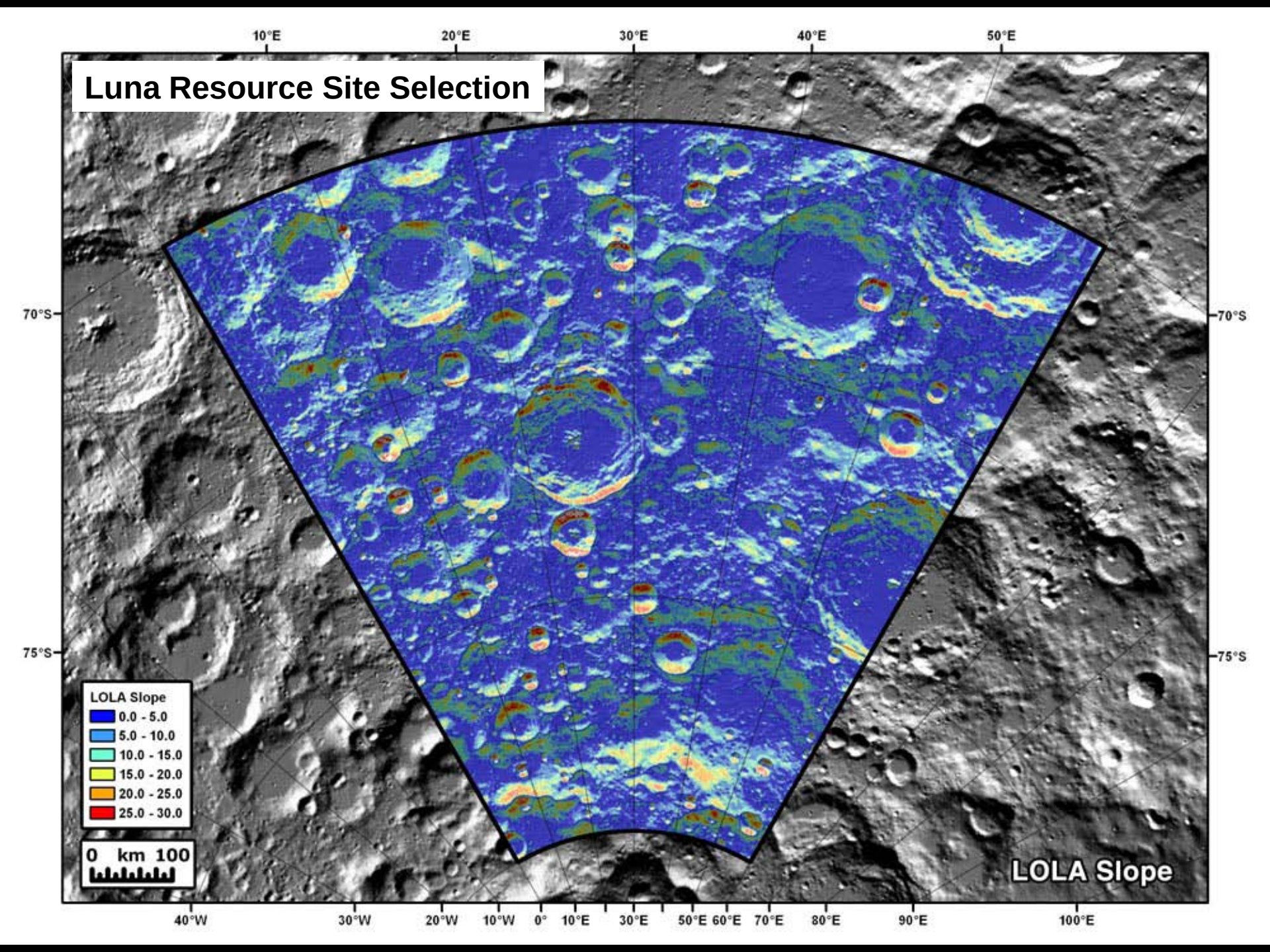

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
Topography (LOLA)
7000
m
-8000
0 km 100
LOLA Topography
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

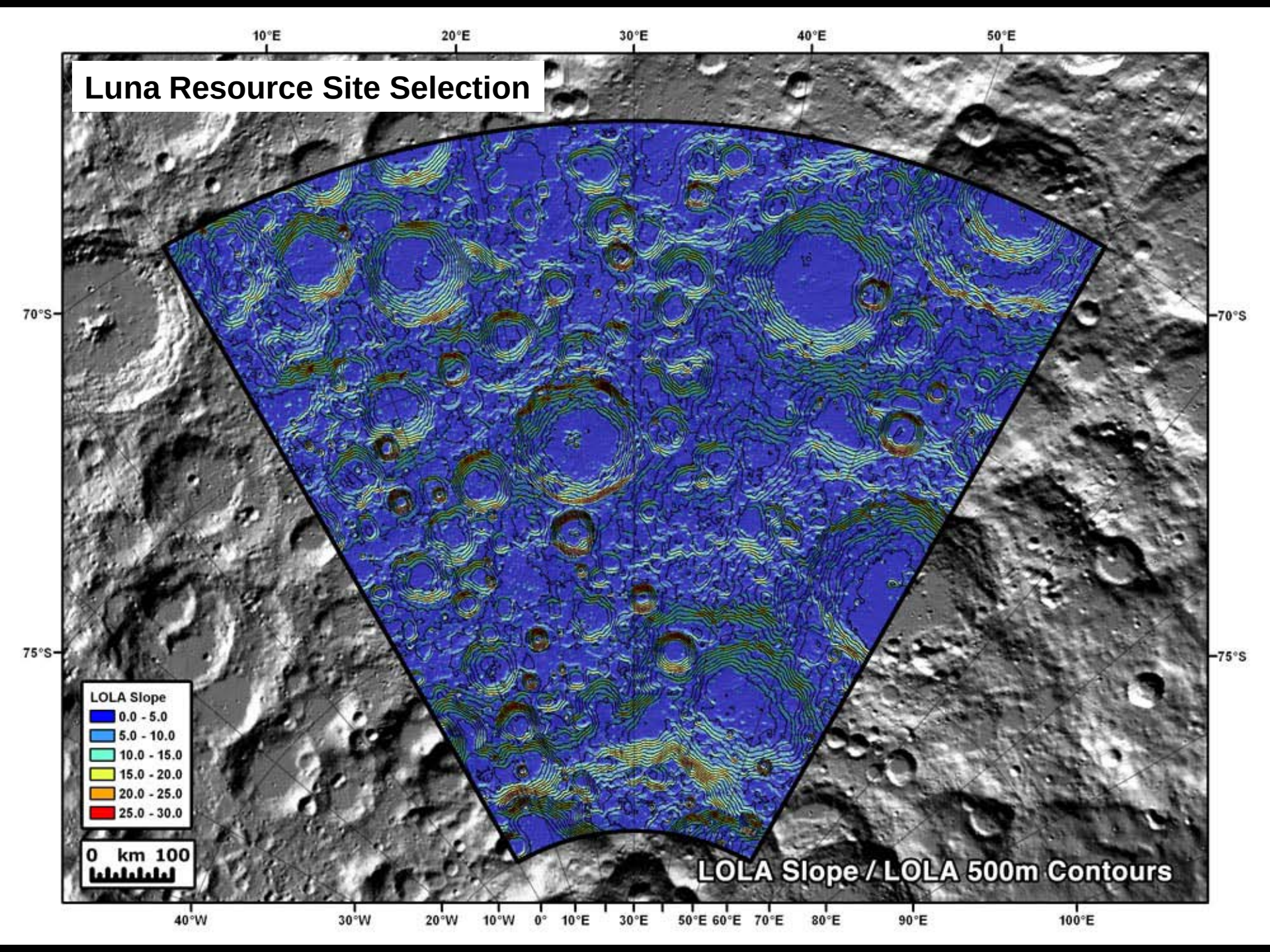

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
Topography (LOLA)
7000
m
-8000
0 km 100
LOLA 500m Contours
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

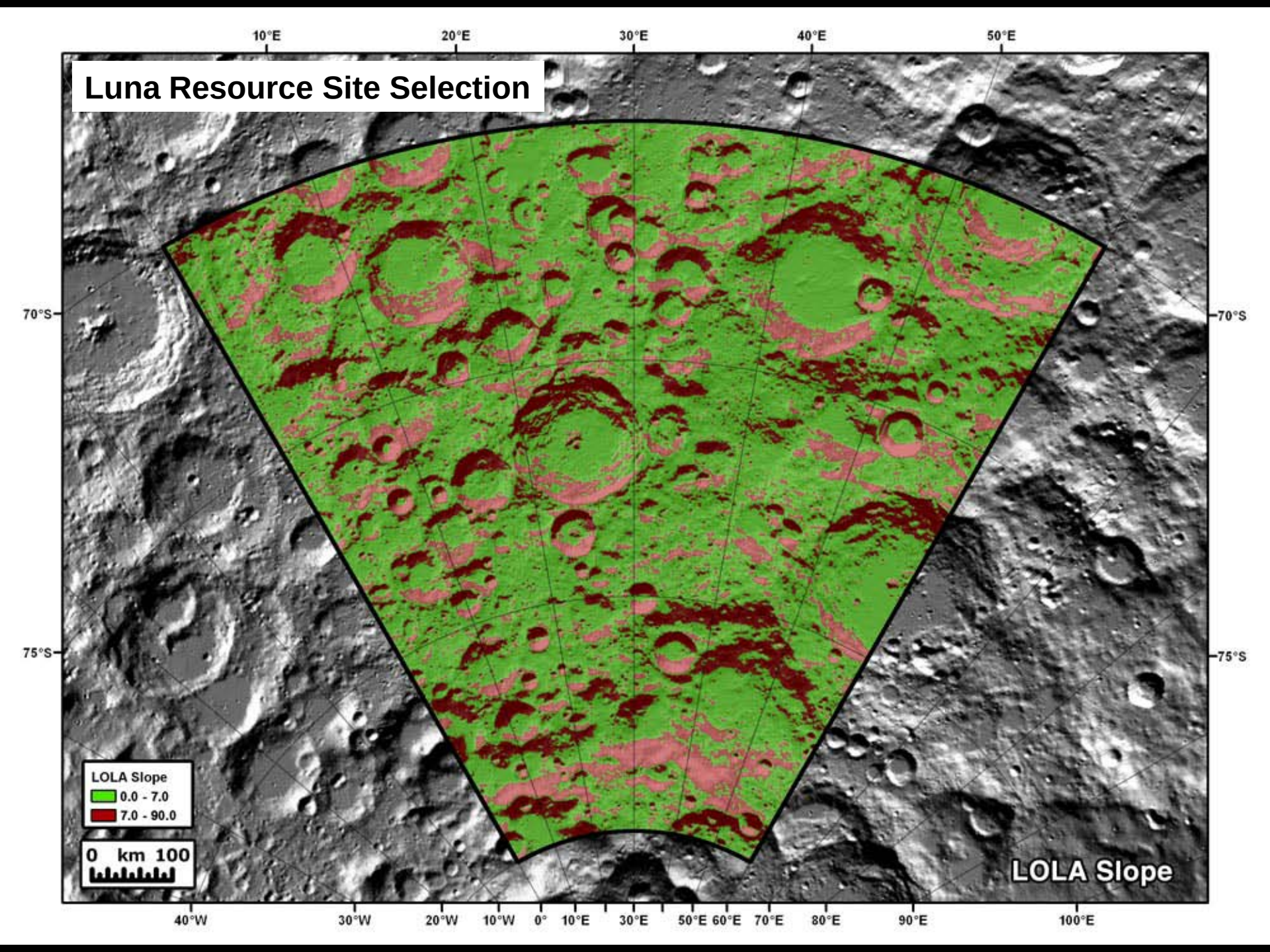

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
Topography (LOLA)
7000
m
-8000
0 km 100
LOLA 250m Contours
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

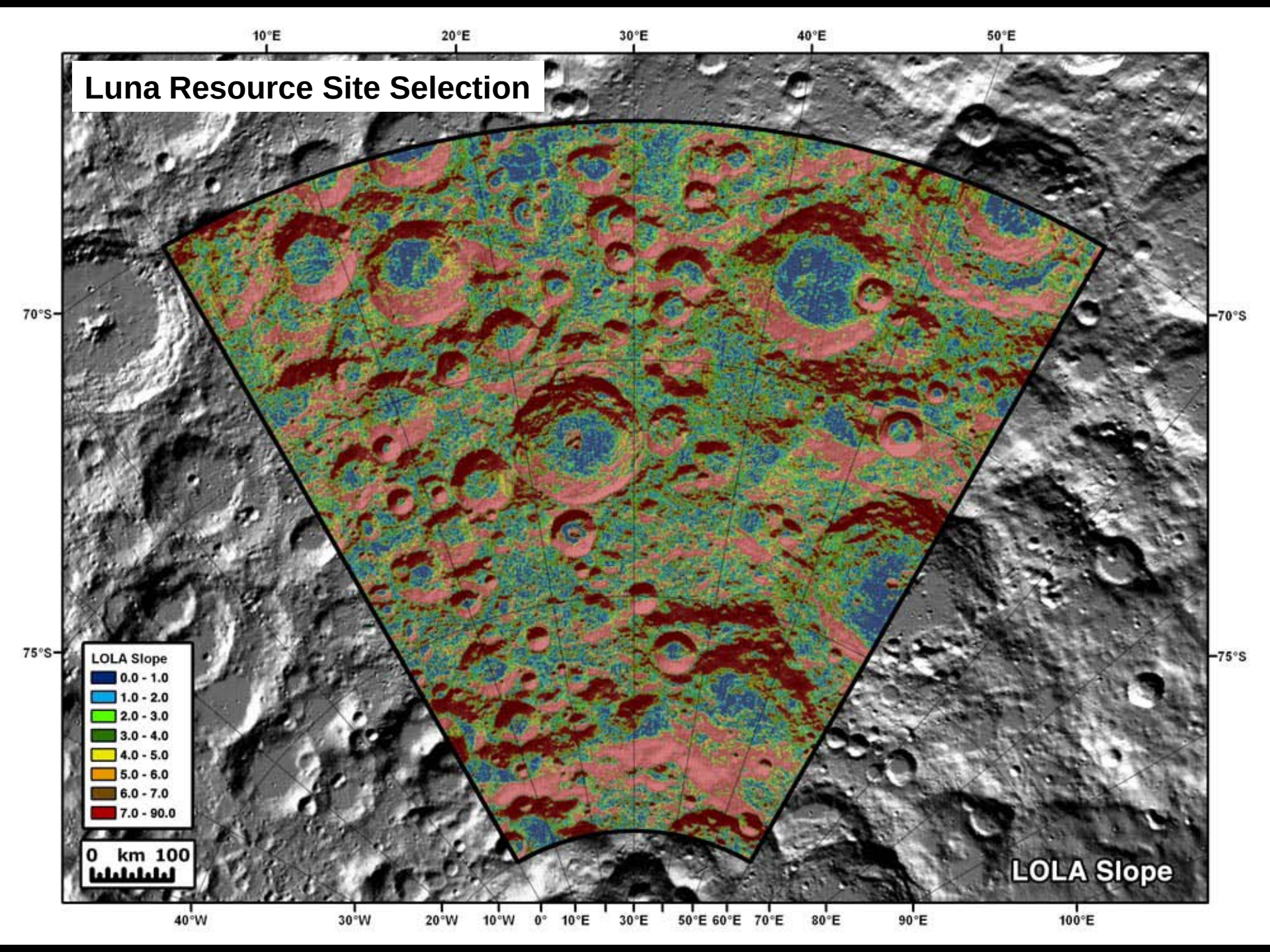

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
Topography (LOLA)
7000
m
-8000
0 km 100
LOLA 100m Contours
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

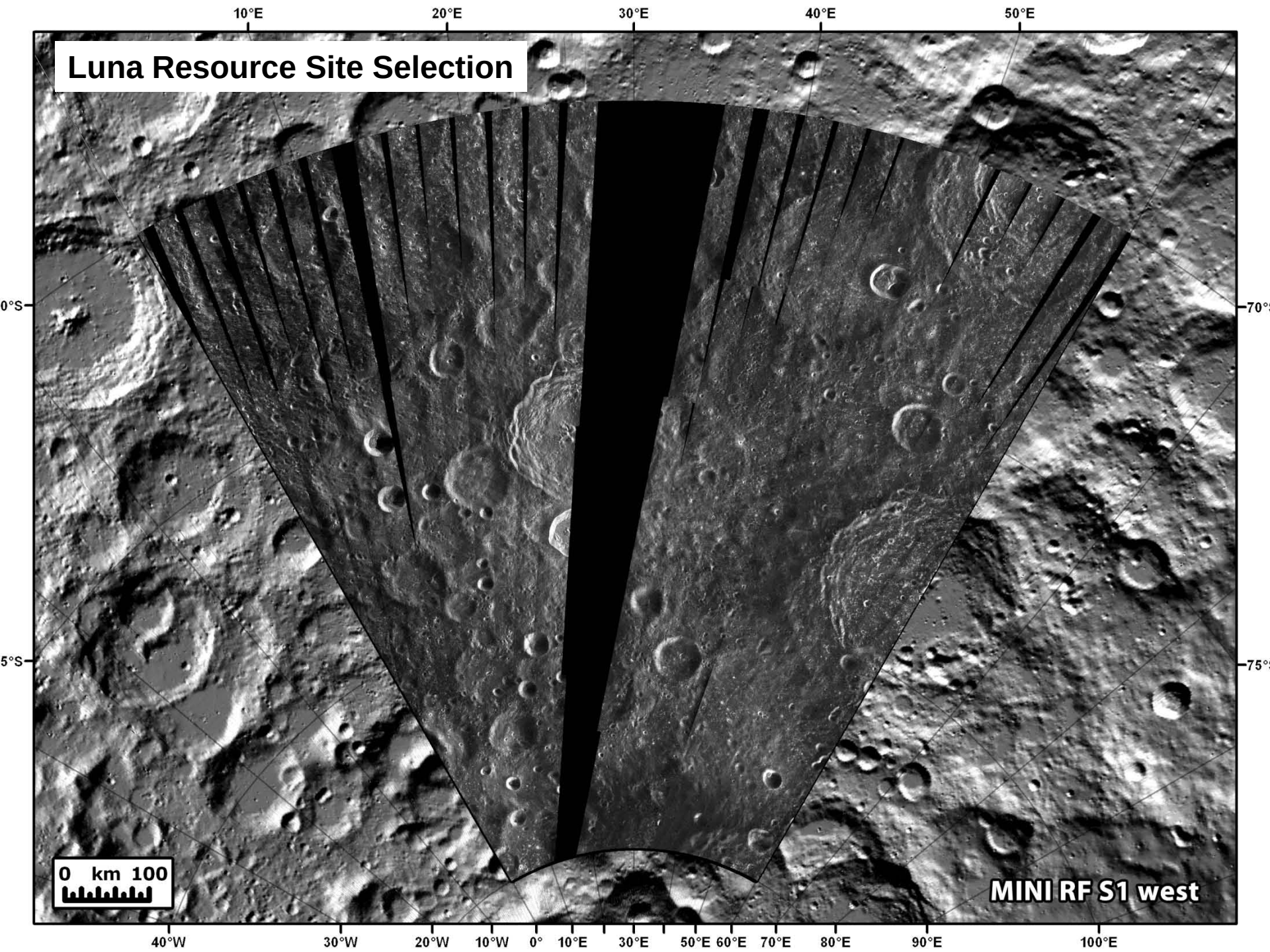

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
Topography (LOLA)
7000
m
-8000
0 km 100
LOLA 50m Contours
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

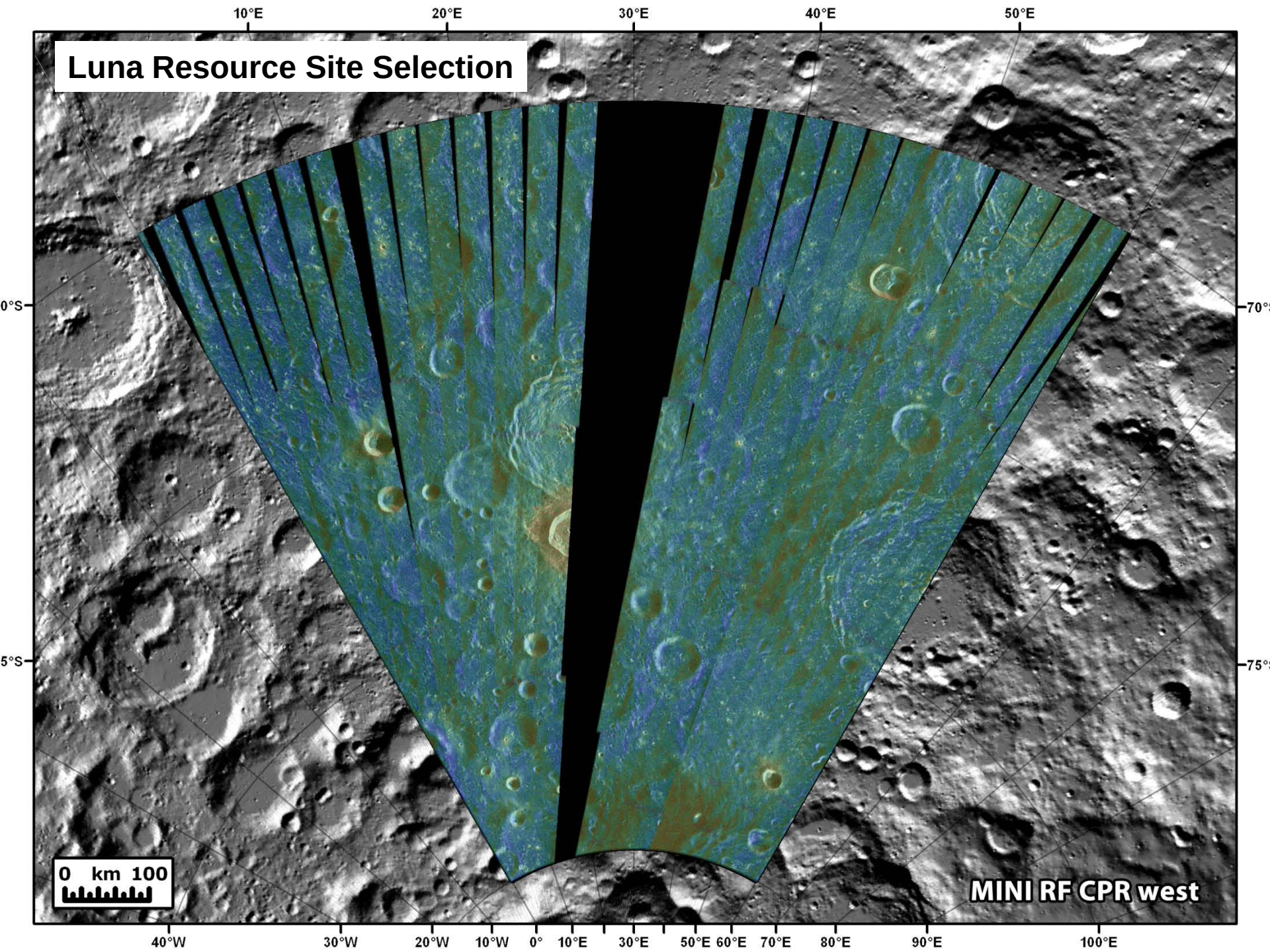

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
LOLA Slope
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
0 km 100
LOLA Slope
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

