Shallow Ridges in the Martian Northern Plains

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The northern plains of Mars, as seen by Viking, are essentially flat and featureless. The causes of their youth and smoothness are still debated. The Mars Orbiter Laser Altimeter (MOLA) instrument on the Mars Global Surveyor (MGS) spacecraft has drastically improved our knowledge of the topography of these plains, reducing km-scale vertical uncertainties from the Viking era by several orders of magnitude. MOLA data reveal that the northern plains are the flattest known surface in the solar system and that the plains are not featureless. The plains are criss-crossed by ridges. The ridges have characteristic heights of 100 metres, characteristic lengths of 100s of kilometres, and characteristic slopes of only a couple of degrees. Their incredibly shallow slopes explain why they escaped detection in the Viking era. Ridge locations and strikes are not distributed randomly. Ridges are most common near obvious stress centres such as Alba Patera and the Utopia Basin. In these regions, ridge strikes are preferentially radial to, or circumferential to, the stress centre. In regions of high ridge density, ridge spacing is on the order of 100 kilometres Profiles across the ridges indicate that the ridges are asymmetric. The distribution of the ridges around obvious stress centres suggests that they have a tectonic origin.

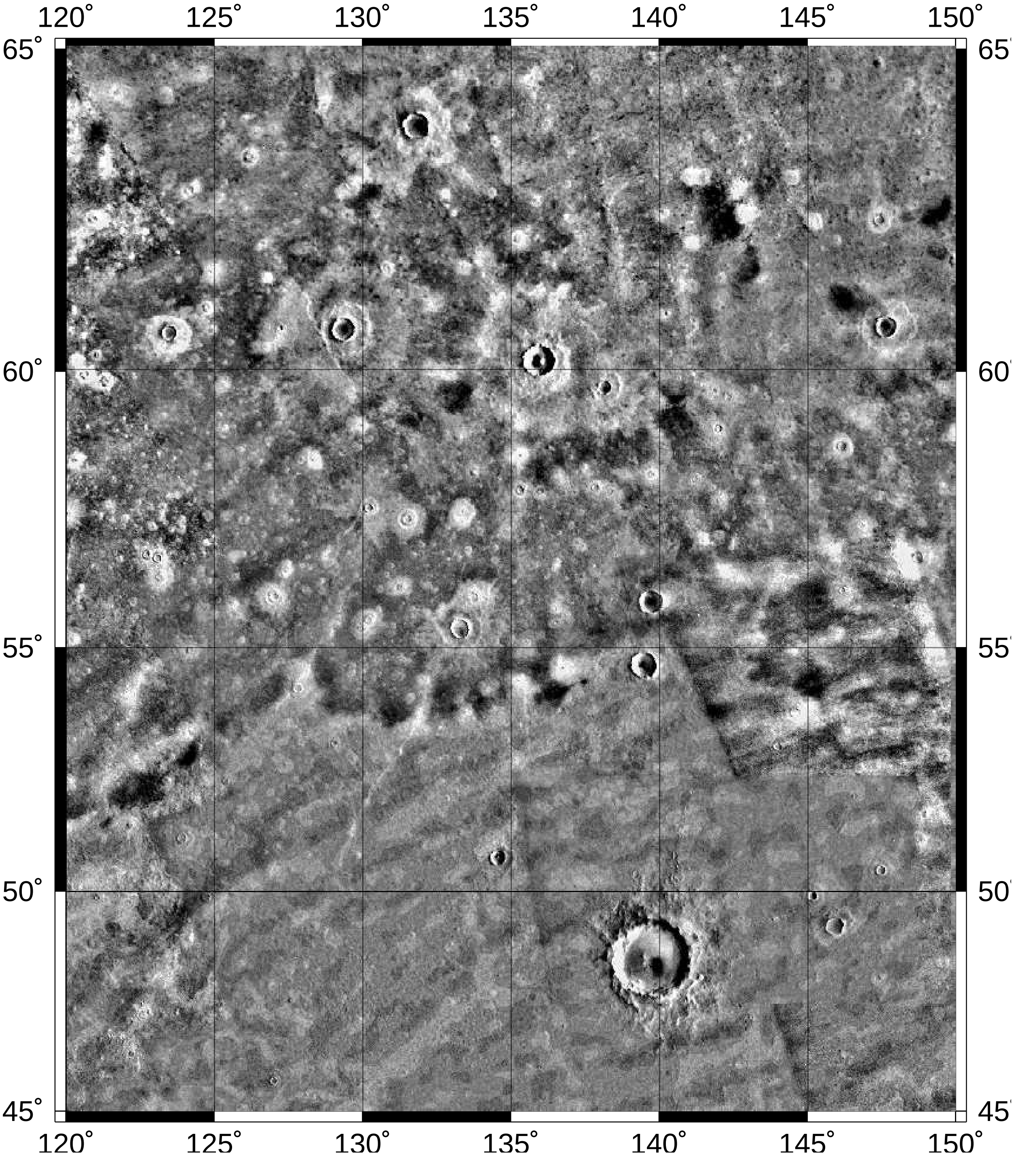
Some of the ridges appear related to known wrinkle ridges in