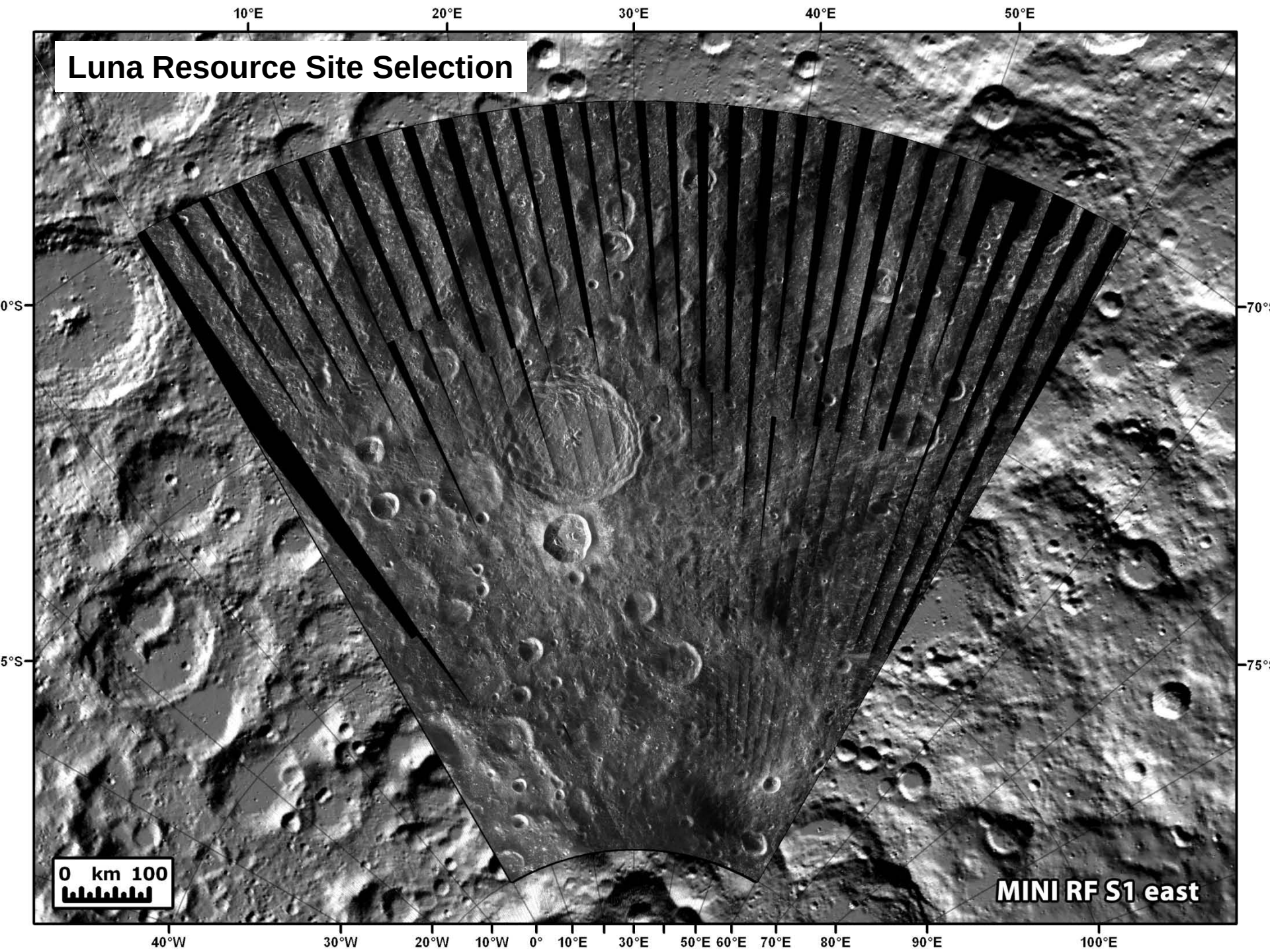

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
LOLA Slope
0.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
20.0 - 25.0
25.0 - 30.0
0 km 100
LOLA Slope / LOLA 500m Contours
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

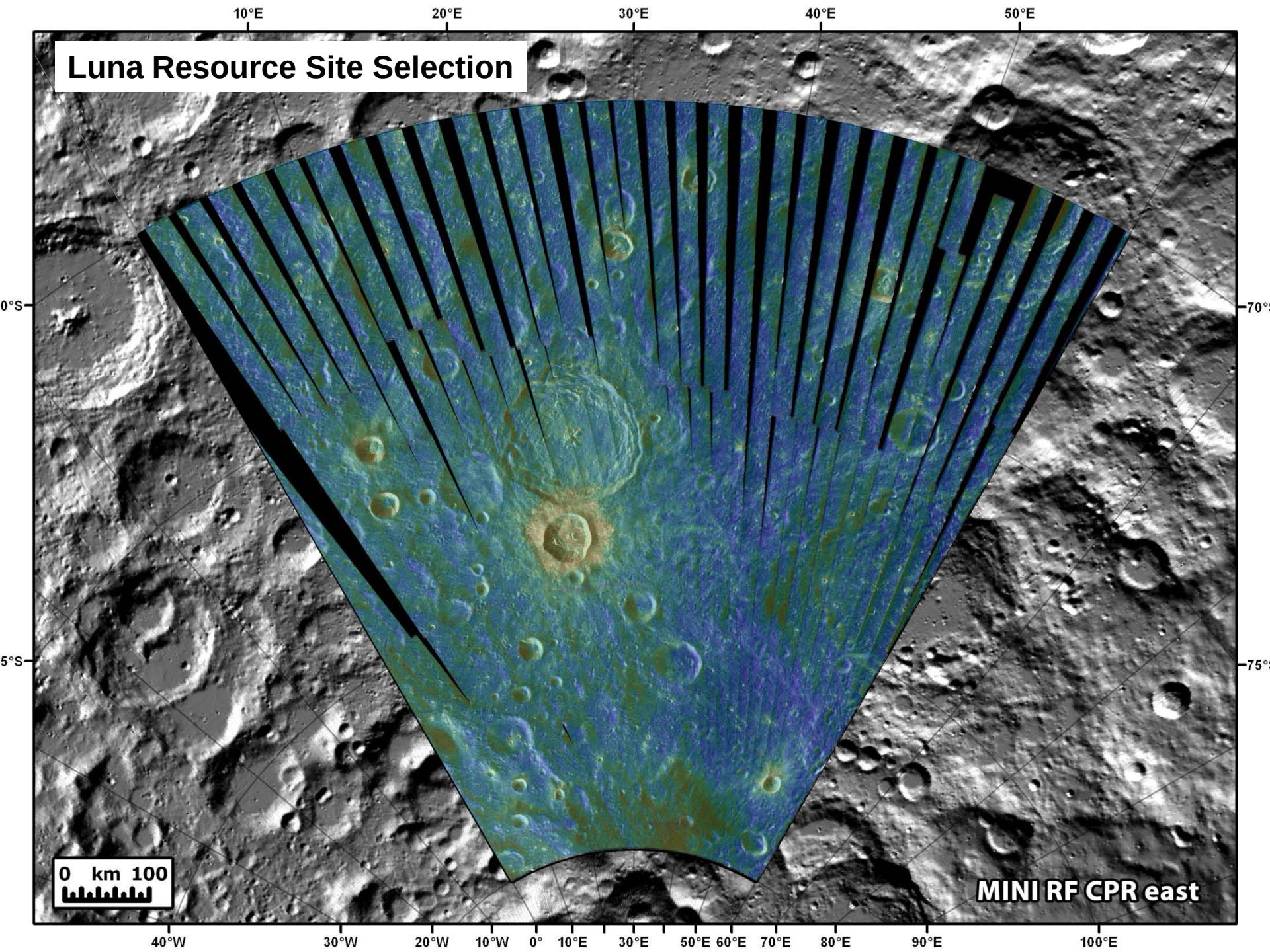

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
LOLA Slope
0.0 - 7.0
7.0 - 90.0
0 km 100
LOLA Slope
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

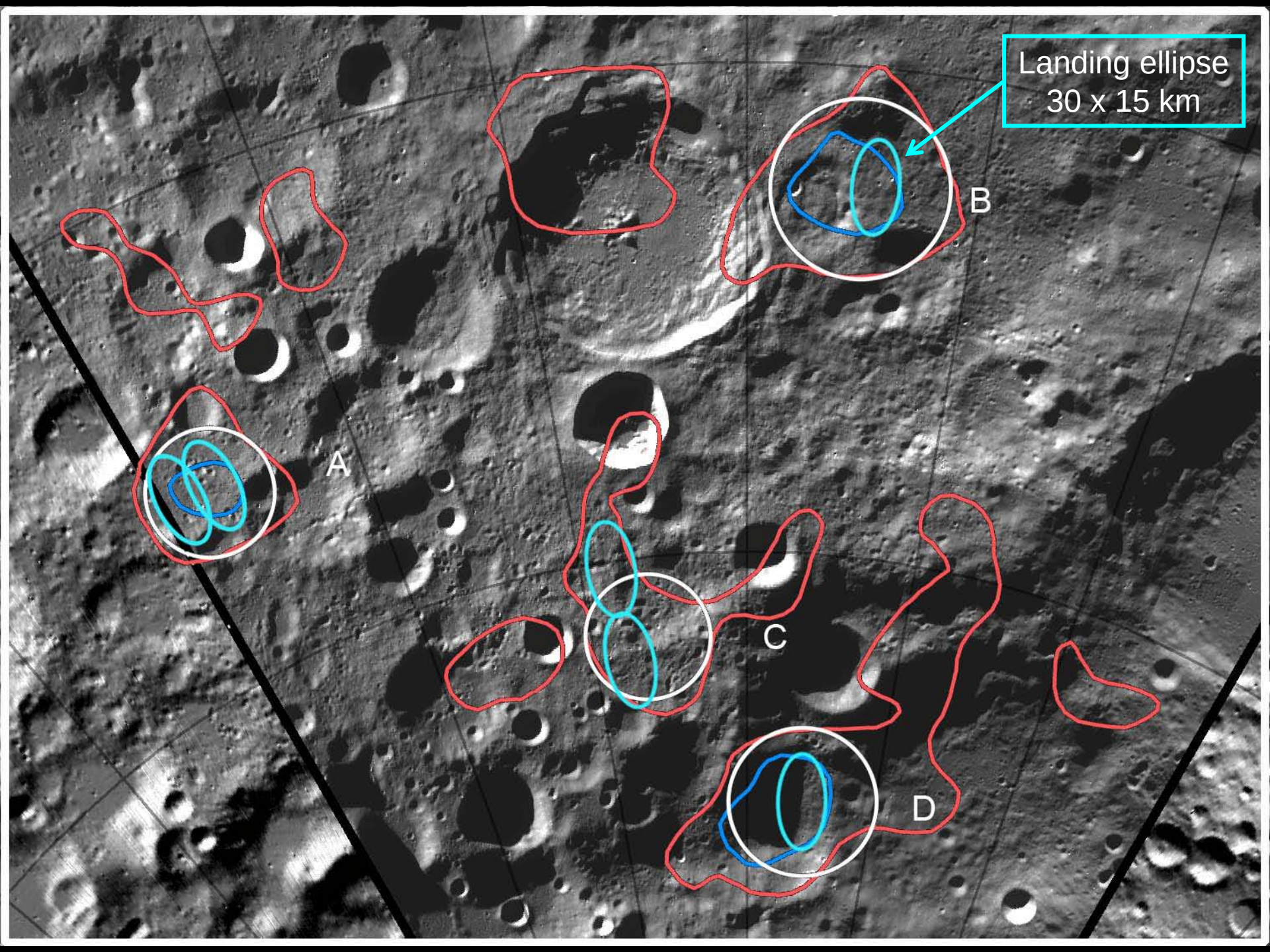

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
70°S
75°S
LOLA Slope
0.0 - 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
4.0 - 5.0
5.0 - 6.0
6.0 - 7.0
7.0 - 90.0
0 km 100
LOLA Slope
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

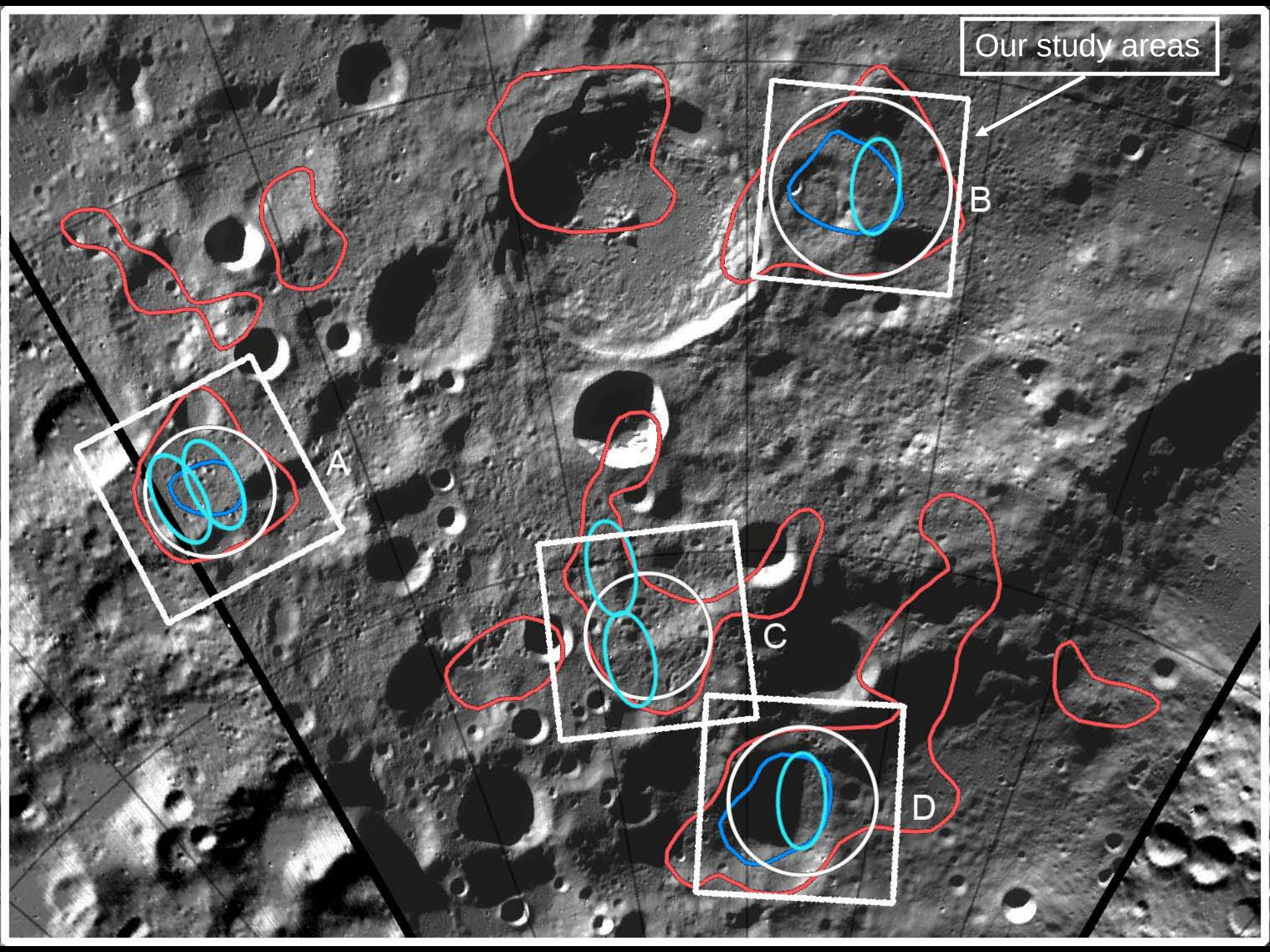

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
0°S
5°S
70°S
75°S
0 km 100
MINI RF S1 west
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E


Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
0°S
5°S
70°S
75°S
0 km 100
MINI RF CPR west
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

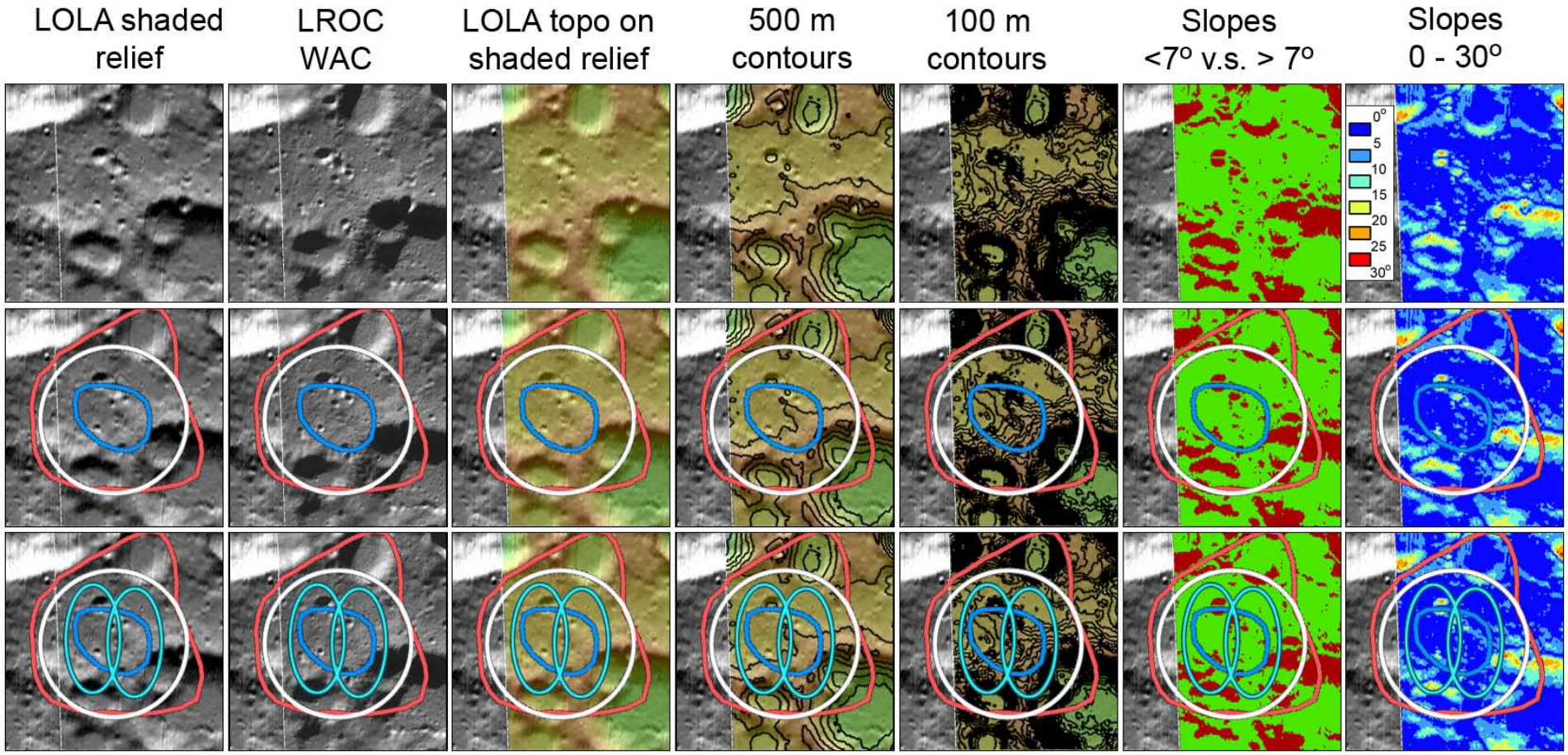

Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
0°S
5°S
70°S
75°S
0 km 100
MINI RF S1 east
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E


Luna Resource Site Selection
10°E
20°E
30°E
40°E
50°E
0°S
5°S
70°
75°
0 km 100
MINI RF CPR east
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

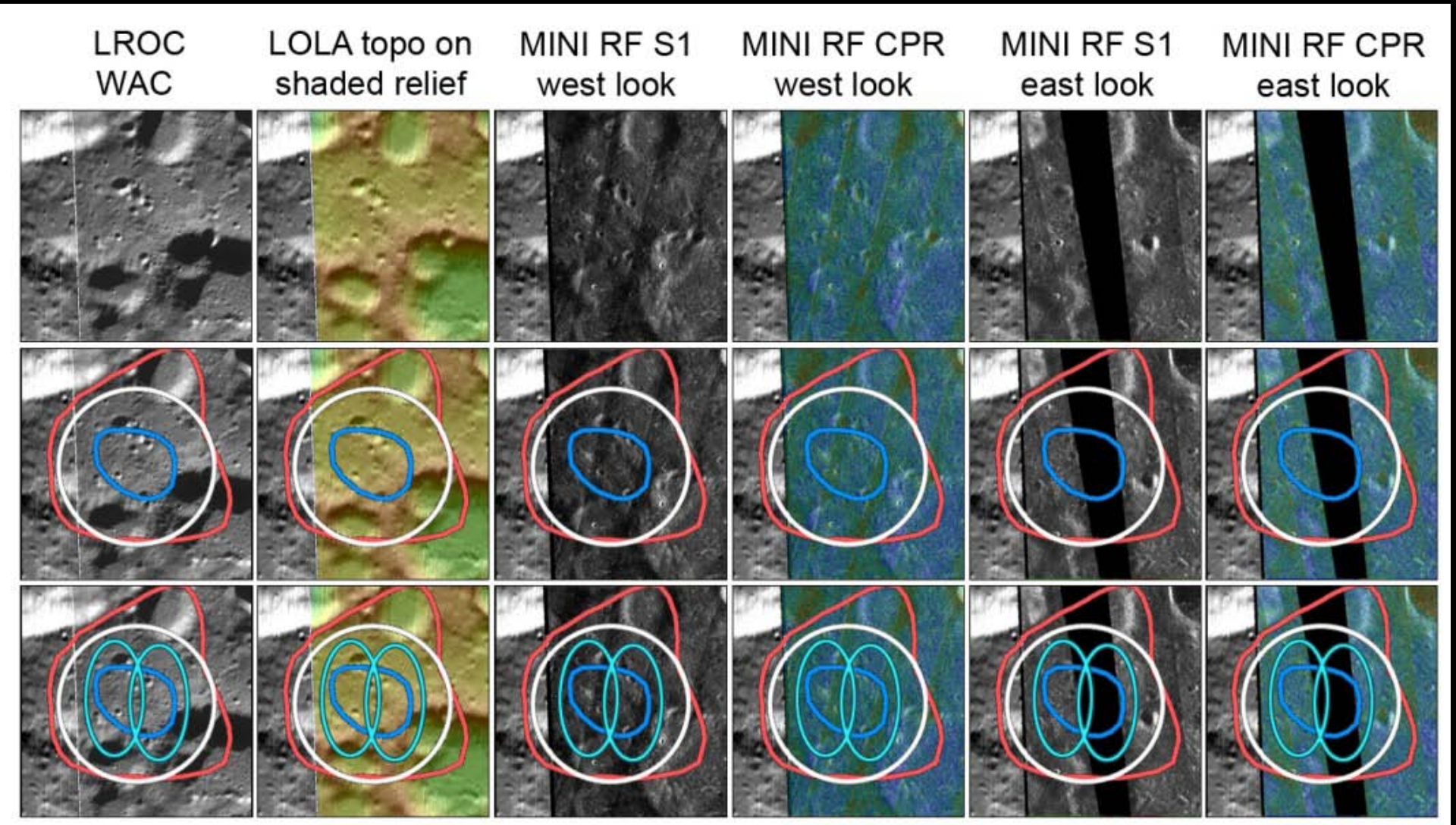

Landing ellipse
30 x 15 km
A
B
C
D


Our study areas
A
B
C
D

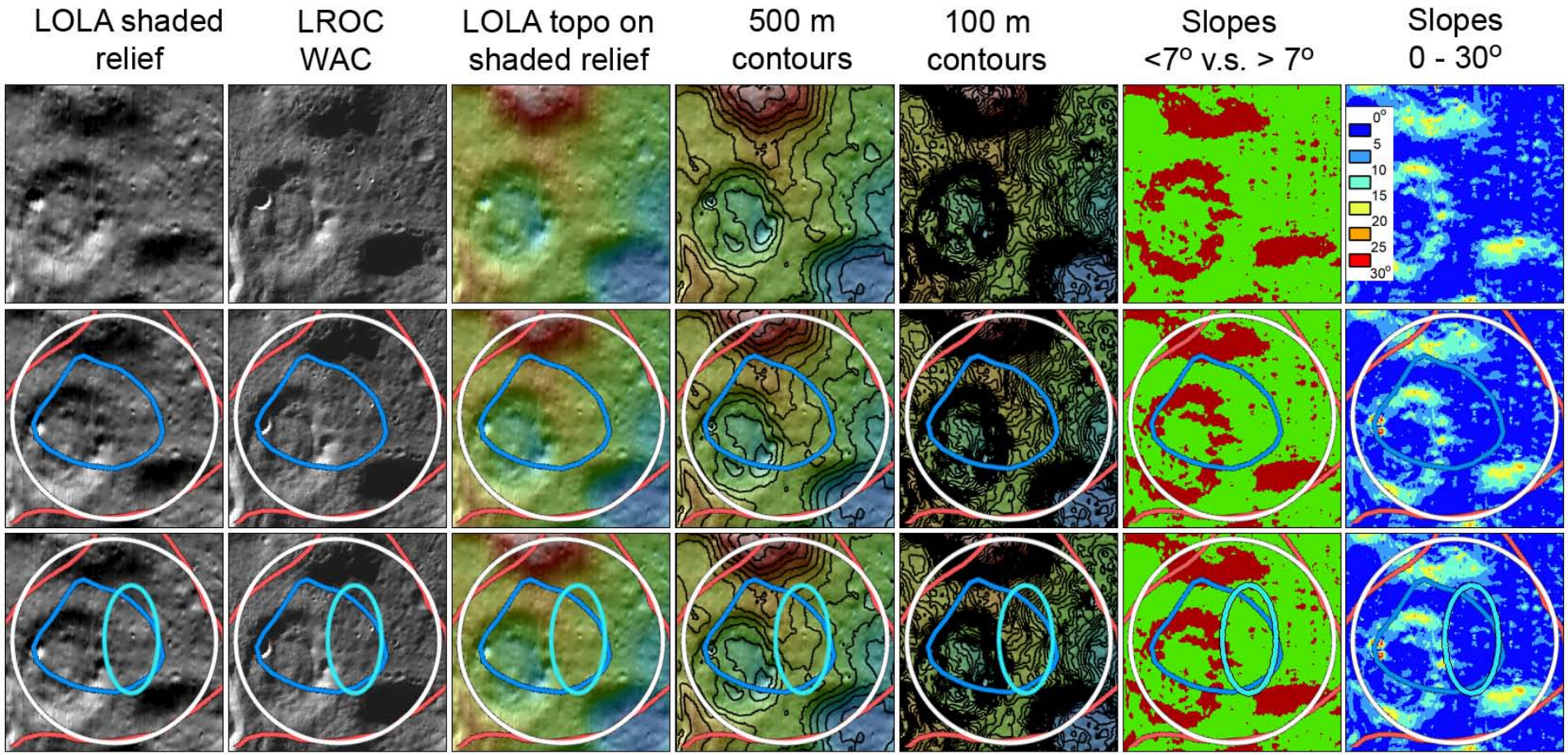
Surface characteristics in the Area South A
LOLA + WAC



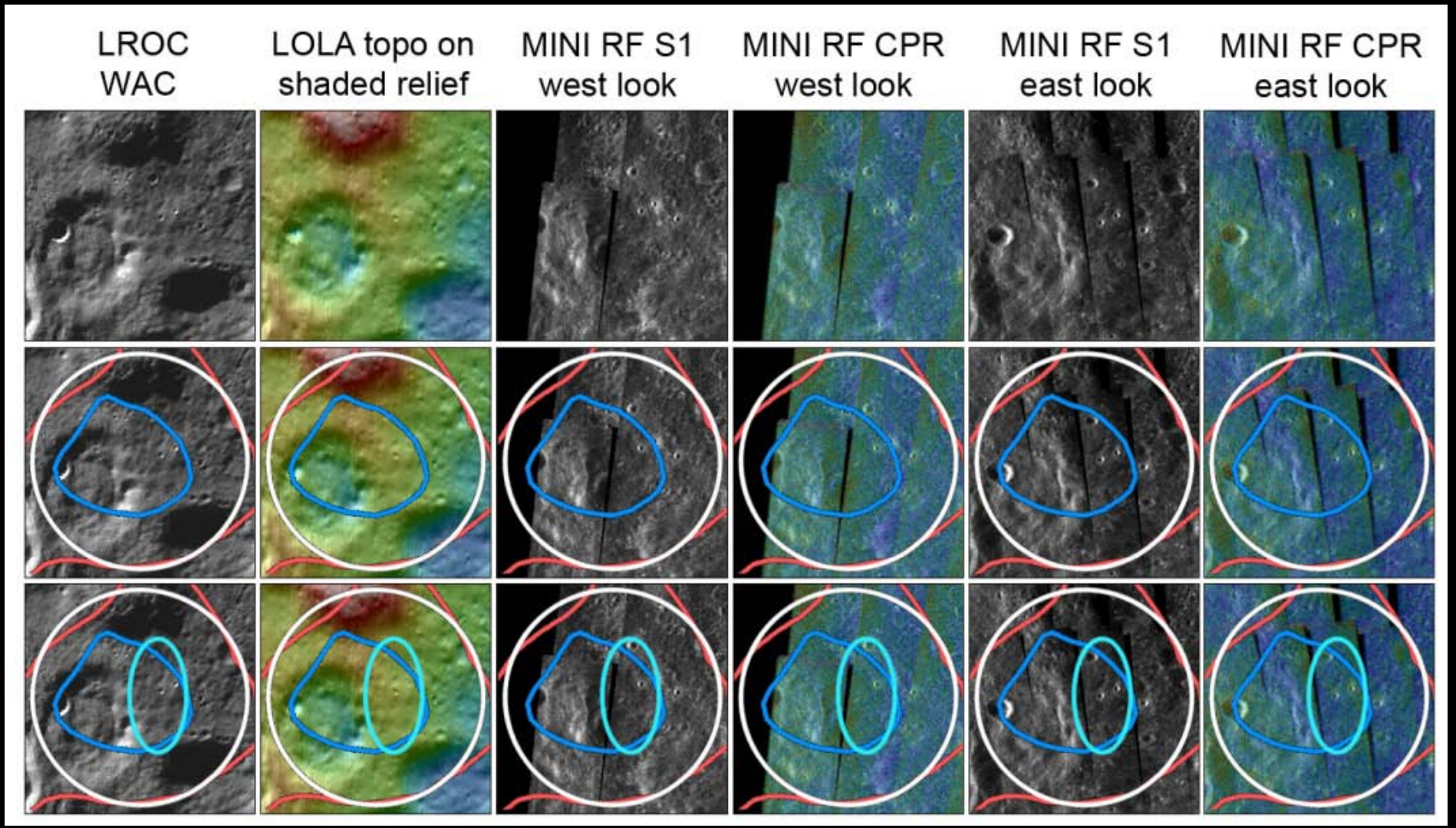
Surface characteristics in the Area South A
LOLA + WAC + MINI-RF



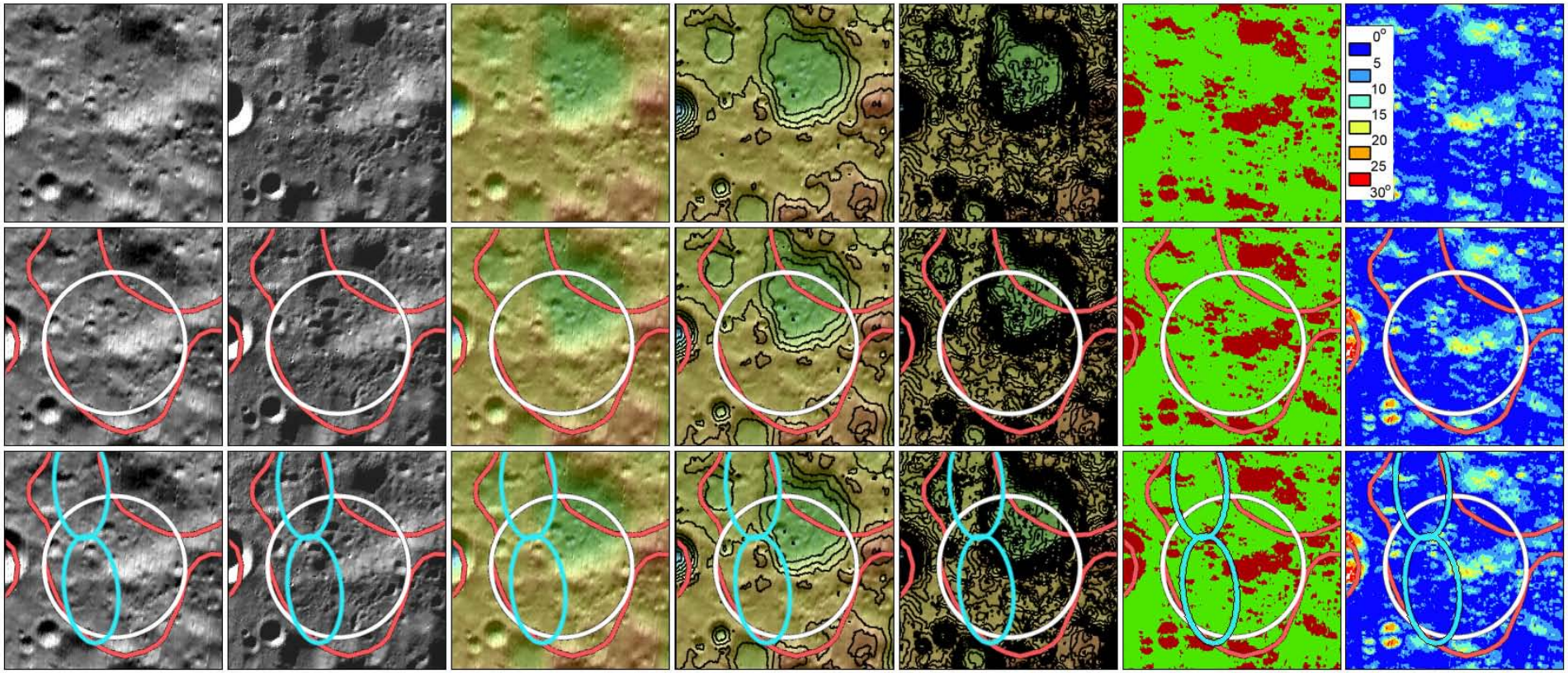
Surface characteristics in the Area South B
LOLA + WAC



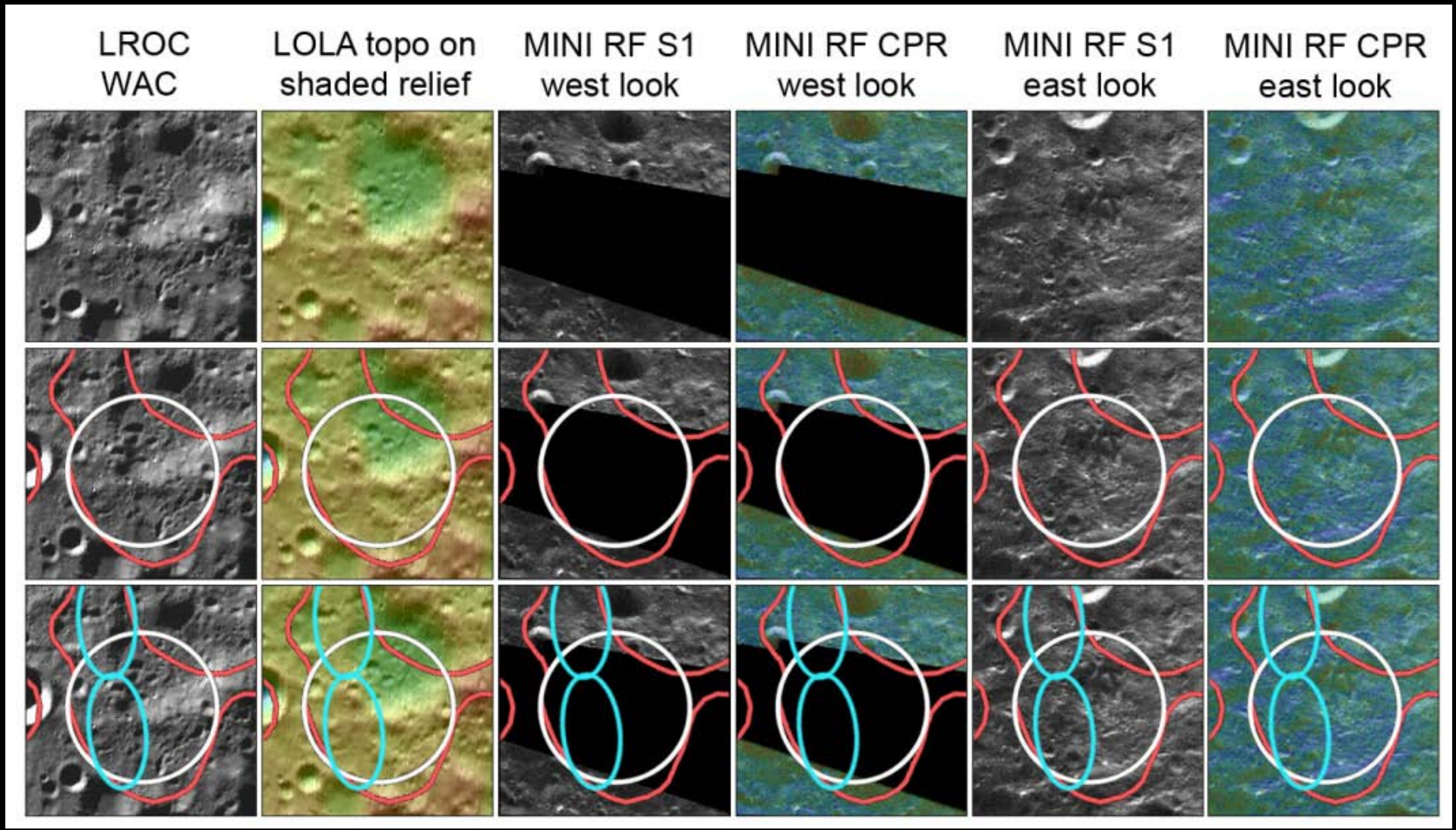
Surface characteristics in the Area South B
LOLA + WAC + MINI-RF



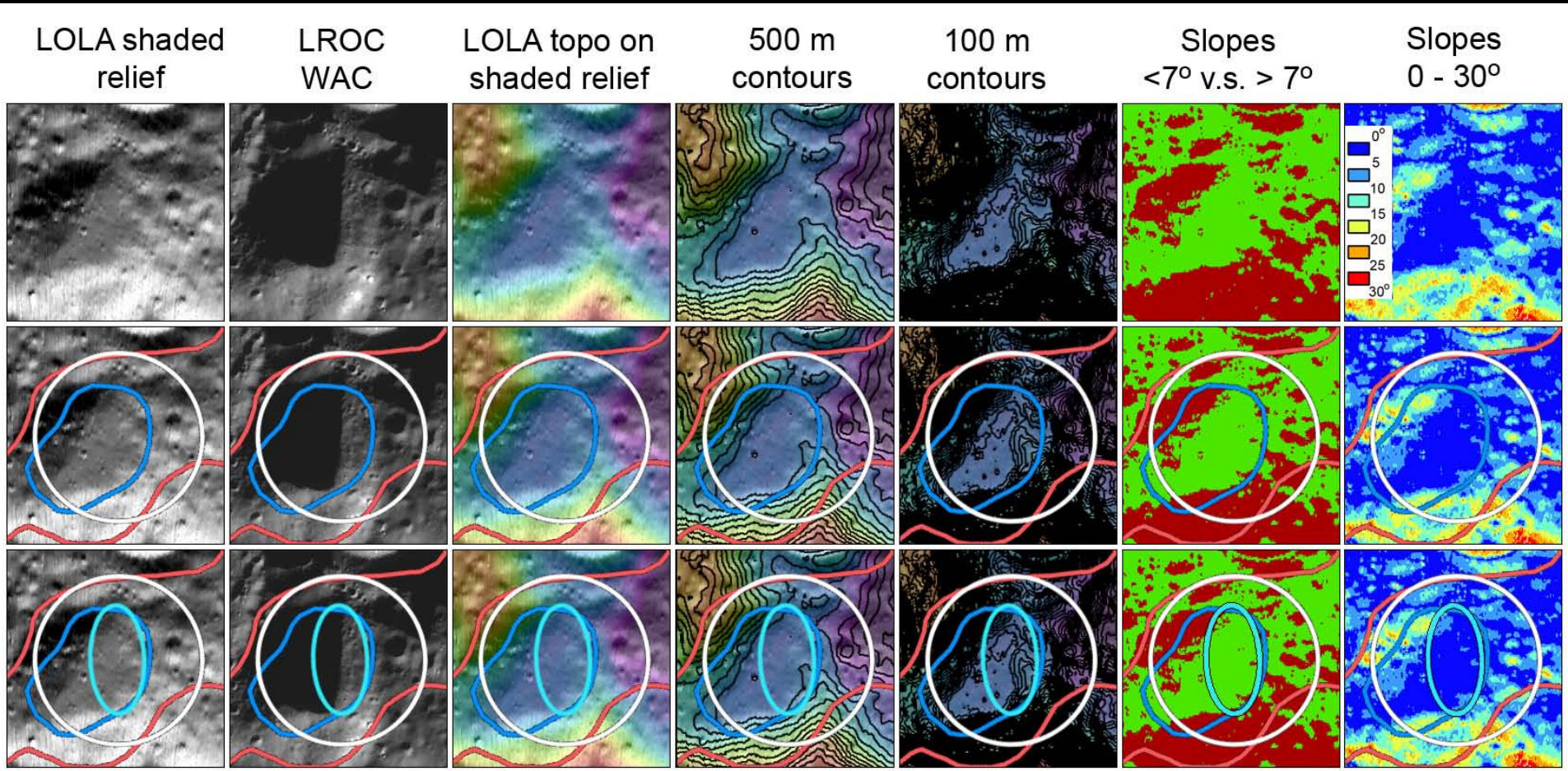
Surface characteristics in the Area South C
LOLA + WAC



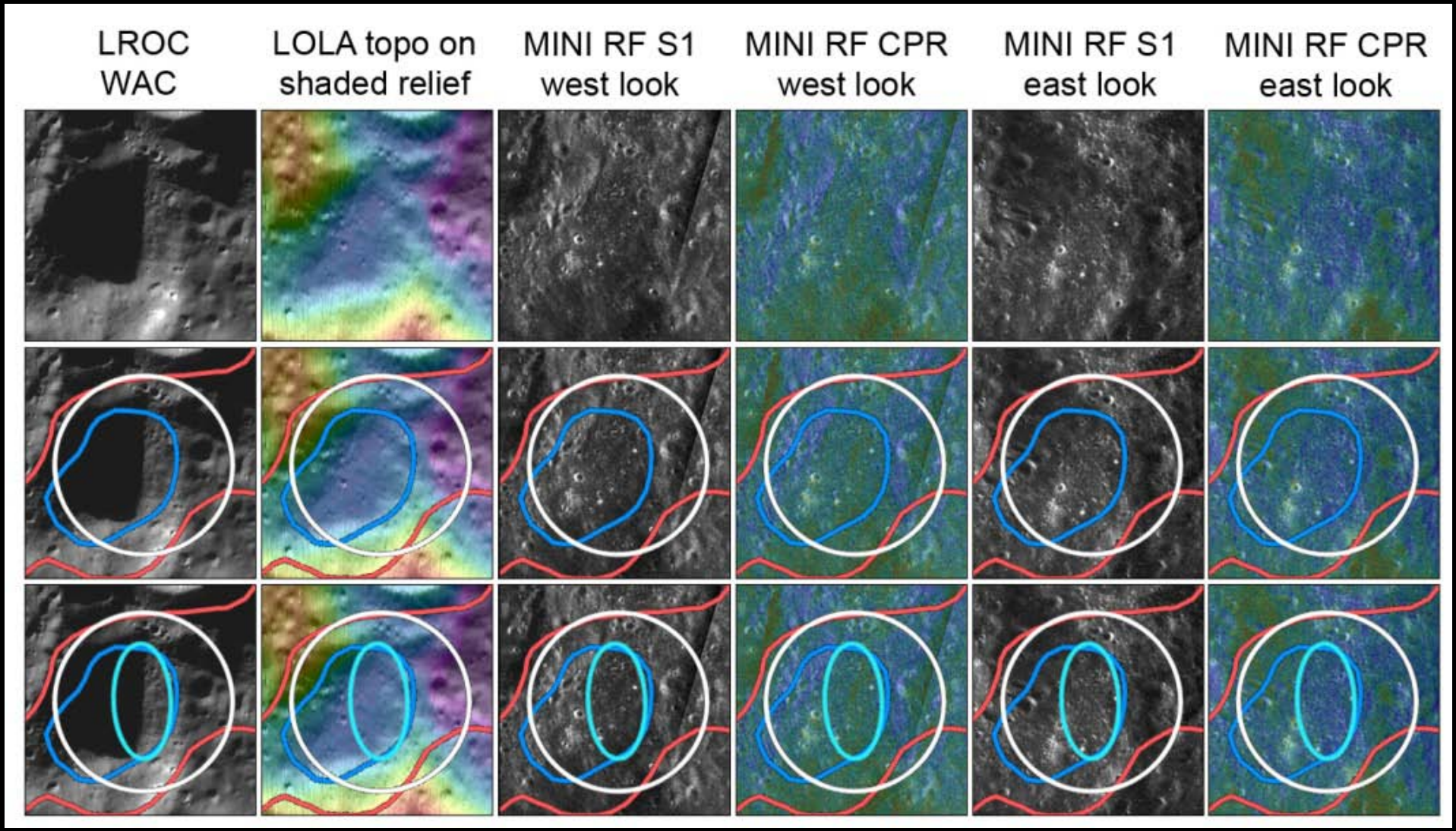
Surface characteristics in the Area South C
LOLA + WAC + MINI-RF