the highlands, suggesting a common origin.

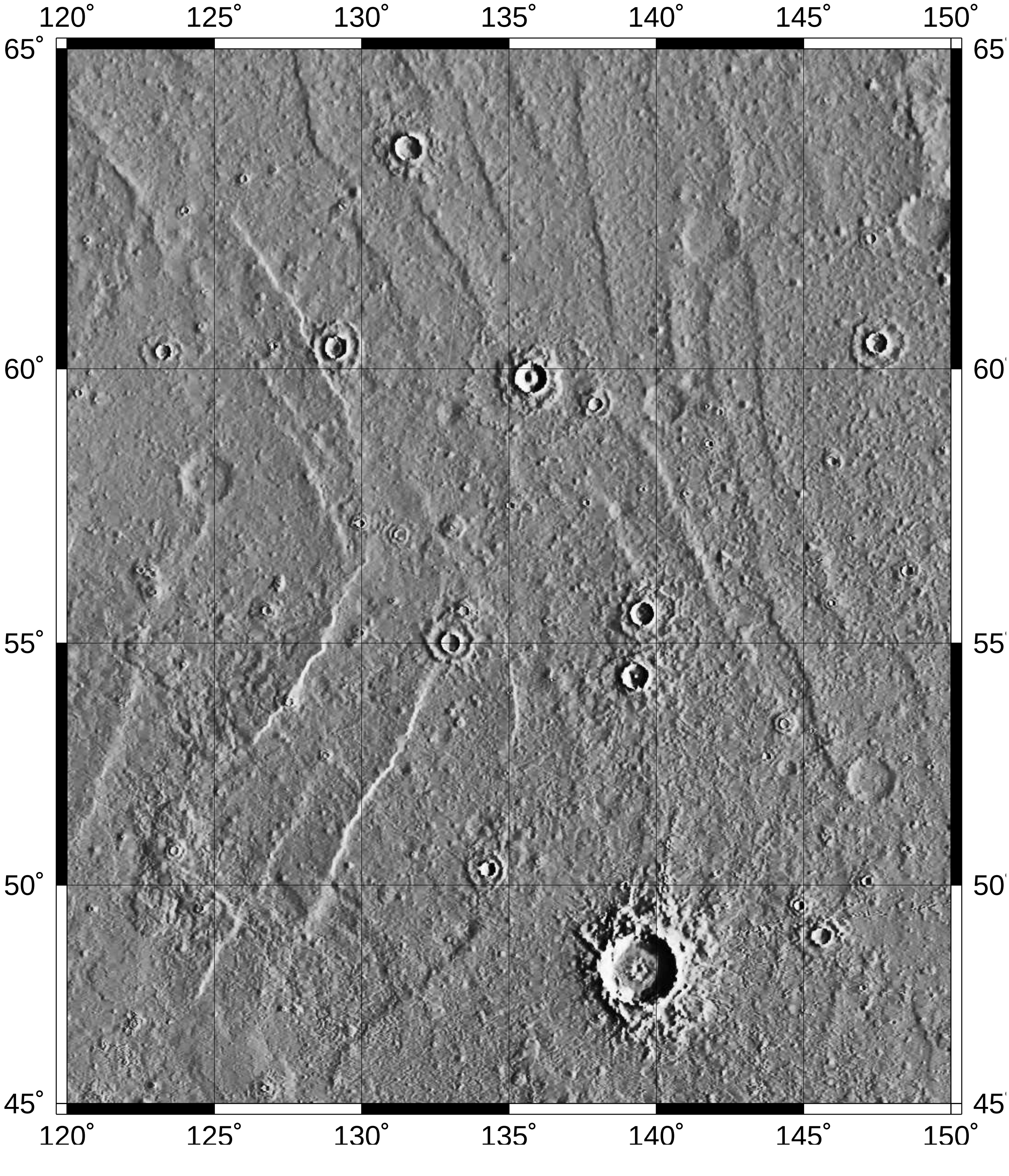
Comparison of ridges circumferential to and radial to the Utopia Basin reveals differences in spacing, amplitude, and morphology.