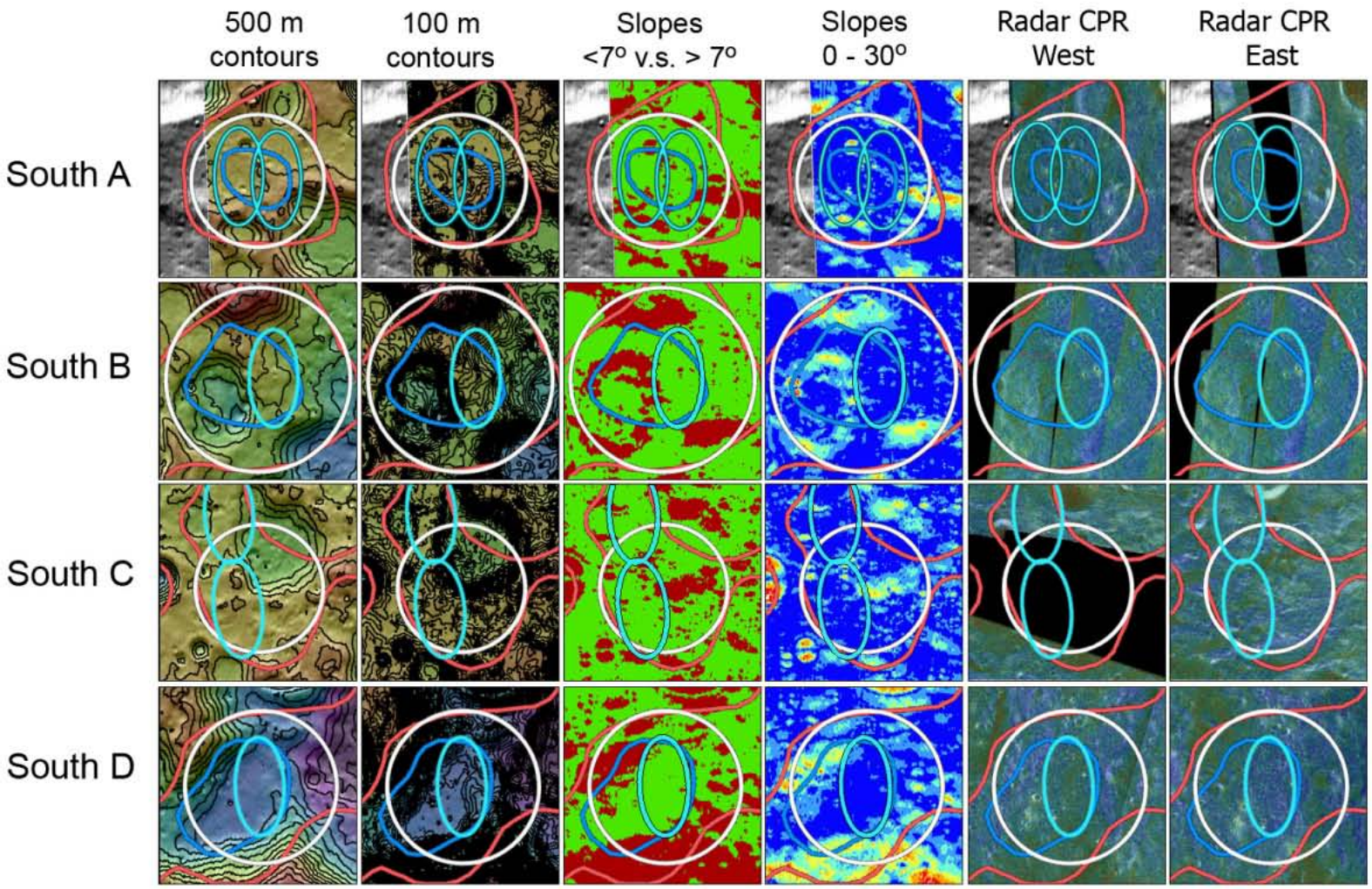


Surface characteristics in the Area South D
LOLA + WAC



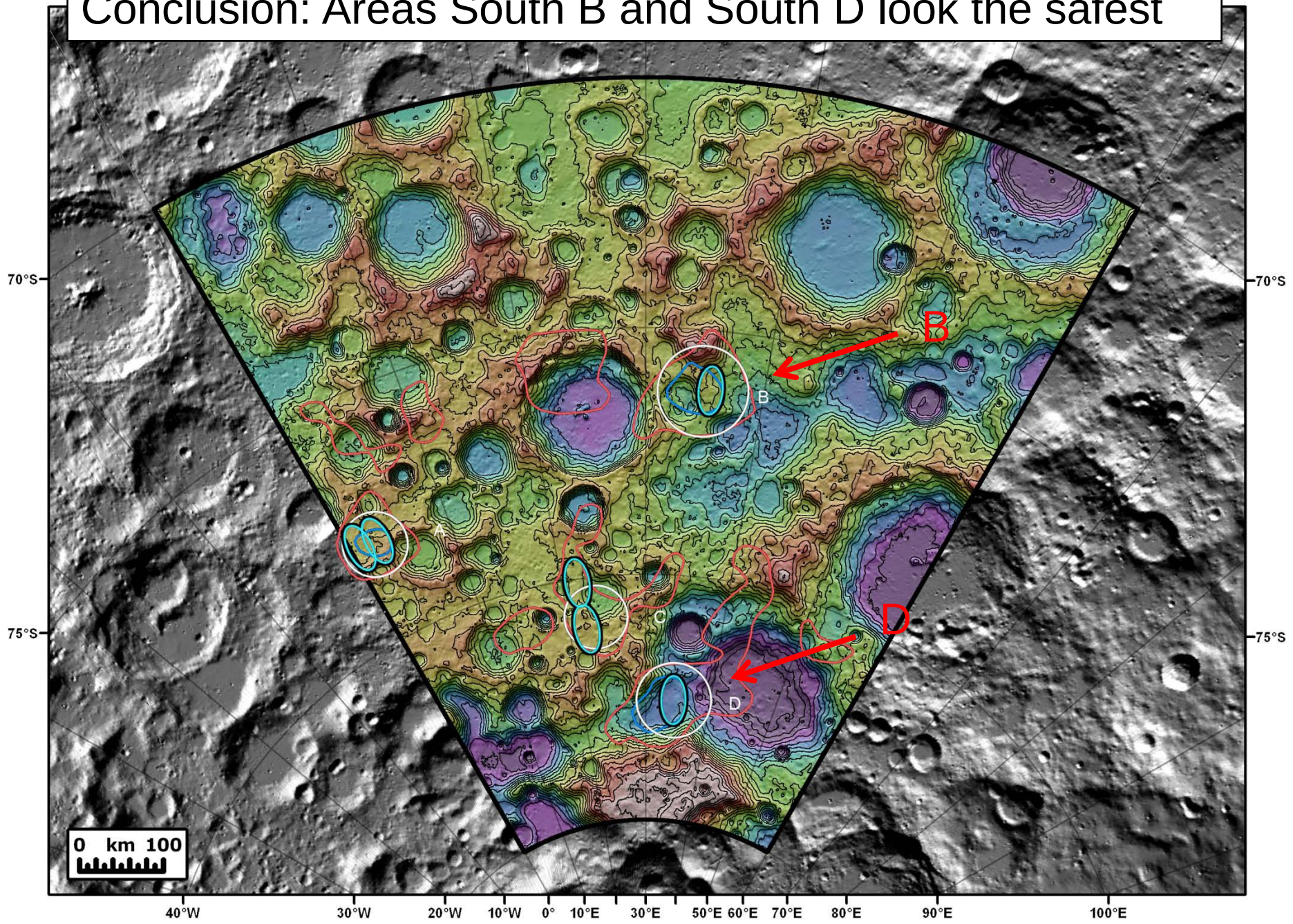
Surface characteristics in the Area South D
LOLA + WAC + MINI-RF



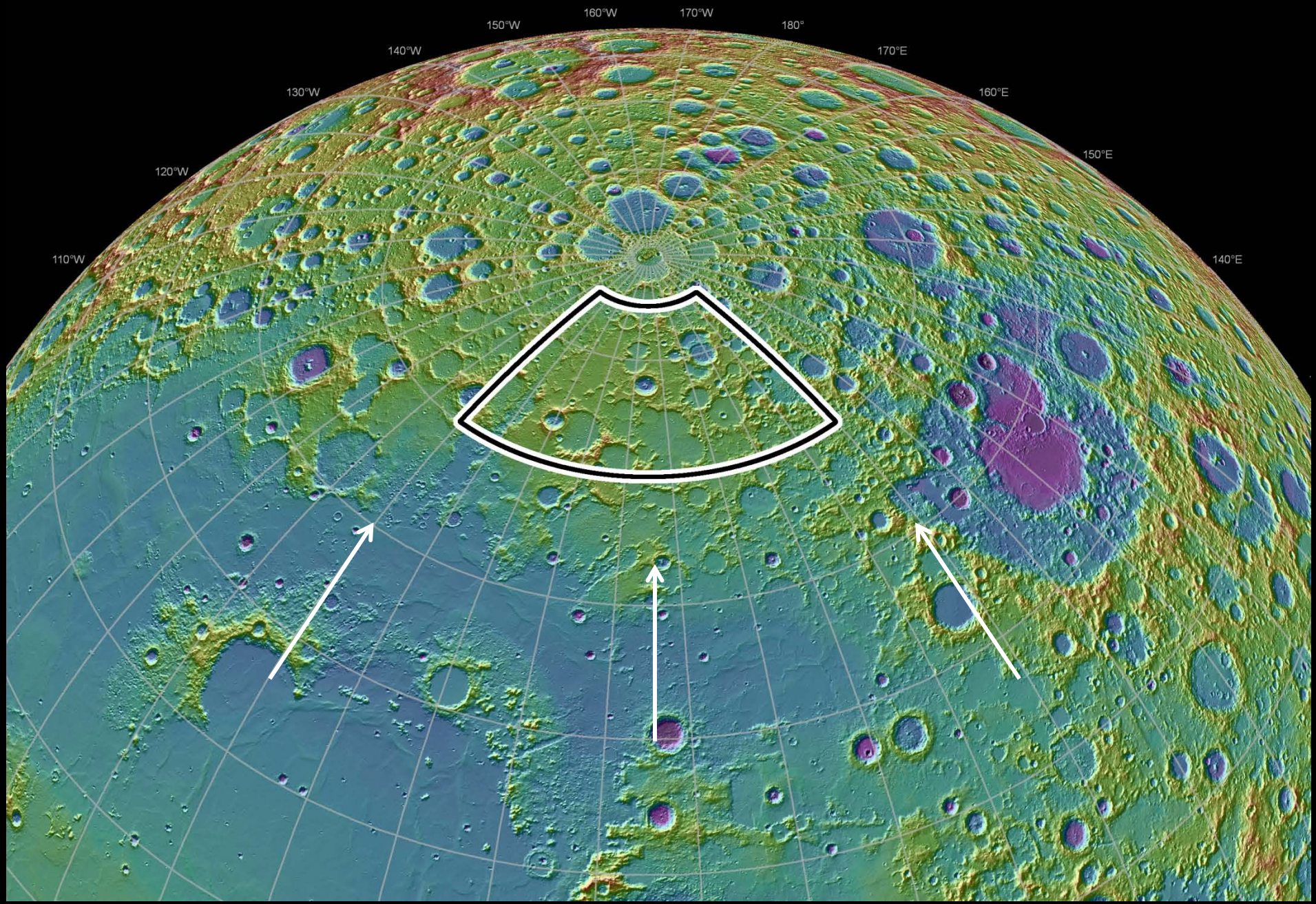


Conclusion: Areas South B and South D look the safest

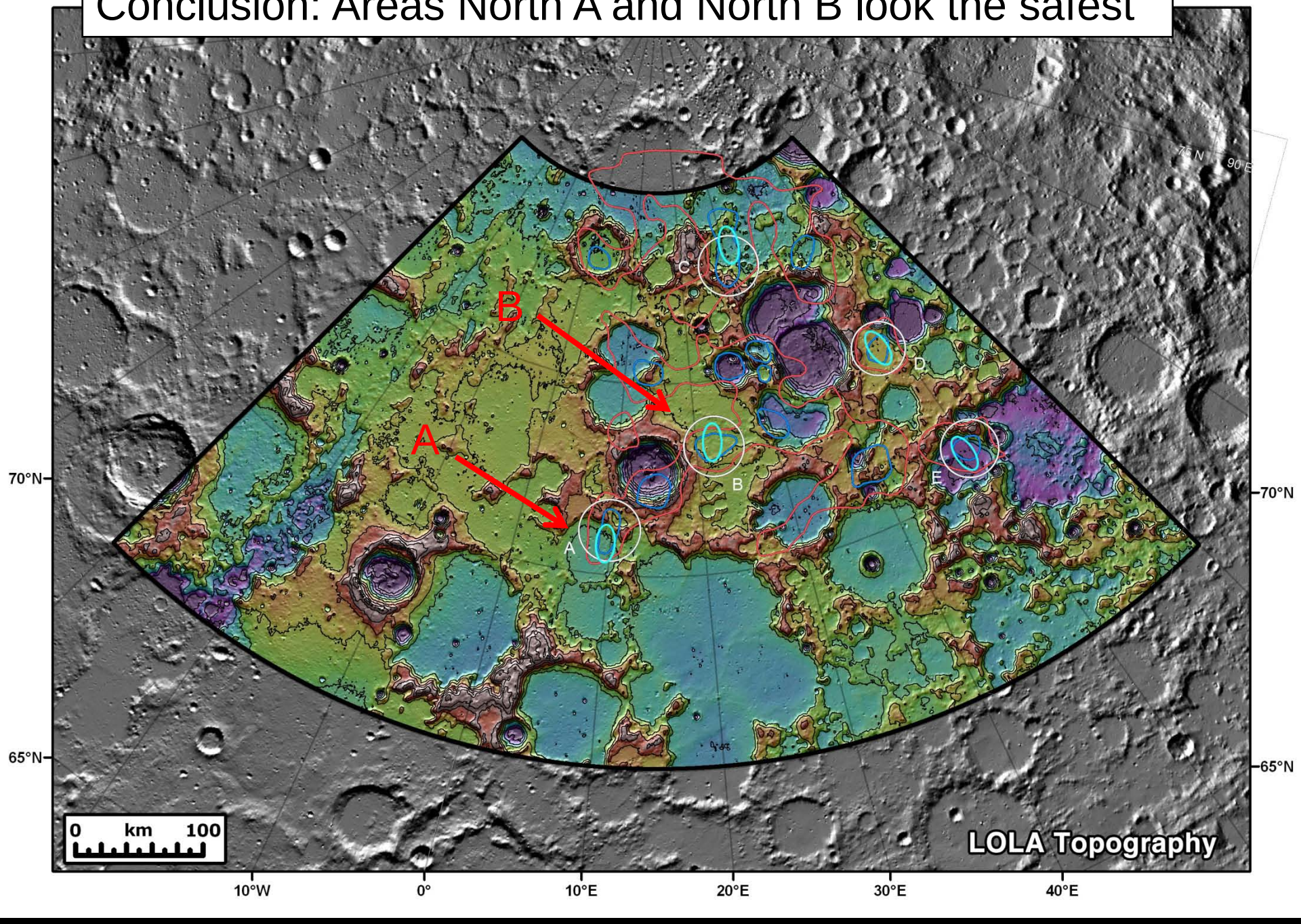
Conclusion: Areas South B and South D look the safest



Luna Glob Site Selection



Conclusion: Areas North A and North B look the safest



Surface characteristics in the potential landing sites

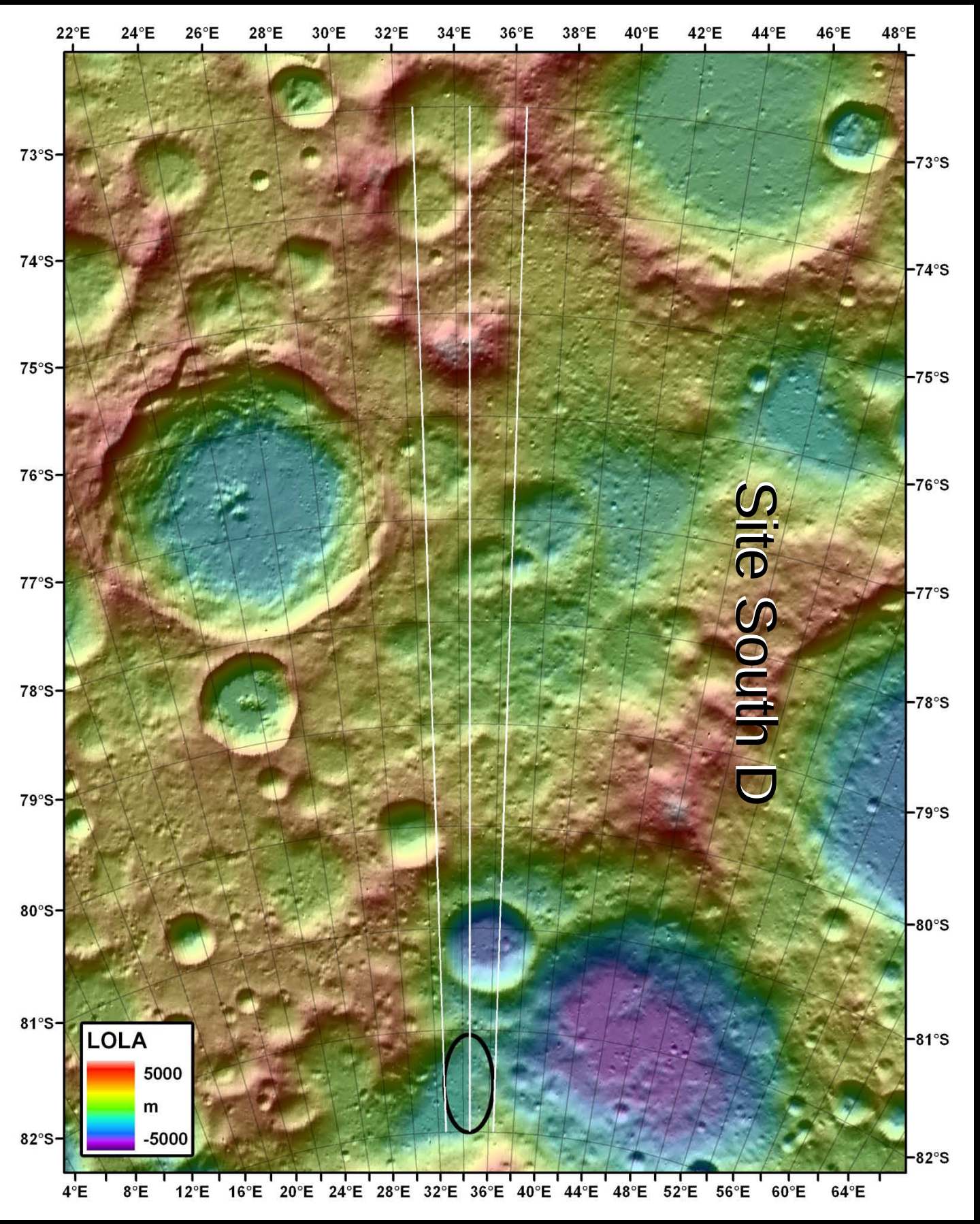
Conclusion:

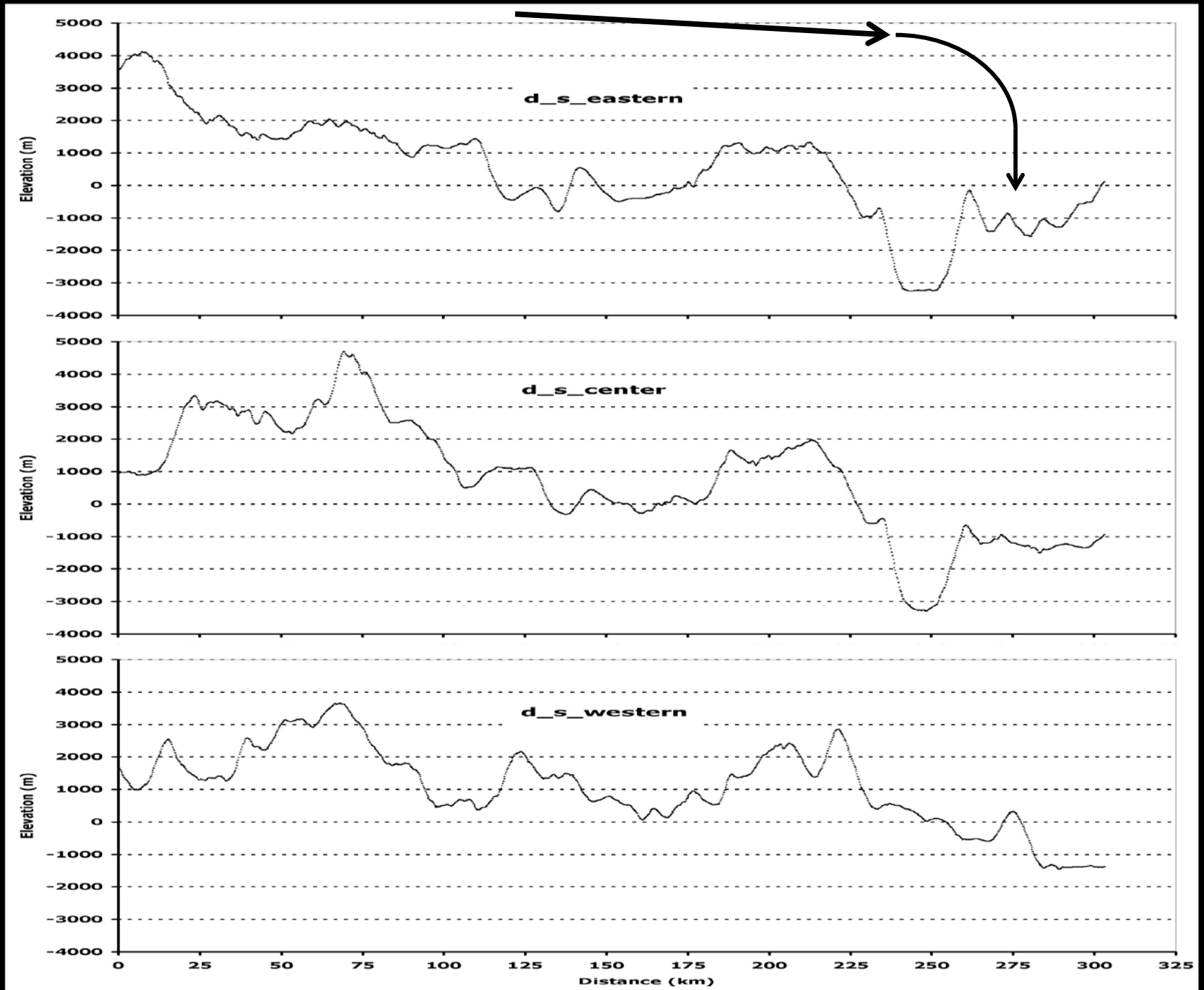
In the
Luna Resource and Luna Glob
landing regions there are several sites
within hydrogen enriched areas, which
have reasonably smooth surfaces,
and are large enough to accomodate
30 x 15 km landing ellipses.

Surface characteristics in the descent profiles

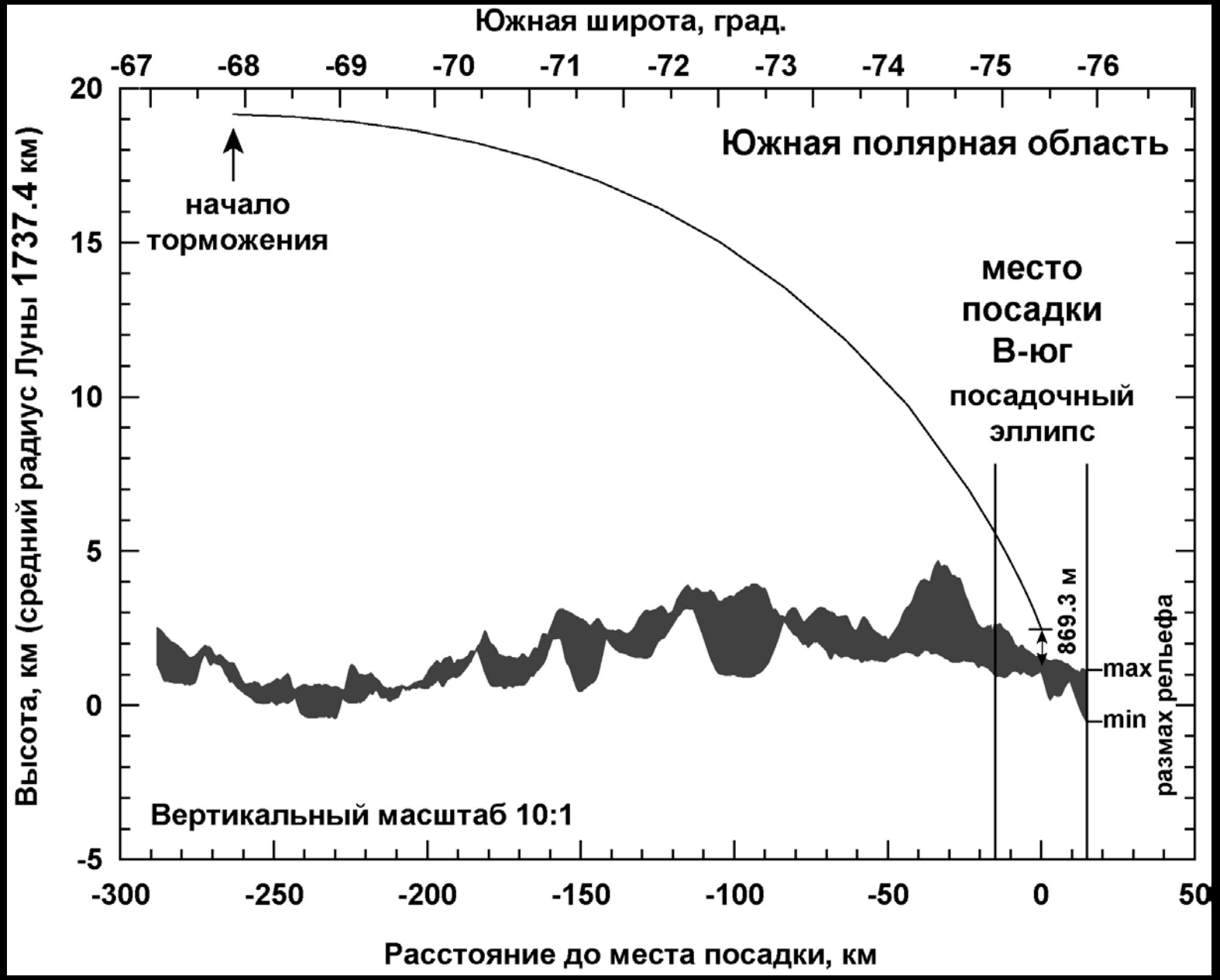
Source of information:

LOLA

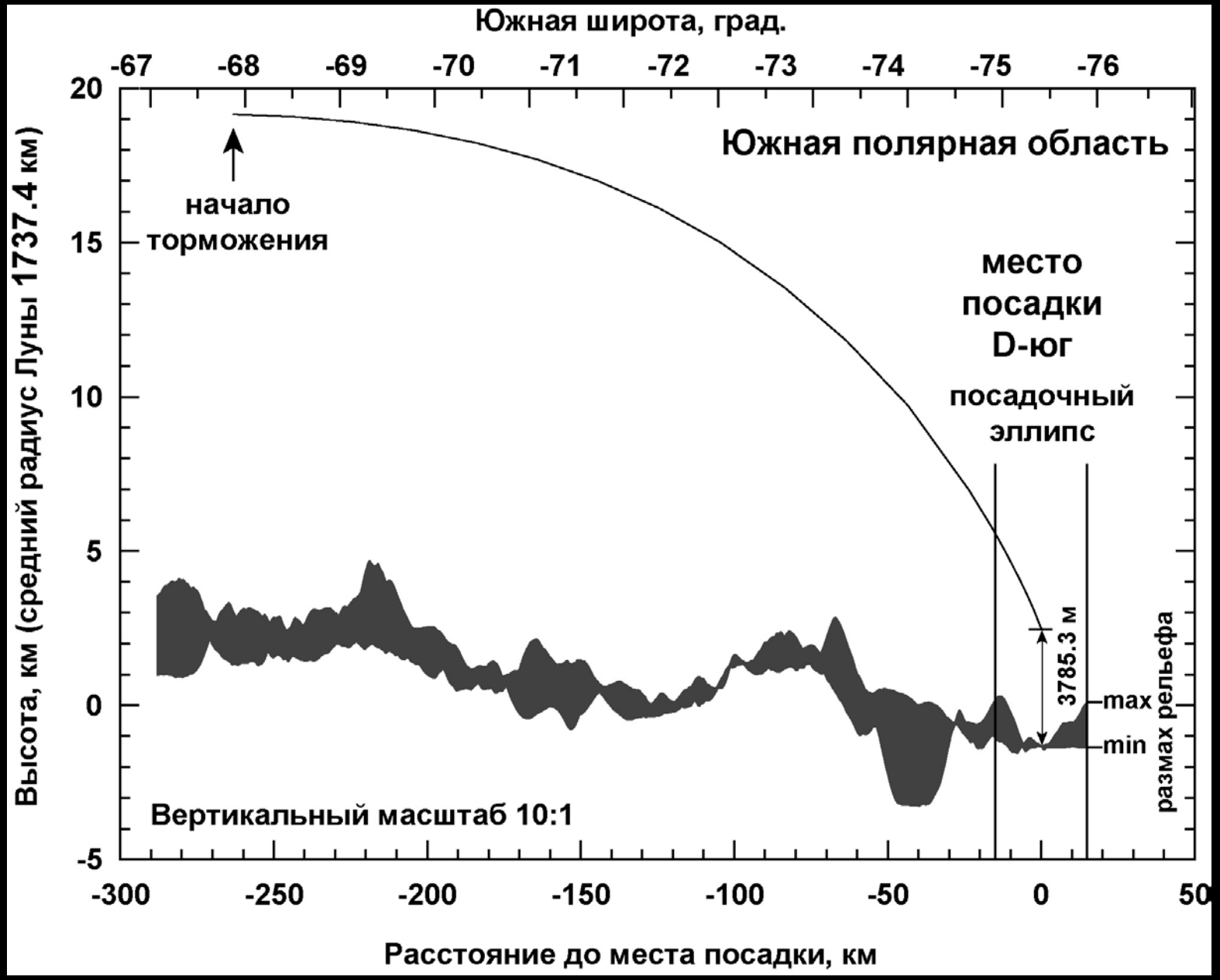

22°E
24°E
26°E
28°E
30°E
32°E
34°E
36°E
38°E
40°E
42°E
44°E
46°E
48°E
73°S
74°S
75°S
76°S
77°S
78°S
79°S
80°S
81°S
82°S
Site South D
LOLA
5000
m
-5000
4°E
8°E
12°E
16°E
20°E
24°E
28°E
32°E
36°E
40°E
44°E
48°E
52°E
56°E
60°E
64°E


d_s_eastern
d_s_center
d_s_western
Elevation (m)
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
0
25
50
75
100
125
150
175
200
225
250
275
300
325
Distance (km)

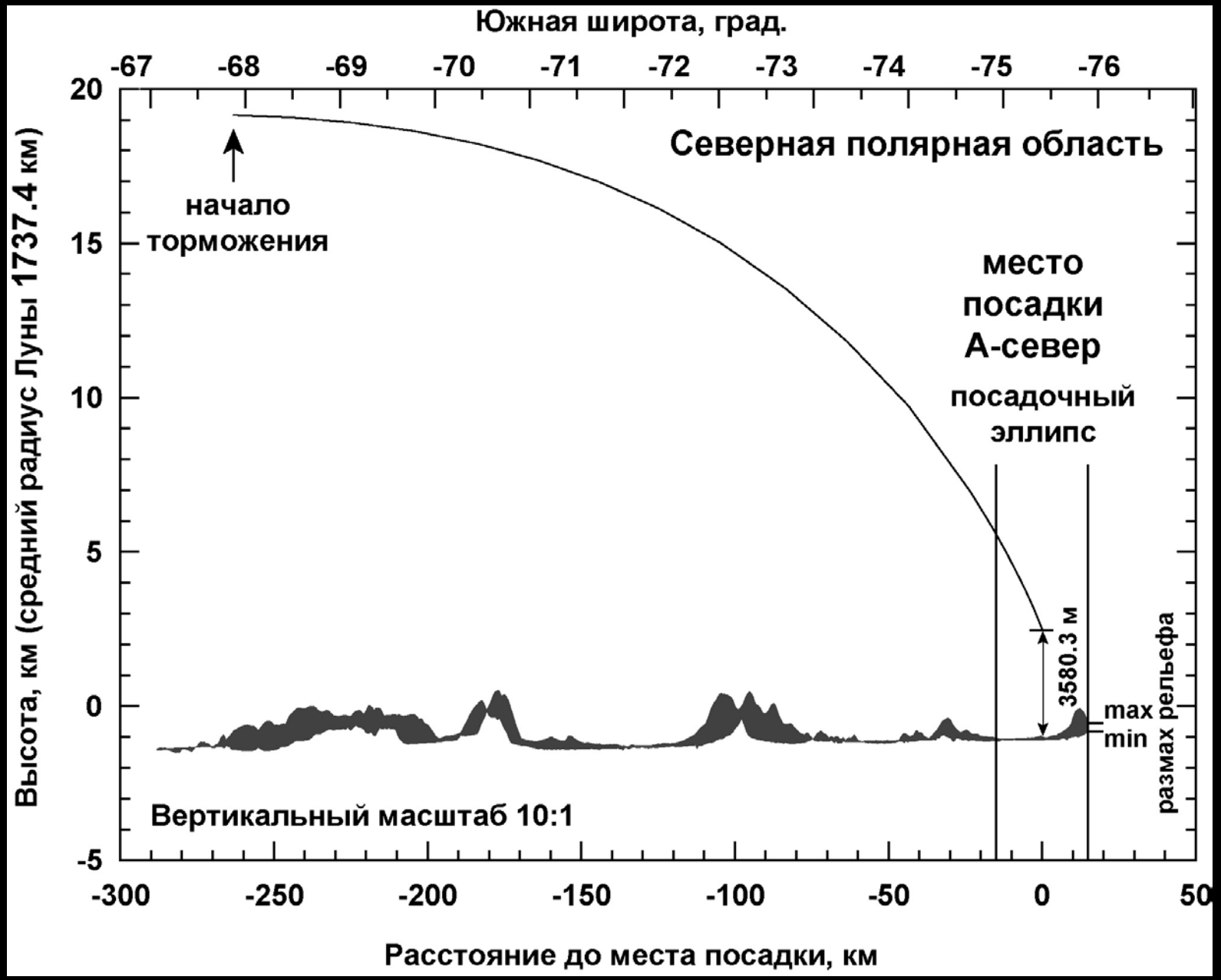
Descent trajectories and the approach topography



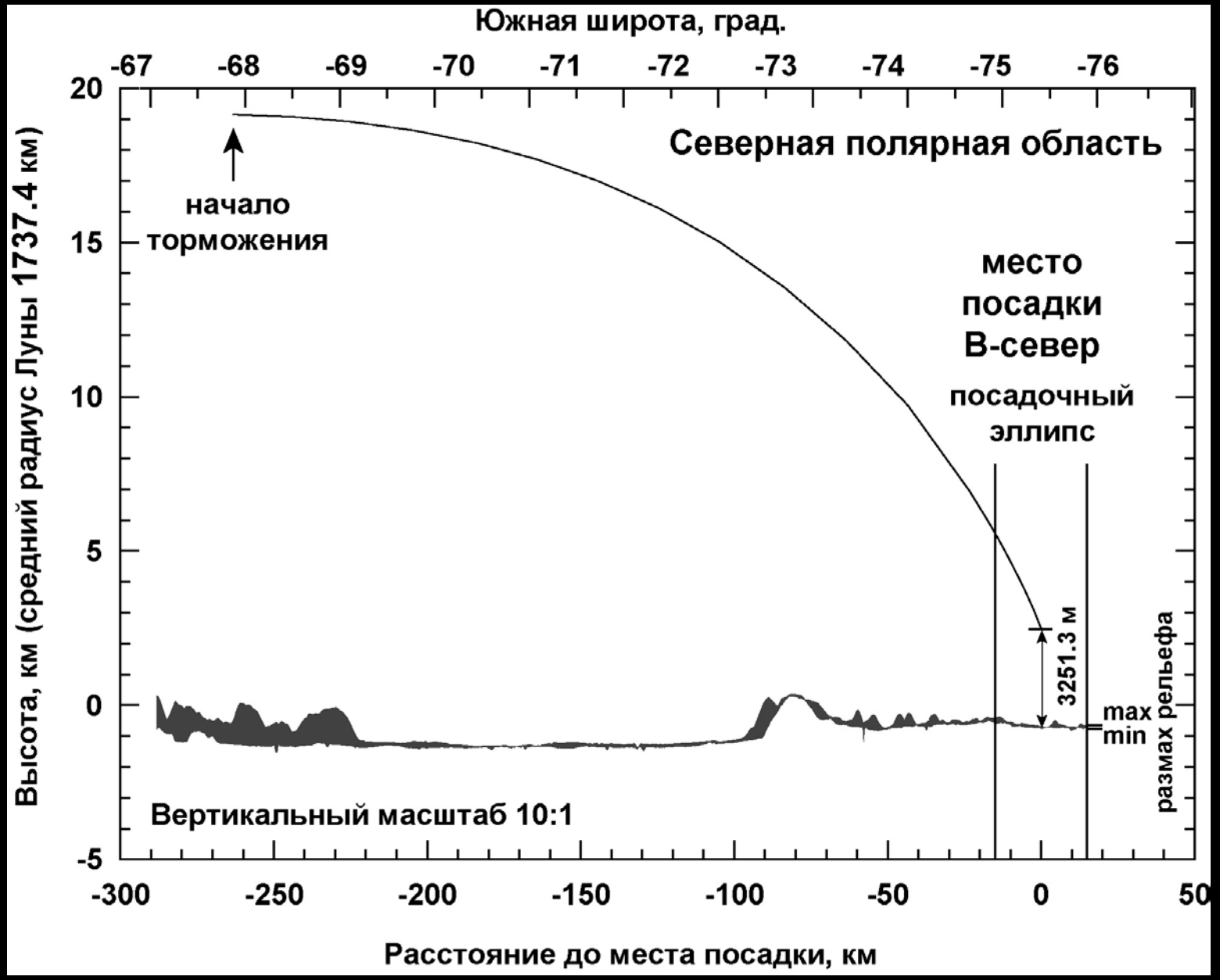
Descent trajectories and the approach topography



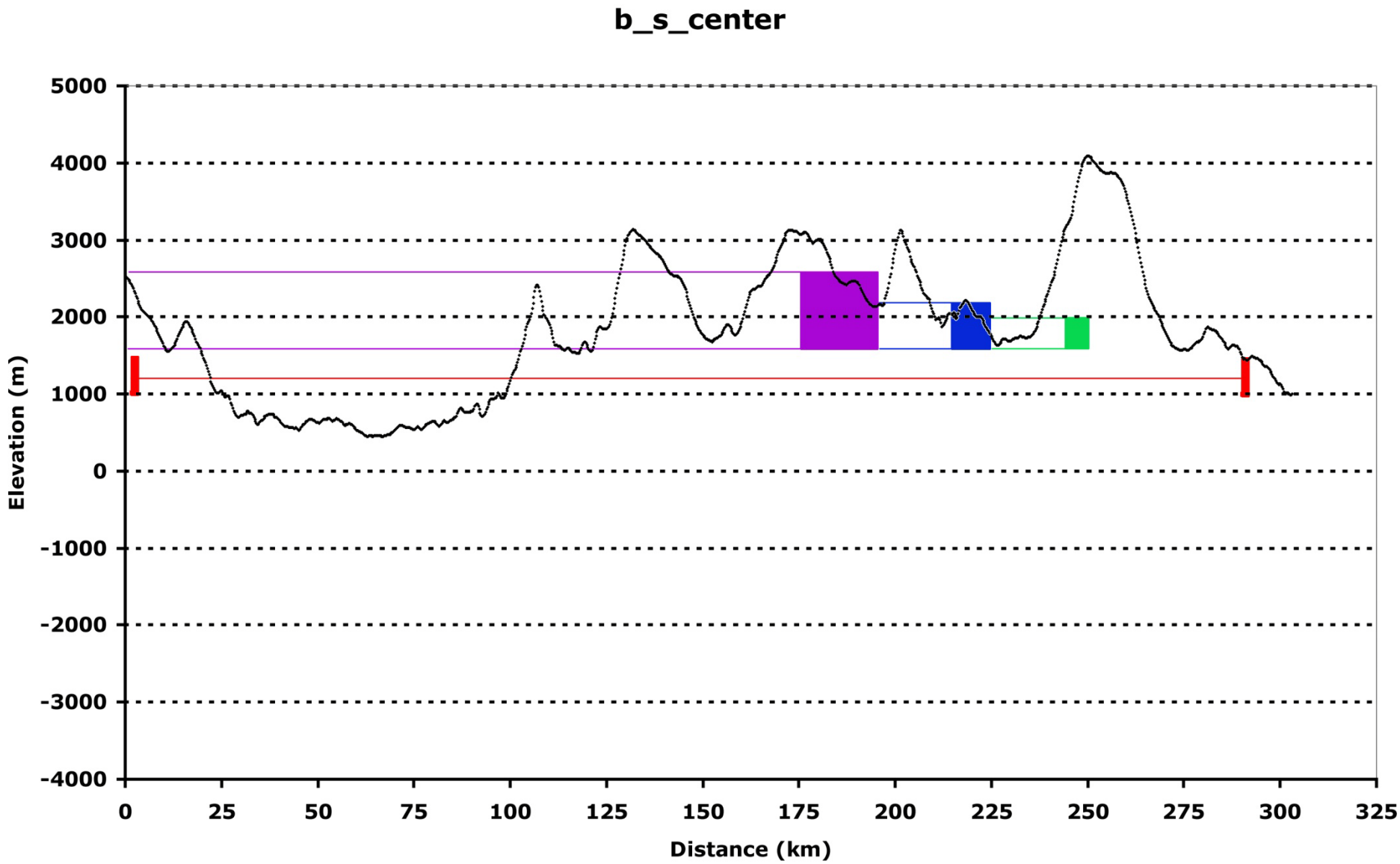
Descent trajectories and the approach topography



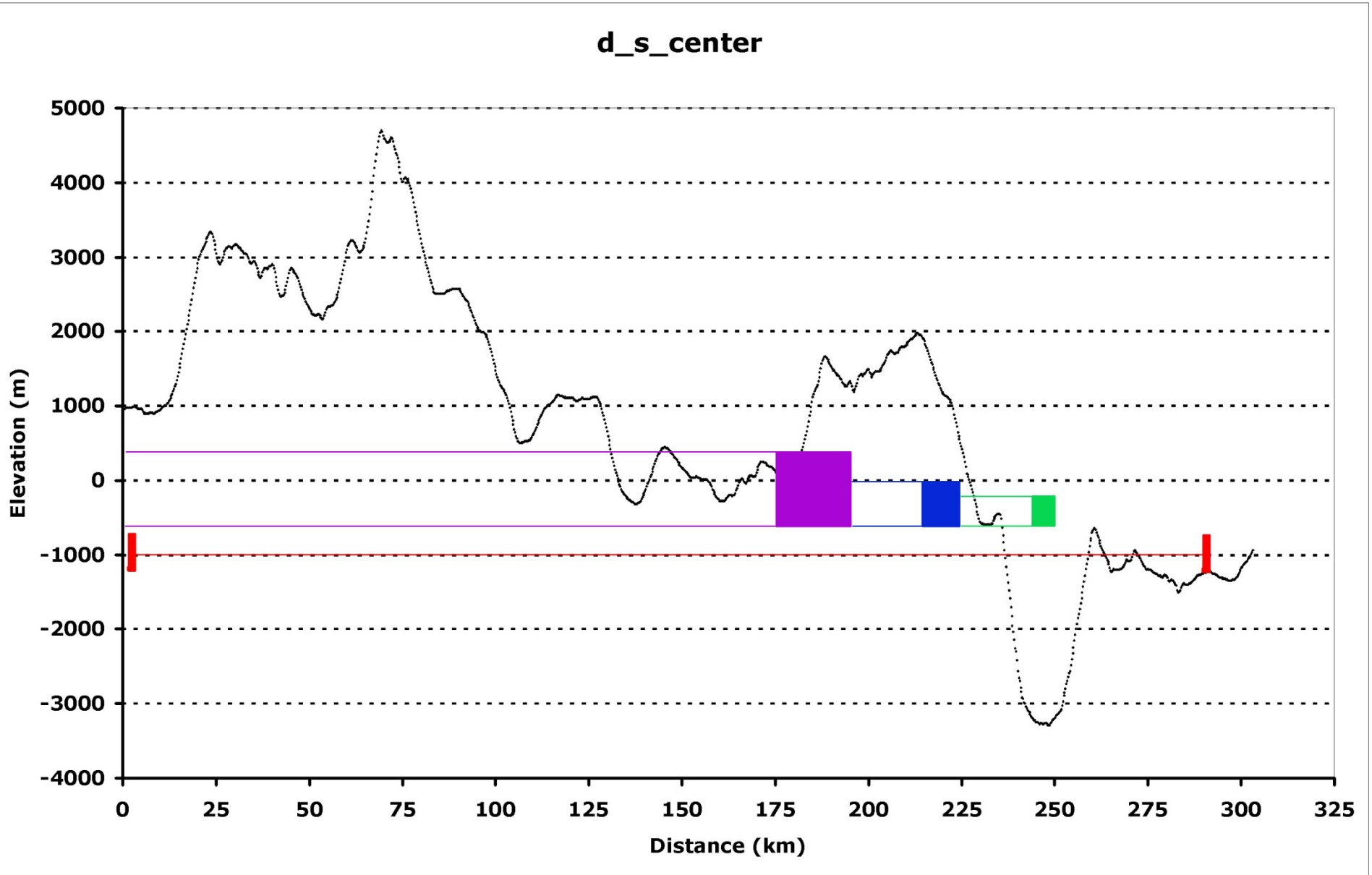
Descent trajectories and the approach topography



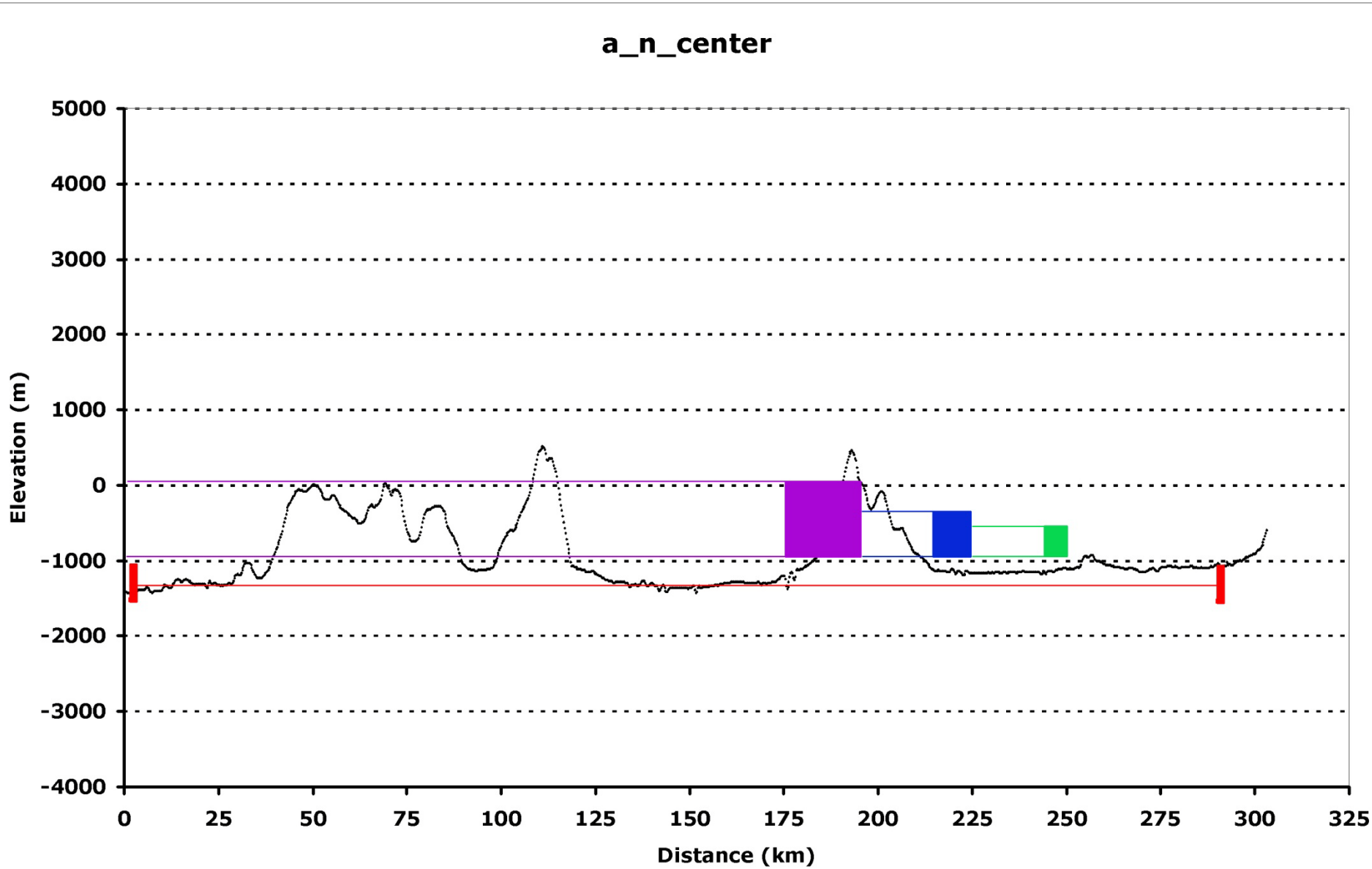
NPOL requirements for the approach topography



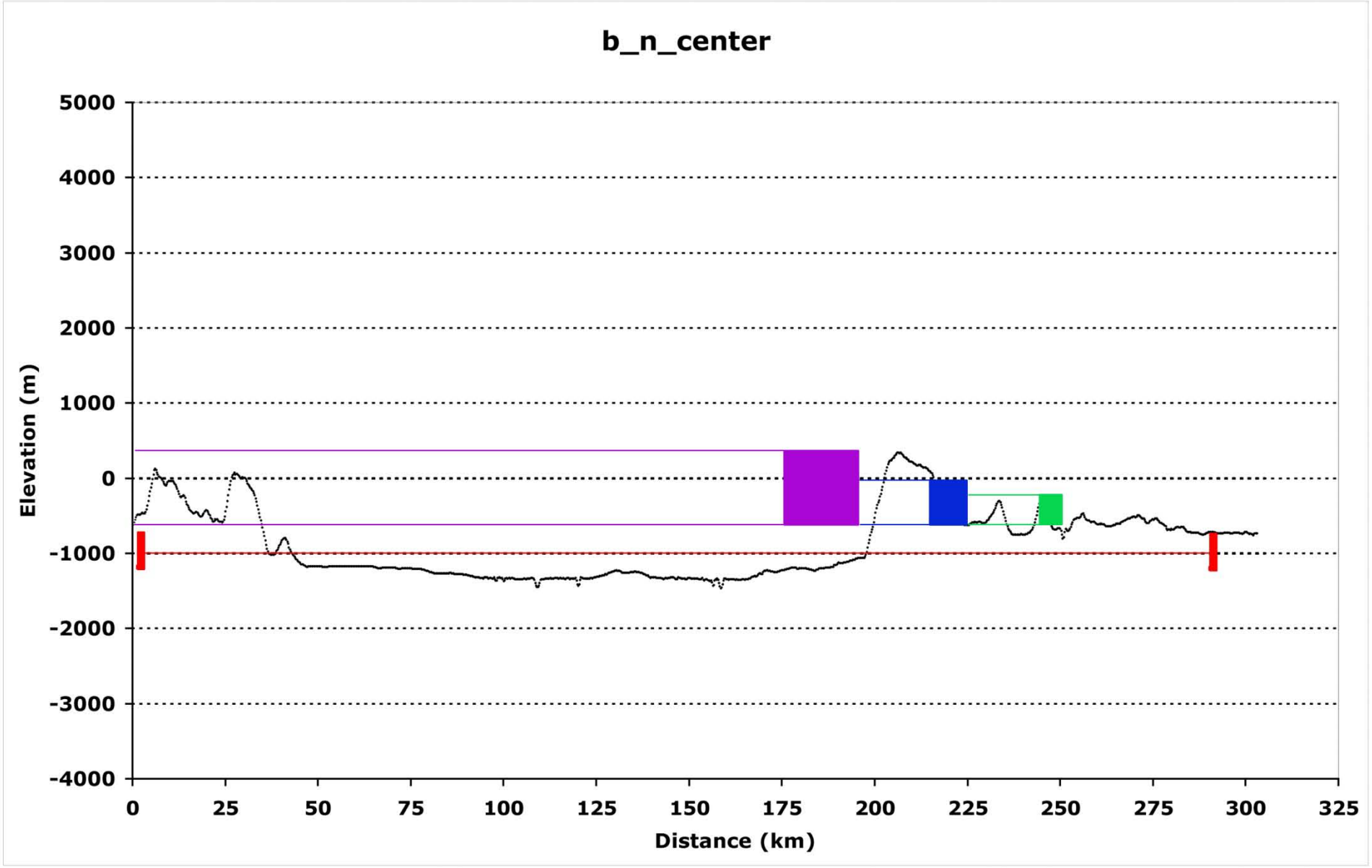
NPOL requirements for the approach topography



NPOL requirements for the approach topography



NPOL requirements for the approach topography



Surface characteristics in the descent profiles

Conclusion:

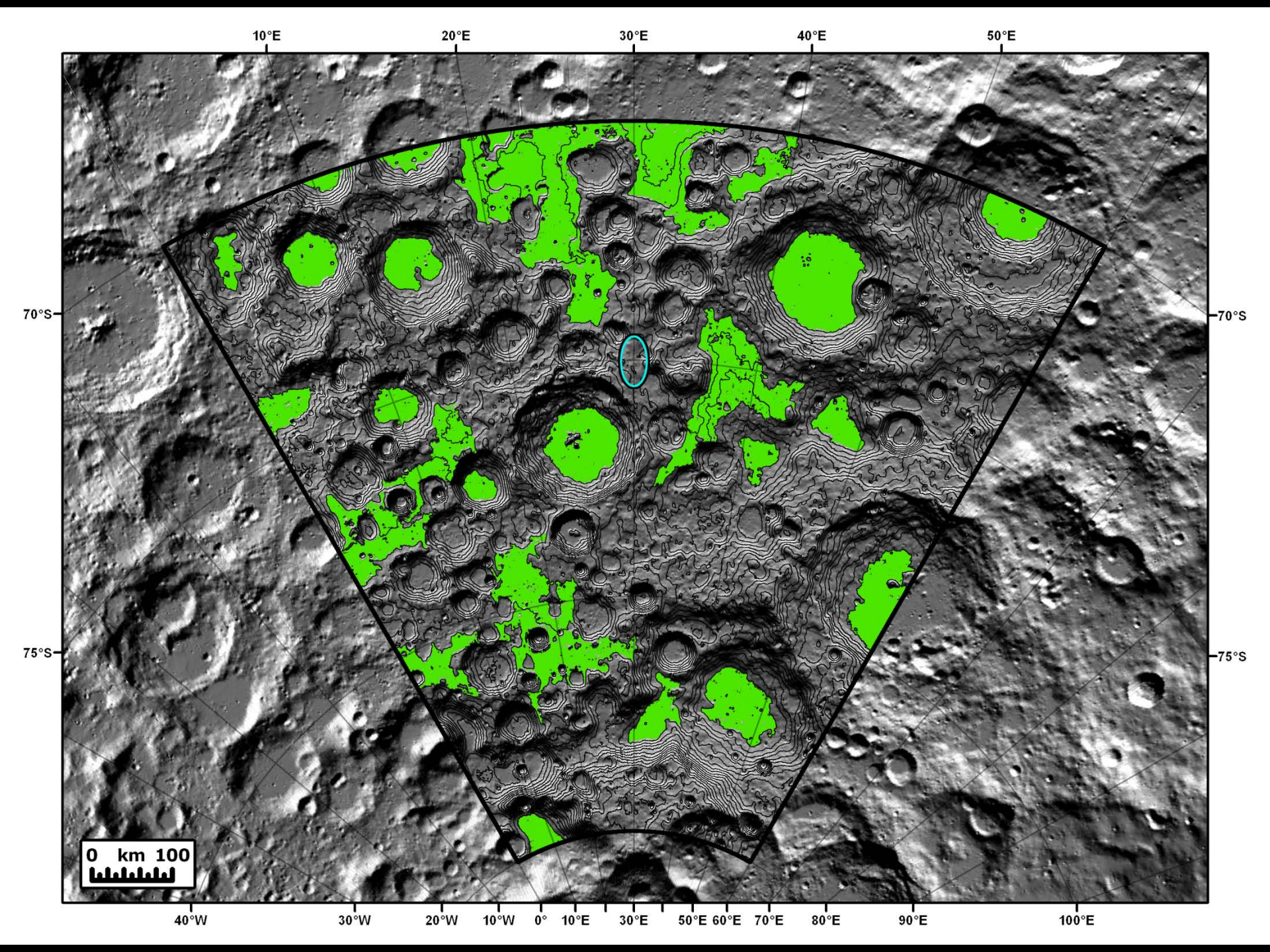
NPOL requirements for the descent profiles' topography do not fit the real topography in all studied cases.

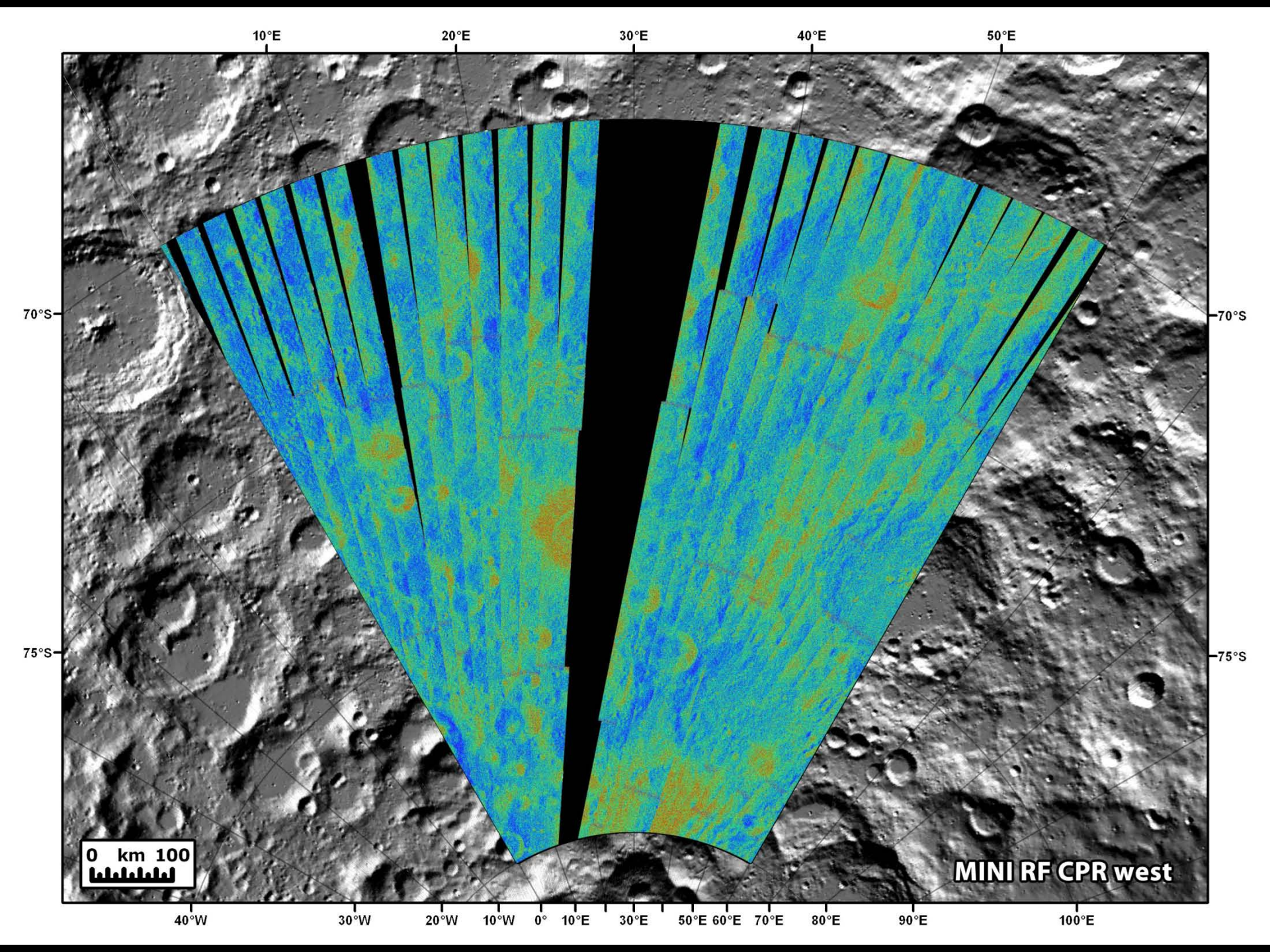
Now NPOL has resolved this problem:
No altimetry measurements on the descent!

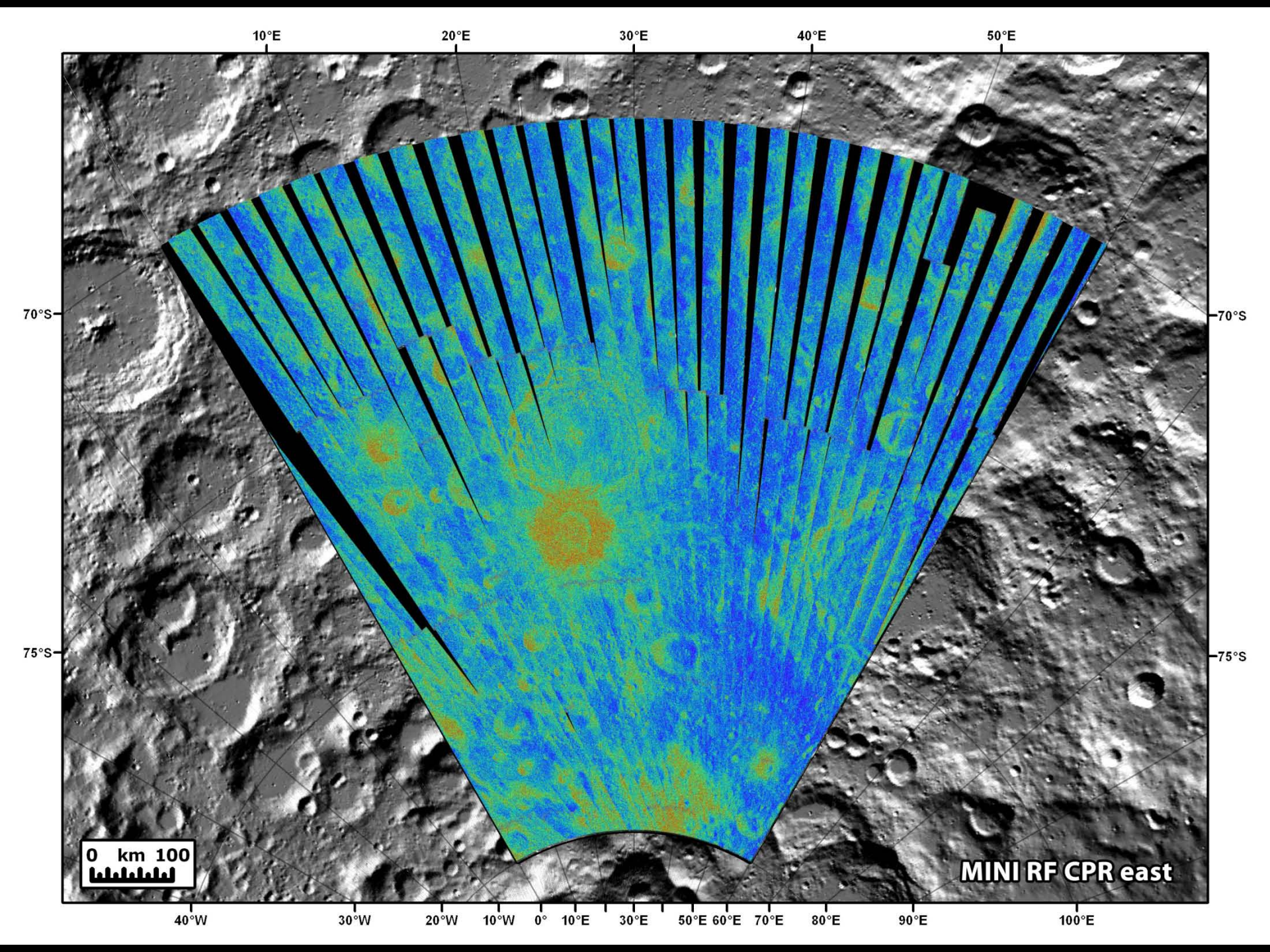
New approach for selection of landing sites suggested by IKI last week: Parallel studies:

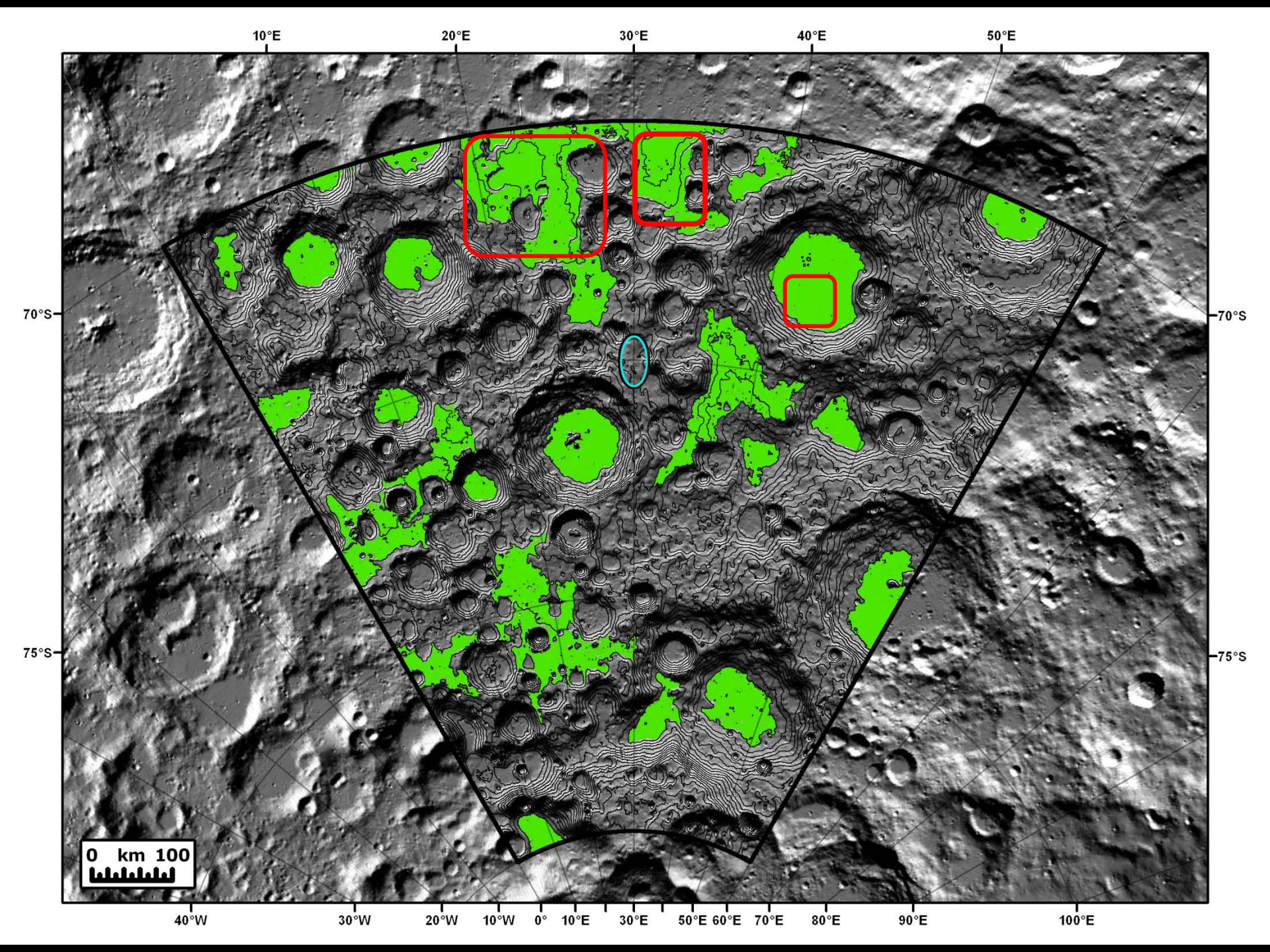
- Vernadsky Institute selects relatively smooth and large enough areas to accommodate landing ellipses;
- Shternberg Institute (GAISH) outlines areas with acceptable solar illumination and visibility from Earth;
- Space Research Institute maps areas enriched with hydrogen.

Then we jointly select the safest site(s) in the hydrogen-rich well illuminated and visible place.


10°E
20°E
30°E
40°E
50°E
70°S
75°S
0 km 100
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E


10°E
20°E
30°E
40°E
50°E
70°S
75°S
0 km 100
MINI RF CPR west
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E


10°E
20°E
30°E
40°E
50°E
70°S
75°S
0 km 100
MINI RF CPR east
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

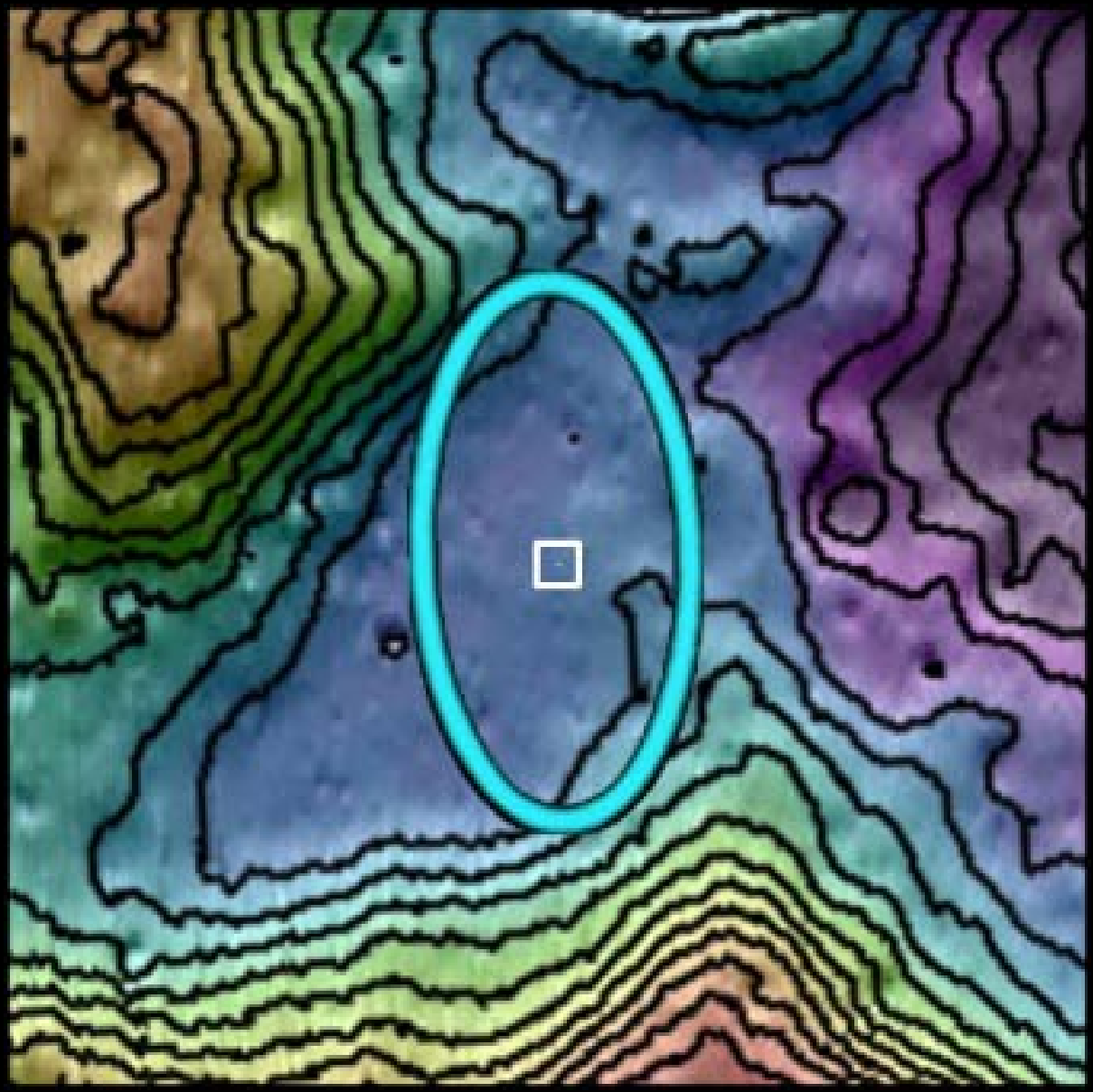

10°E
20°E
30°E
40°E
50°E
70°S
75°S
0 km 100
40°W
30°W
20°W
10°W
0°
10°E
30°E
50°E
60°E
70°E
80°E
90°E
100°E

Detailed surface characteristics in the potential landing sites

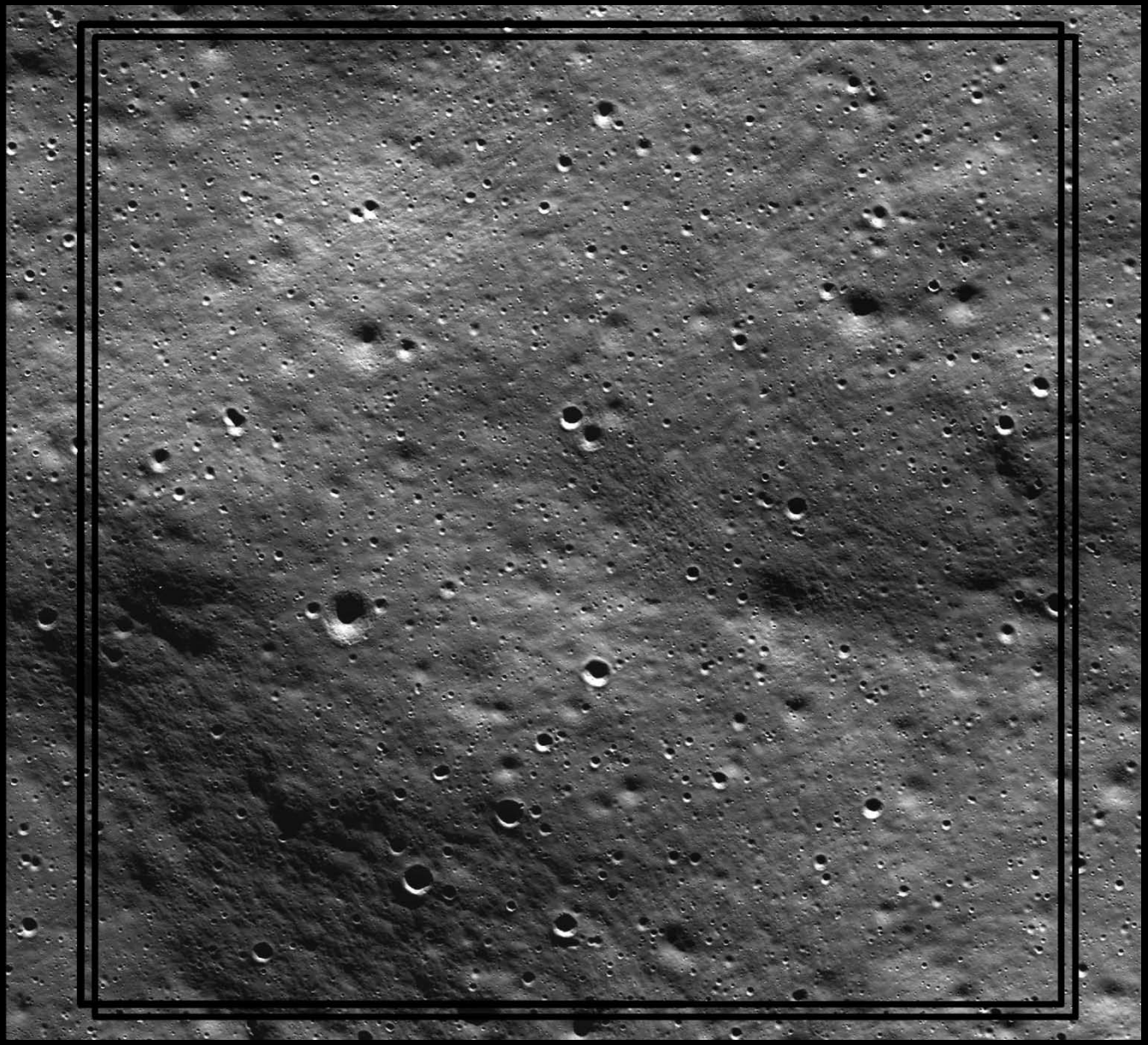
Sources of information:

LROC NAC
LOLA
MINI-RF
(in progress)

Site D South
Box 2 x 2 km in the center of landing ellipse

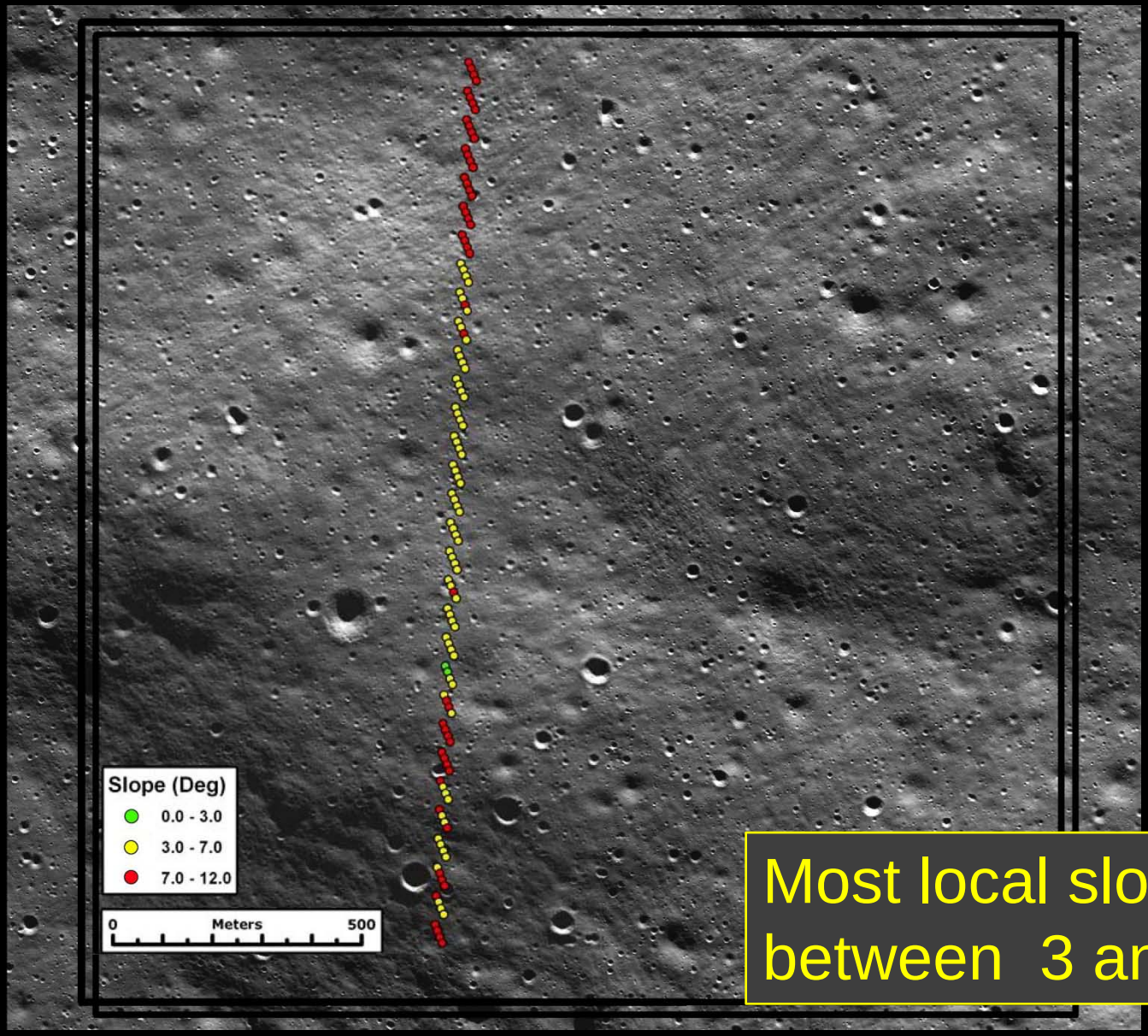


Site D South, Box 2 x 2 km in the center of landing ellipse



Mosaic of LROC images M142050286 L & R, mismatch ~30 m

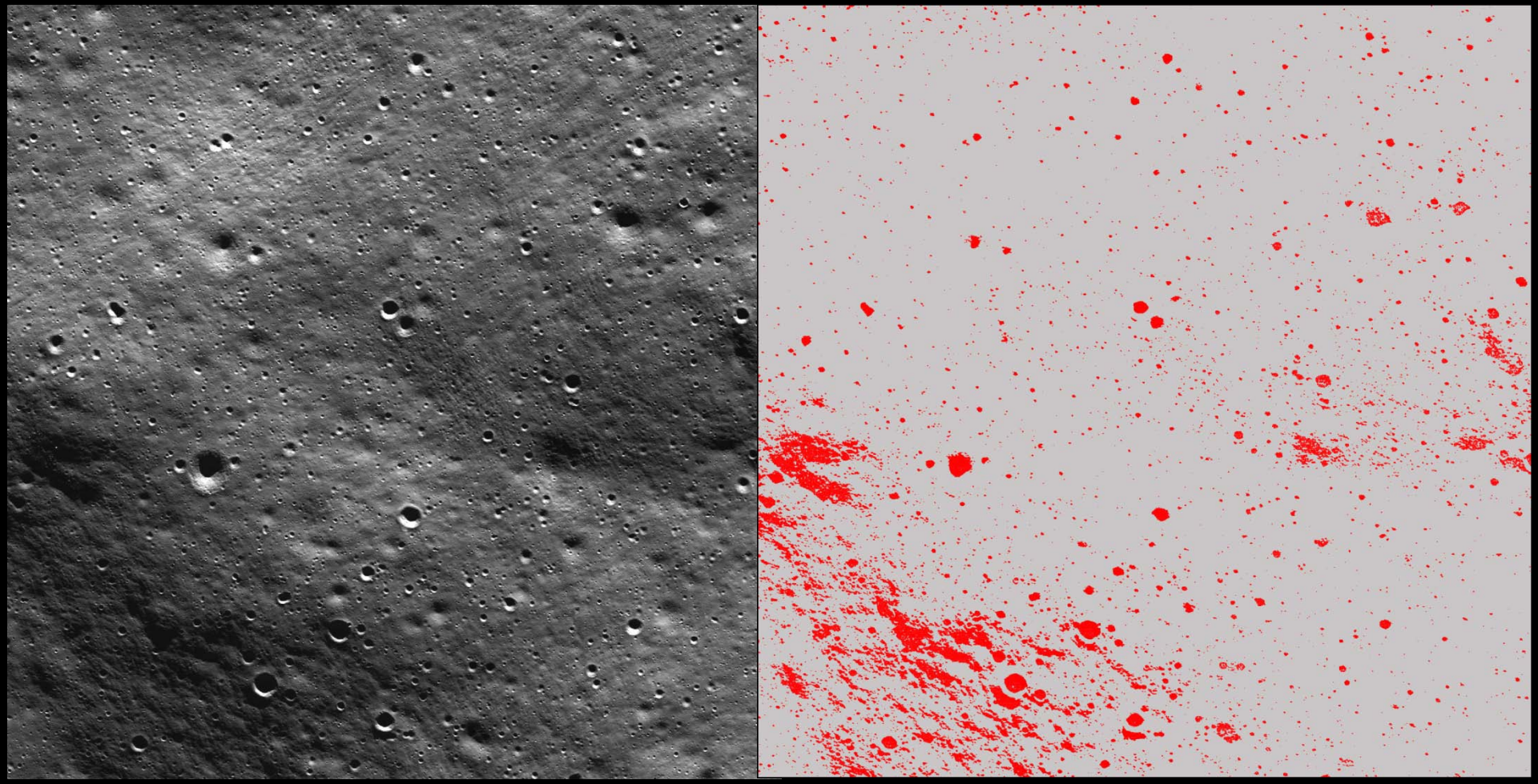
Site D South, Box 2 x 2 km in the center of landing ellipse



Most local slopes are between 3 and 12°.

LOLA based slopes with 25 m base on M142050286LR

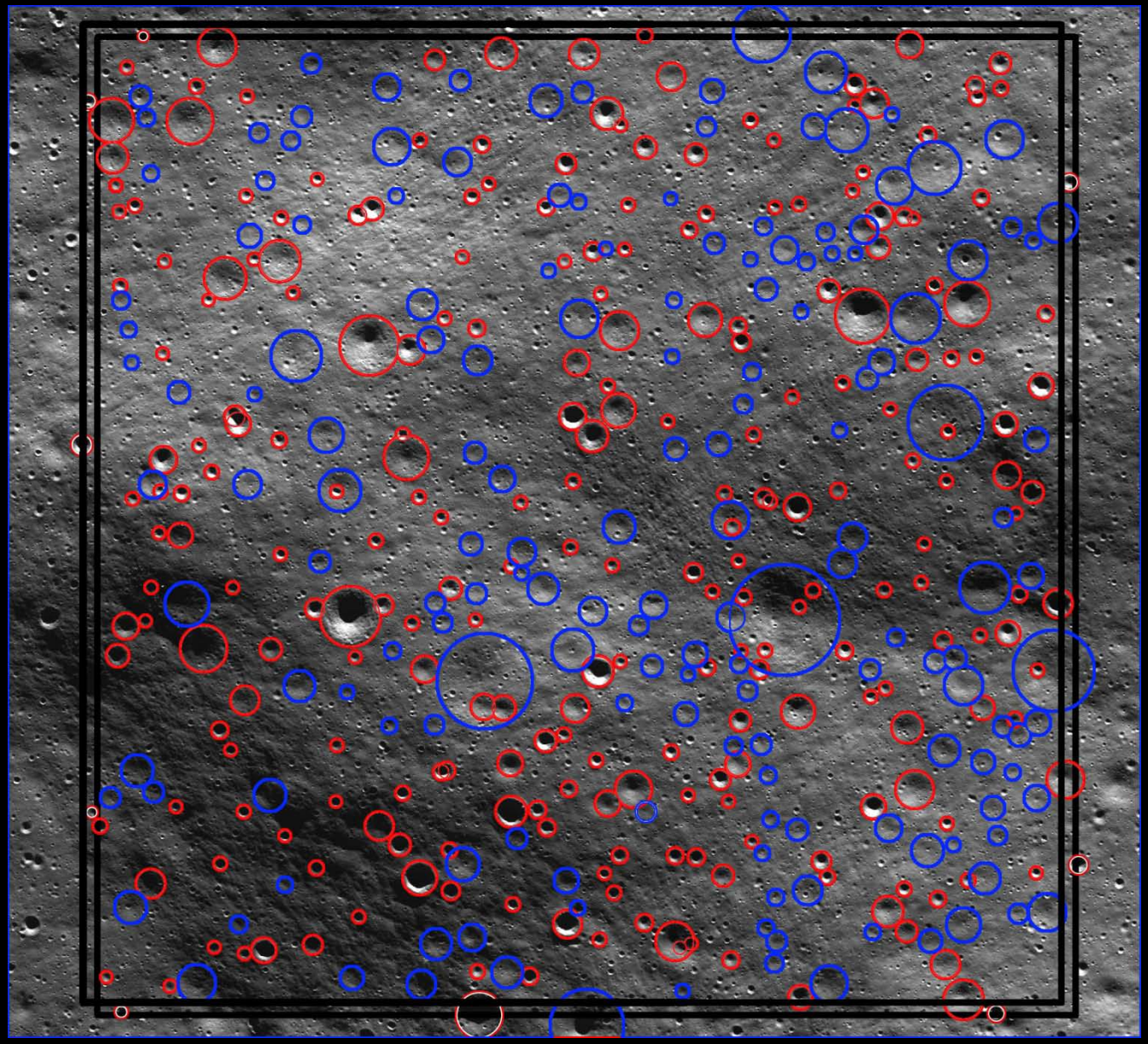
LROC images M142050286L & R combined
Solar elevation 8 deg above the horizon



Reds are shadows: The way
to estimate percentage of area with slopes larger than 7 deg

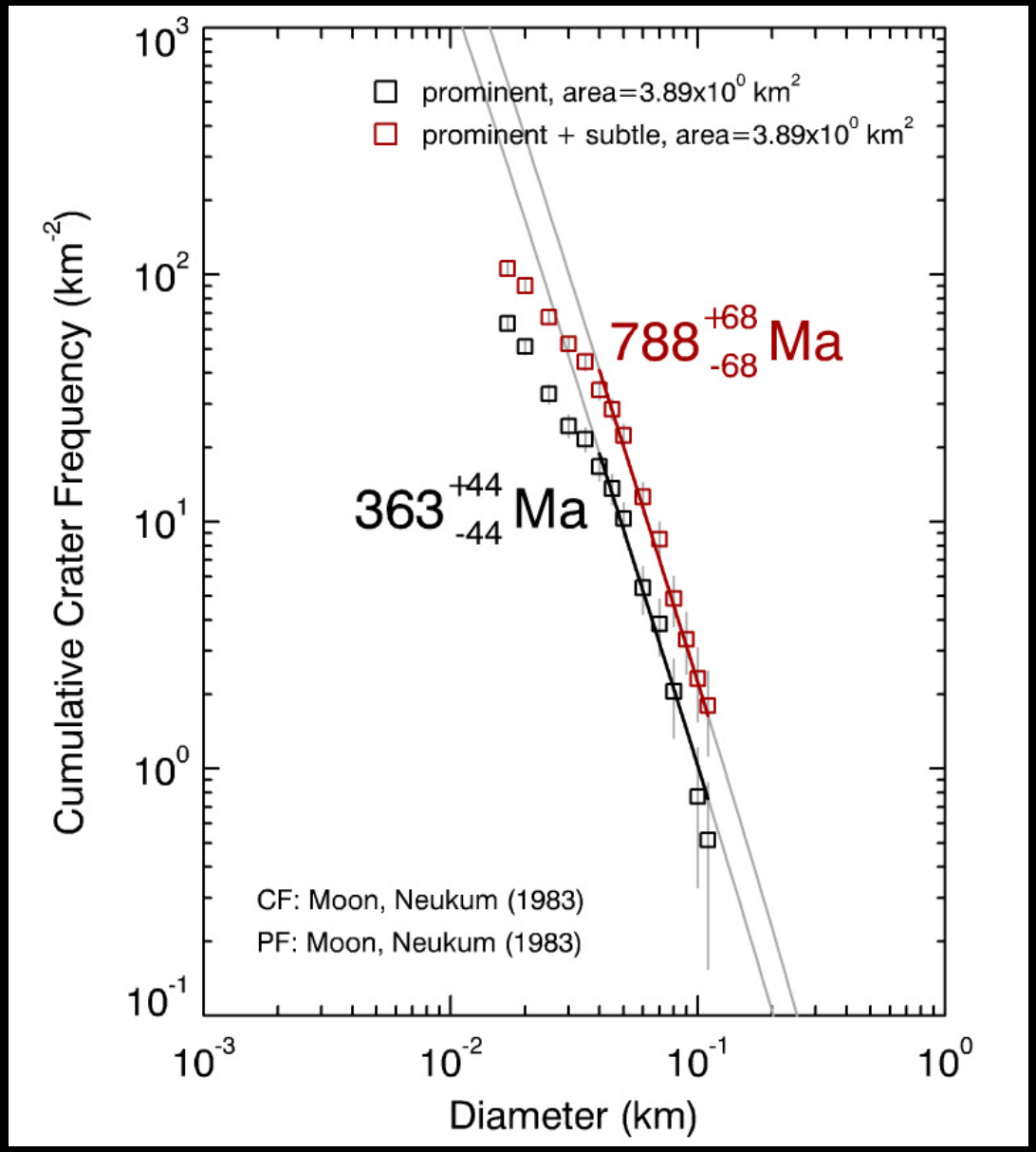
LROC NAC based DTMs
produced by DLR
for landing ellipses
would be
extremely helpful

Site D South, Box 2 x 2 km in the center of landing ellipse



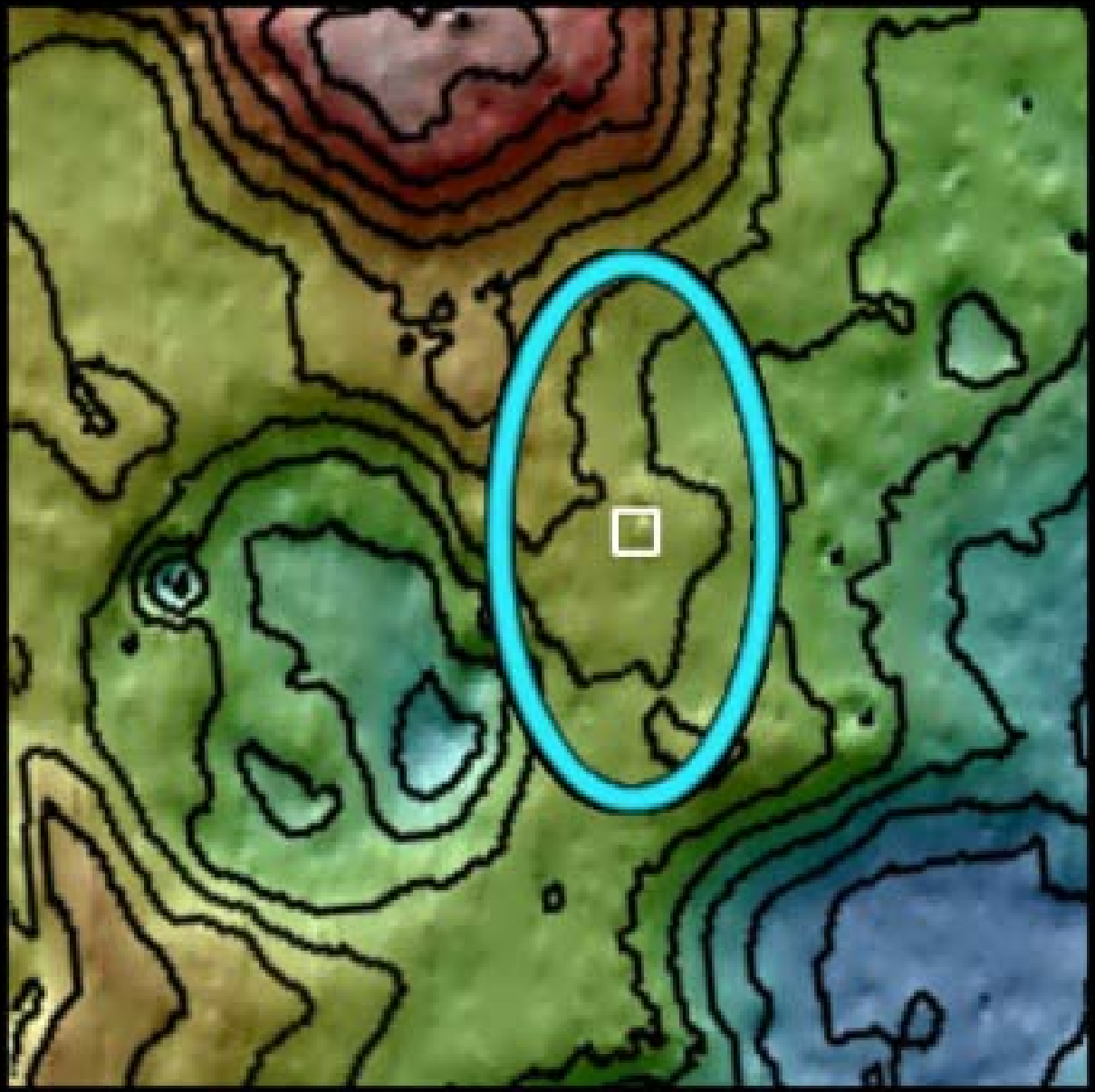
Craters prominent and subtle identified on M142050286

Site D South, Box 2 x 2 km in the center of landing ellipse

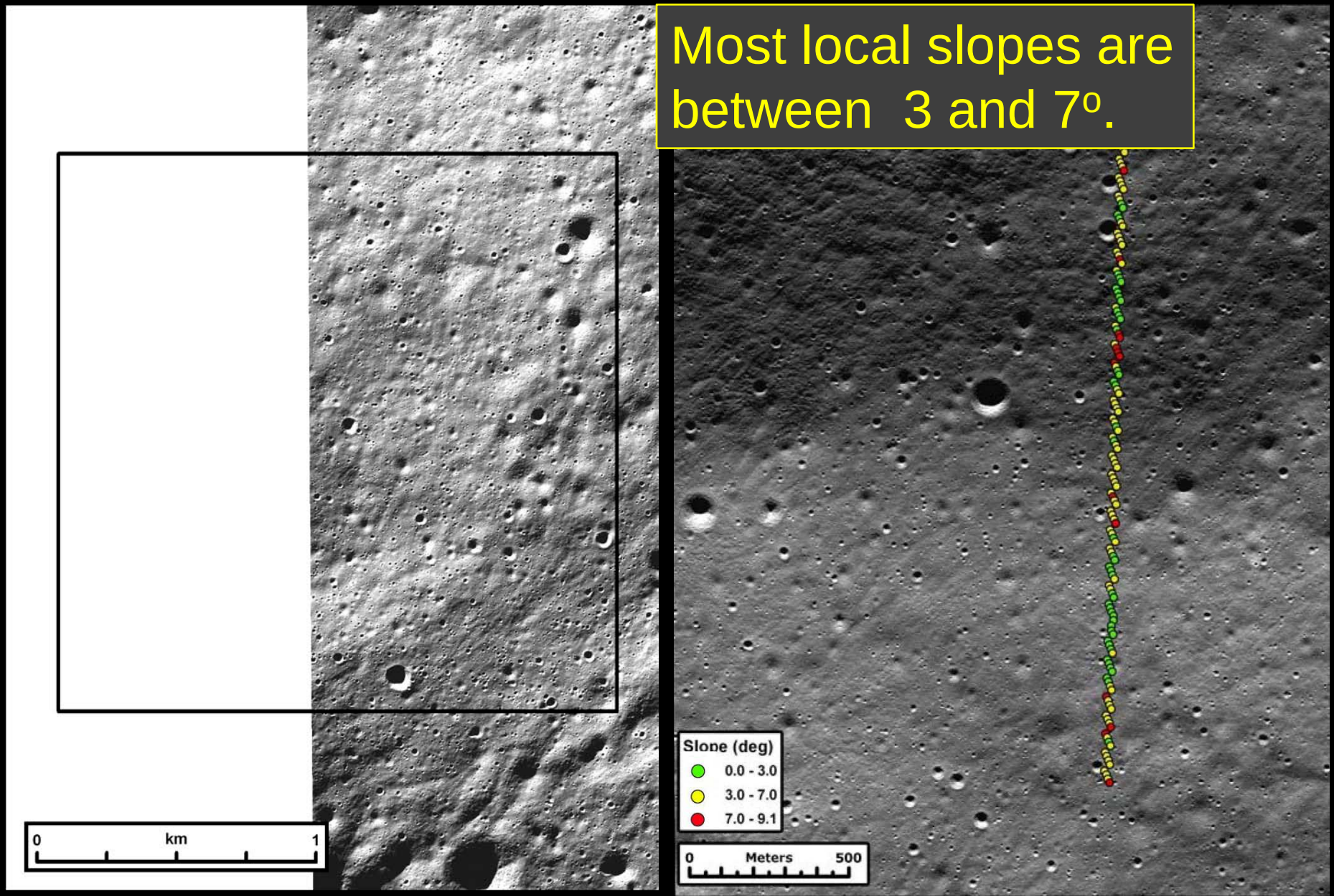


Crater age estimates done by Gregg Michael. FU Berlin

Site B South
Box 2 x 2 km in the center of landing ellipse

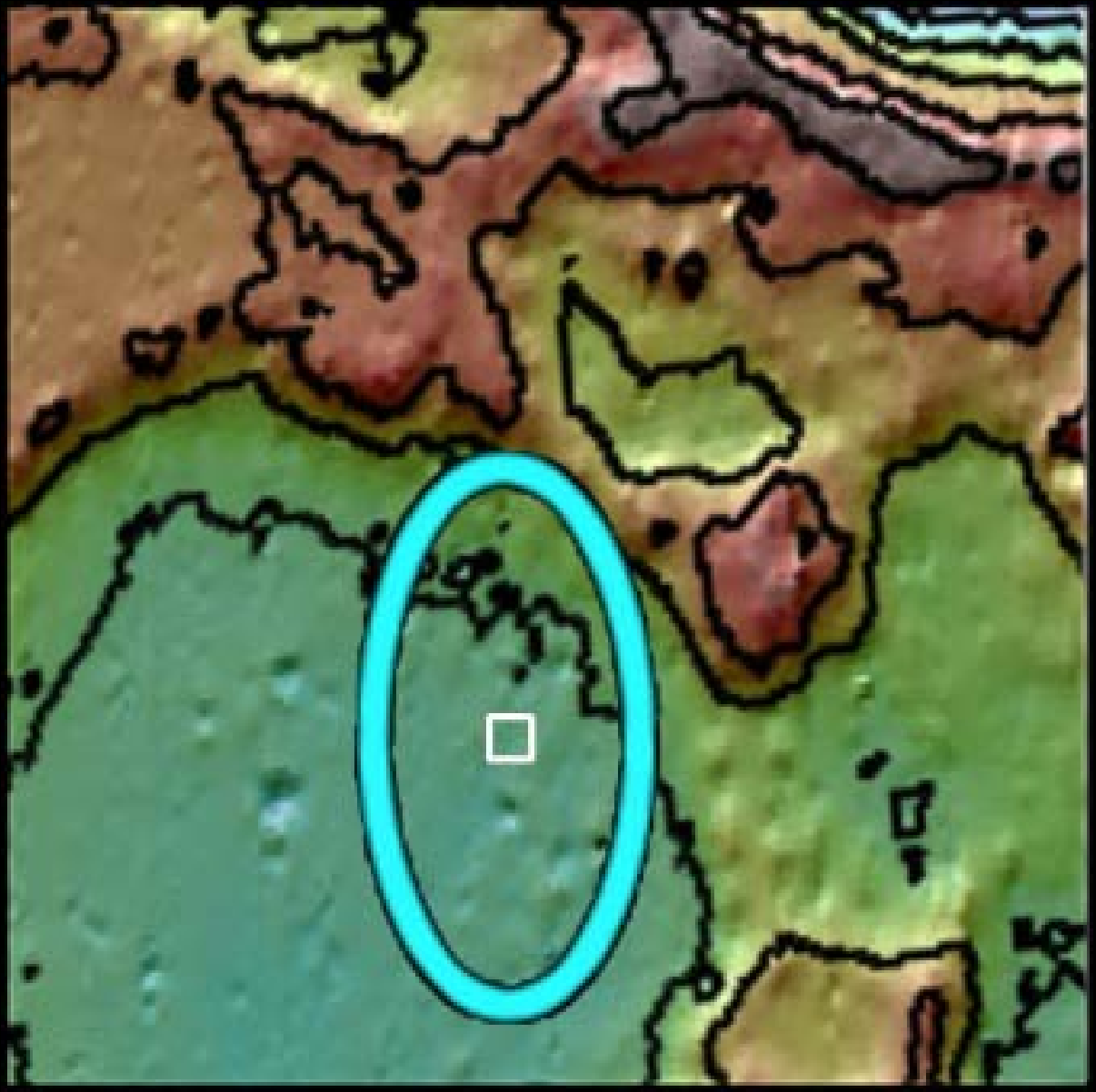


Site B South, Box 2 x 2 km in the center of landing ellipse

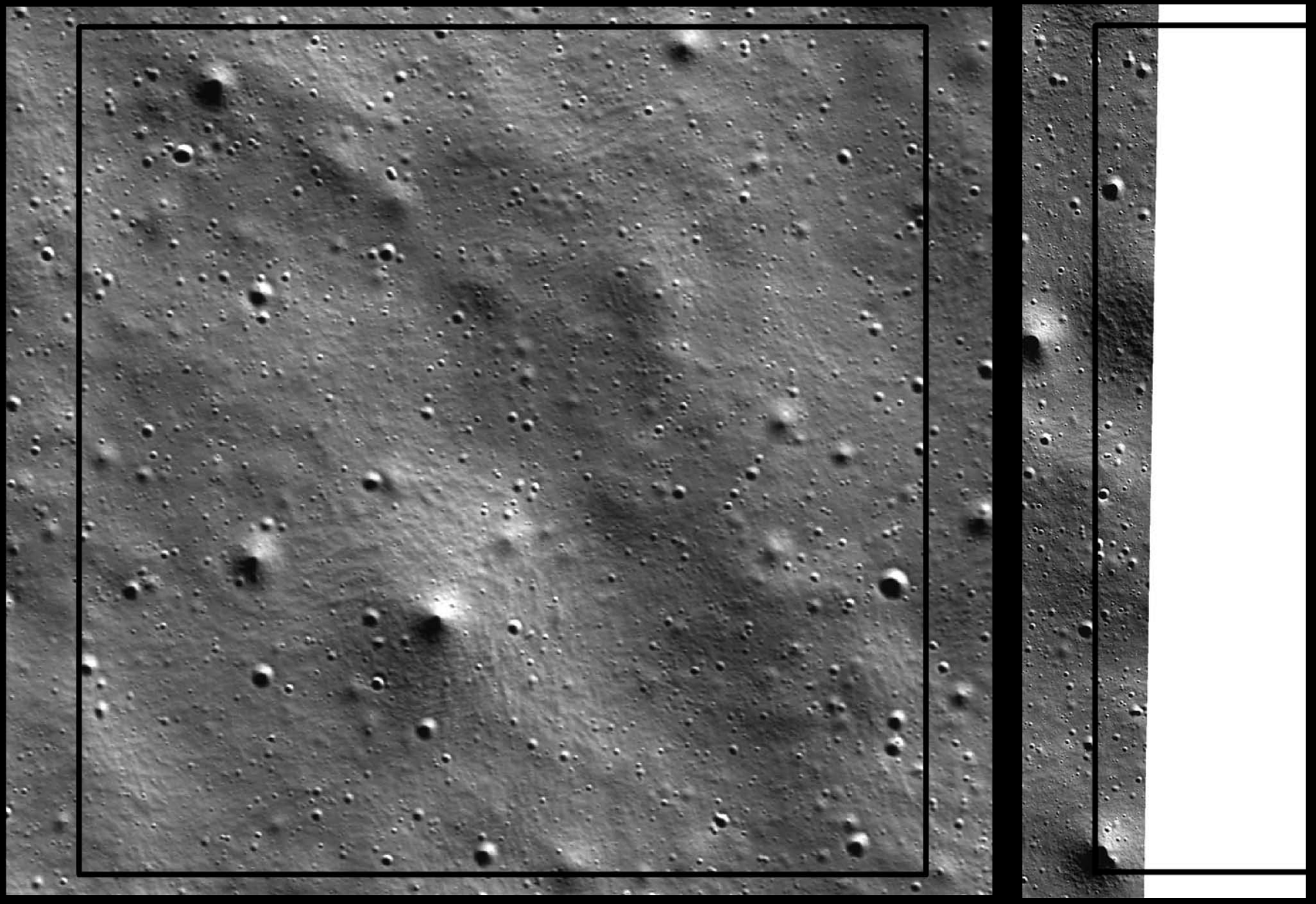


LROC image M121978591L, 25 m base slopes, mismatch ?

Site A North
Box 2 x 2 km in the center of landing ellipse

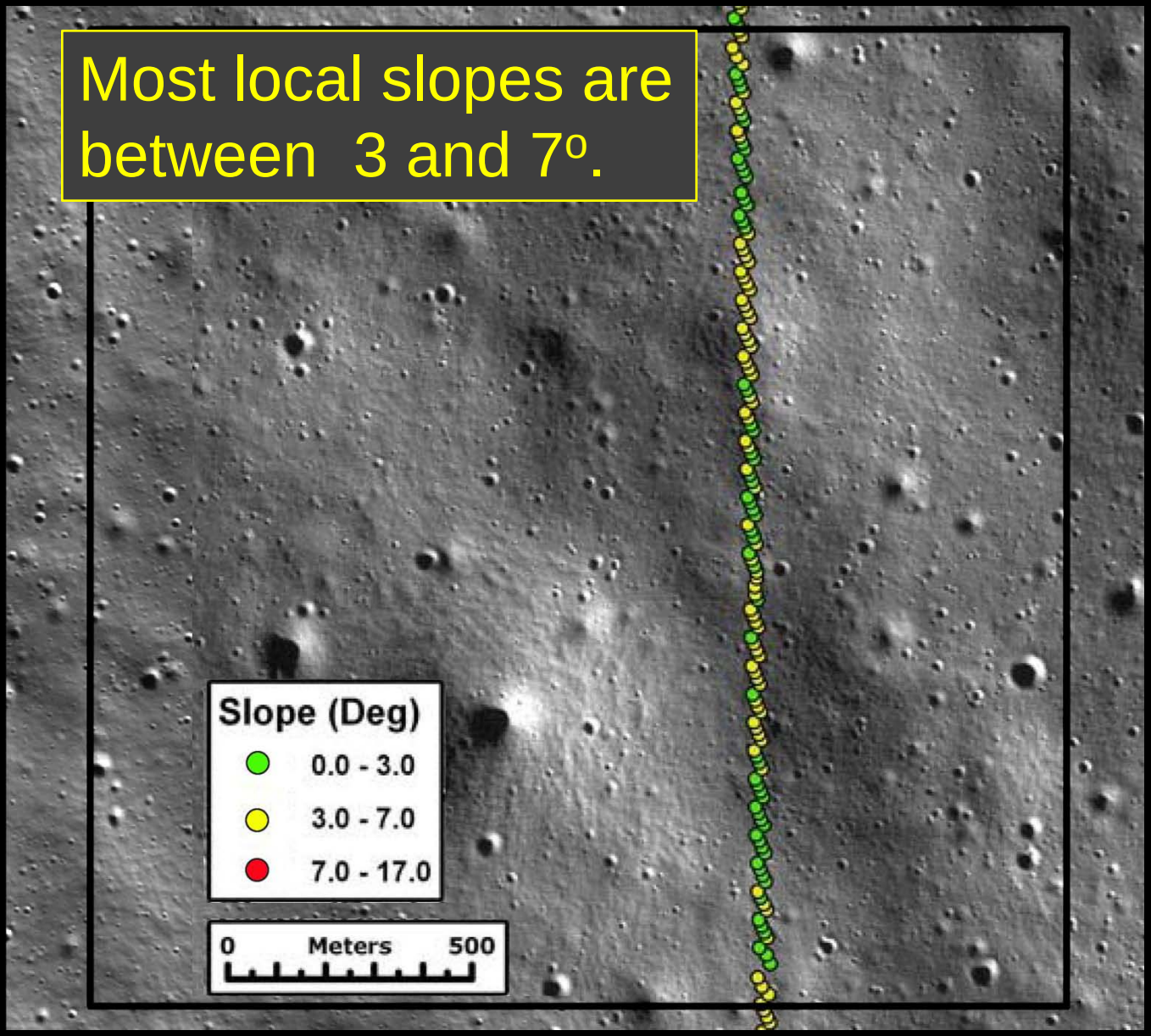


Site A North, Box 2 x 2 km in the center of landing ellipse



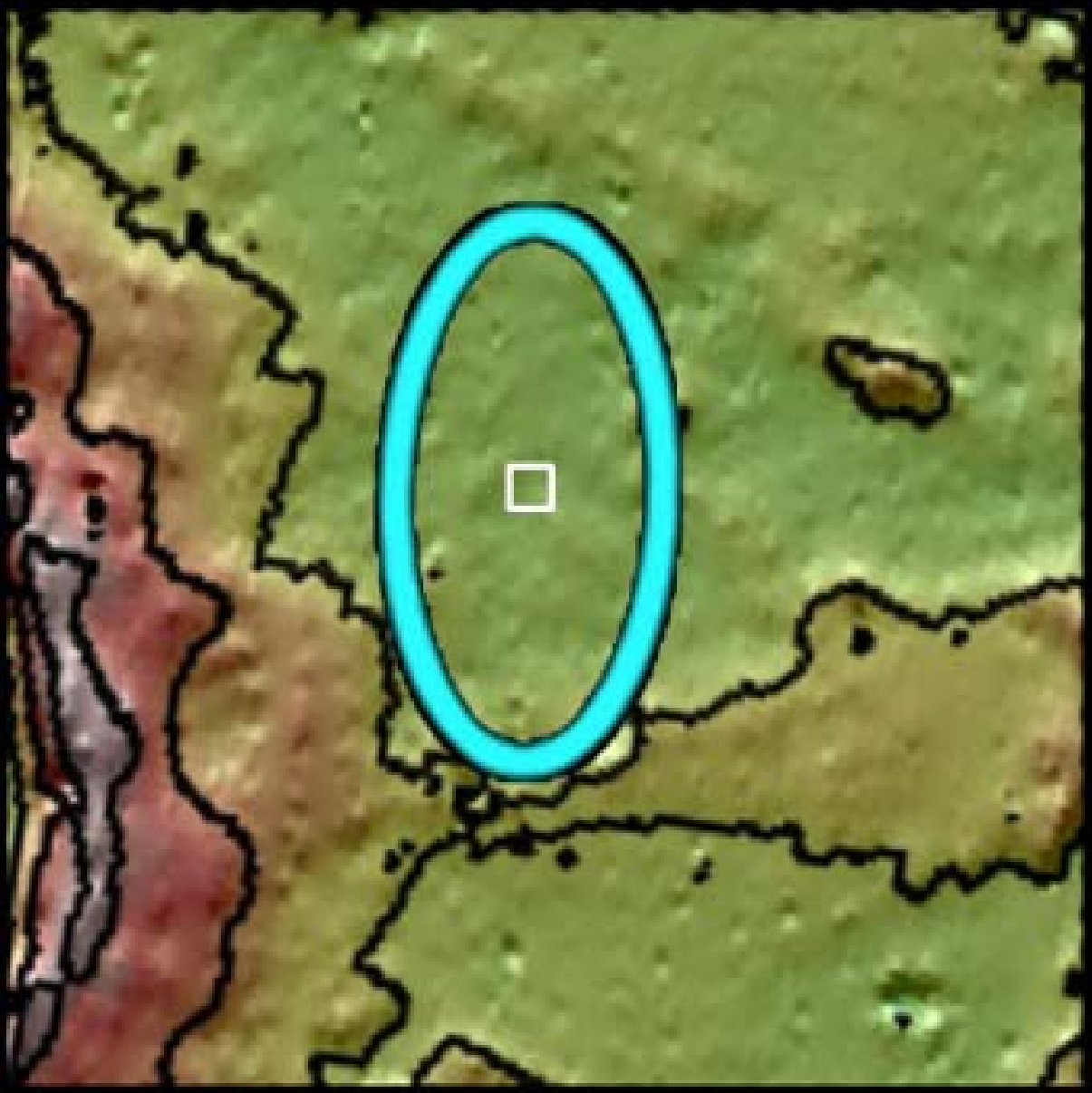
LROC images M106832552R & M137494481R, , mismatch > 1 km

Site A North, Box 2 x 2 km in the center of landing ellipse

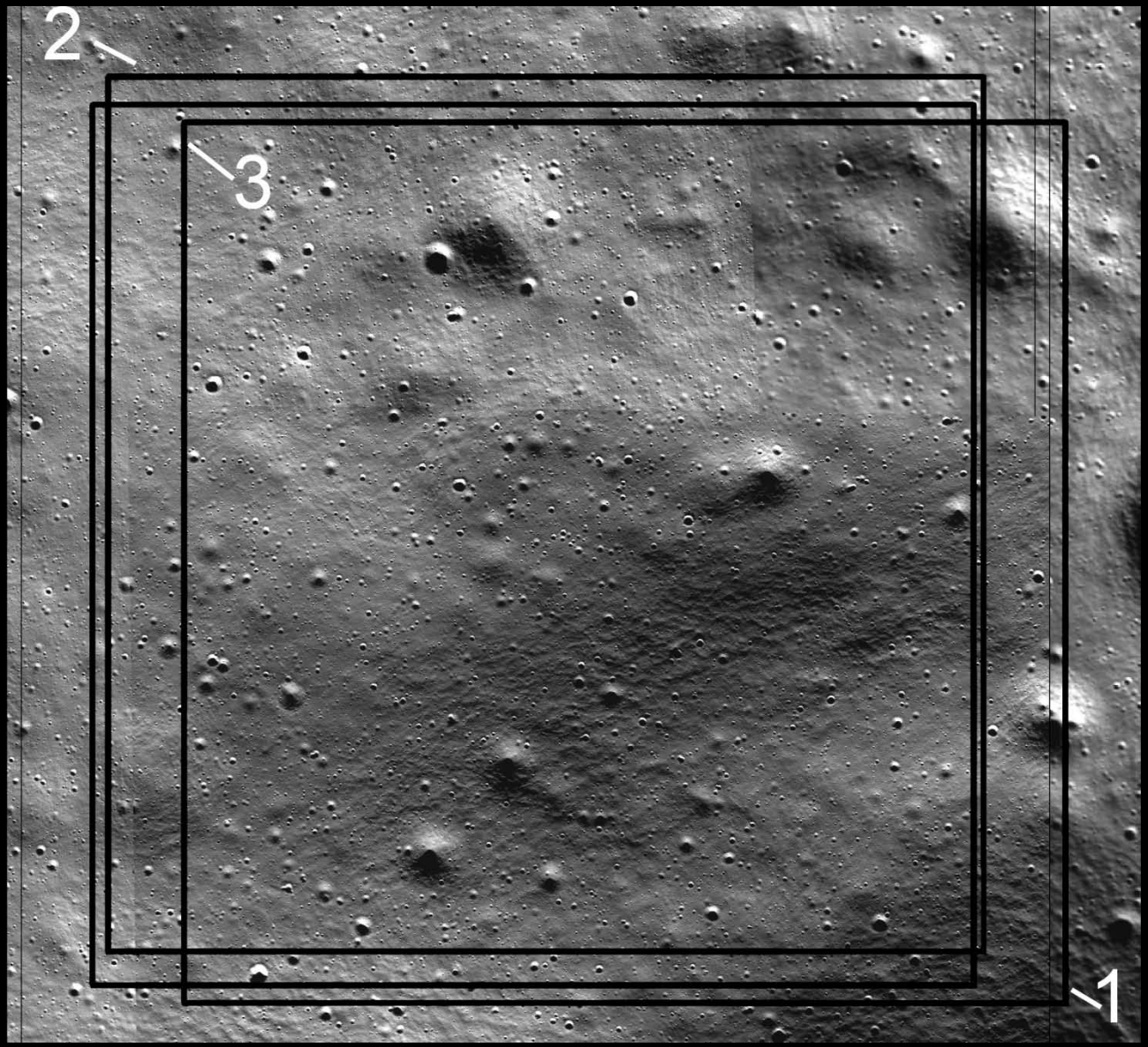


LOLA based slopes with 25 m base on M106832952R

Site B North
Box 2 x 2 km in the center of landing ellipse

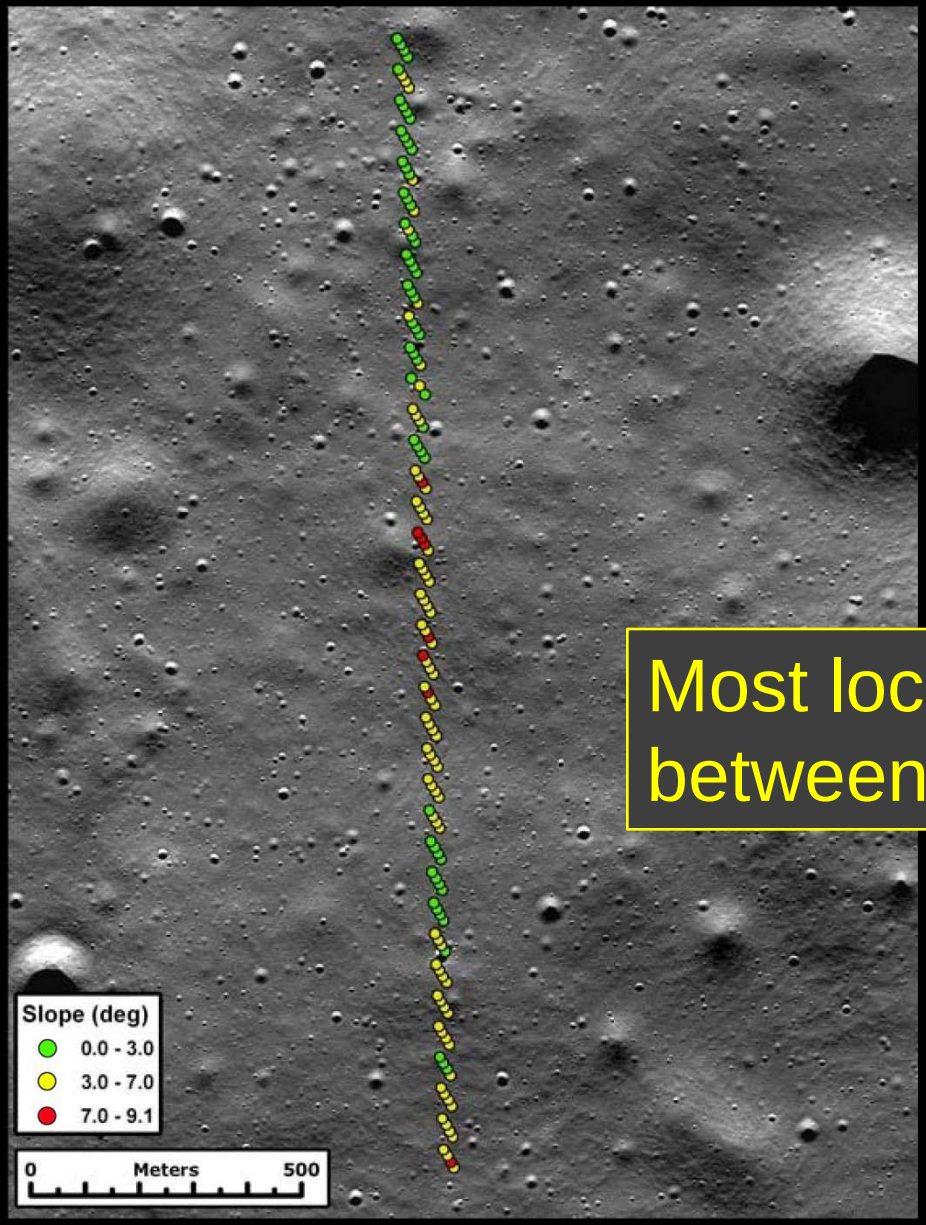


Site B North, Box 2 x 2 km in the center of landing ellipse



LROC M106761081R (1), M122049365L (2), M139767260L (3)

Site B North, Box 2 x 2 km in the center of landing ellipse



Most local slopes are between 3 and 7°.

LOLA based slopes with 25 m base on ?, mismatch ?

To study detailed surface characteristics within the landing ellipses we need to be sure that the selected sites are more or less final.

So we (IKI, GEOKHI, GAISH) should come to “final” selection ASAP

Early September?

Acknowledgements:

We are doing selection of landing sites on different bodies of the Solar system since late 60’s, but it is the first time when we have so good data for that. These data are being provided by our coauthors who specially process them for us and we express our gratitude to these colleagues and institutions which support their and thus our activity. They are:

- Department of Geological Sciences, Brown University, Providence, RI, USA
- Goddard Space Flight Center, Greenbelt, MD, USA
- Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA, USA
- The John Hopkins University Applied Physics Lab, Laurel, MD 20723
- NASA USA

Thank you for your attention!