Some of the ridges are candidates for ancient shorelines. These candidates are not obviously different from all the other non-shoreline ridges.

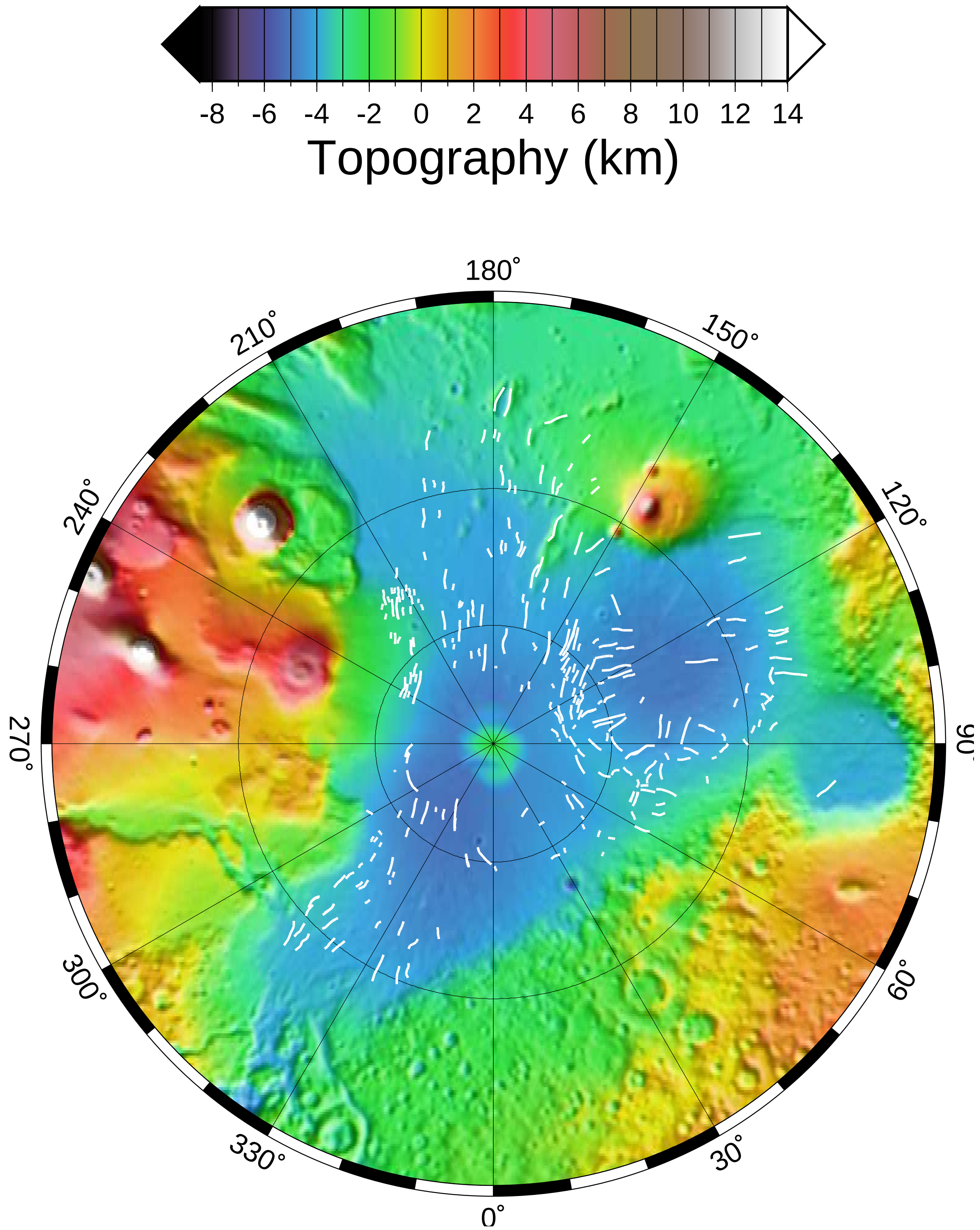
Viking Photograph



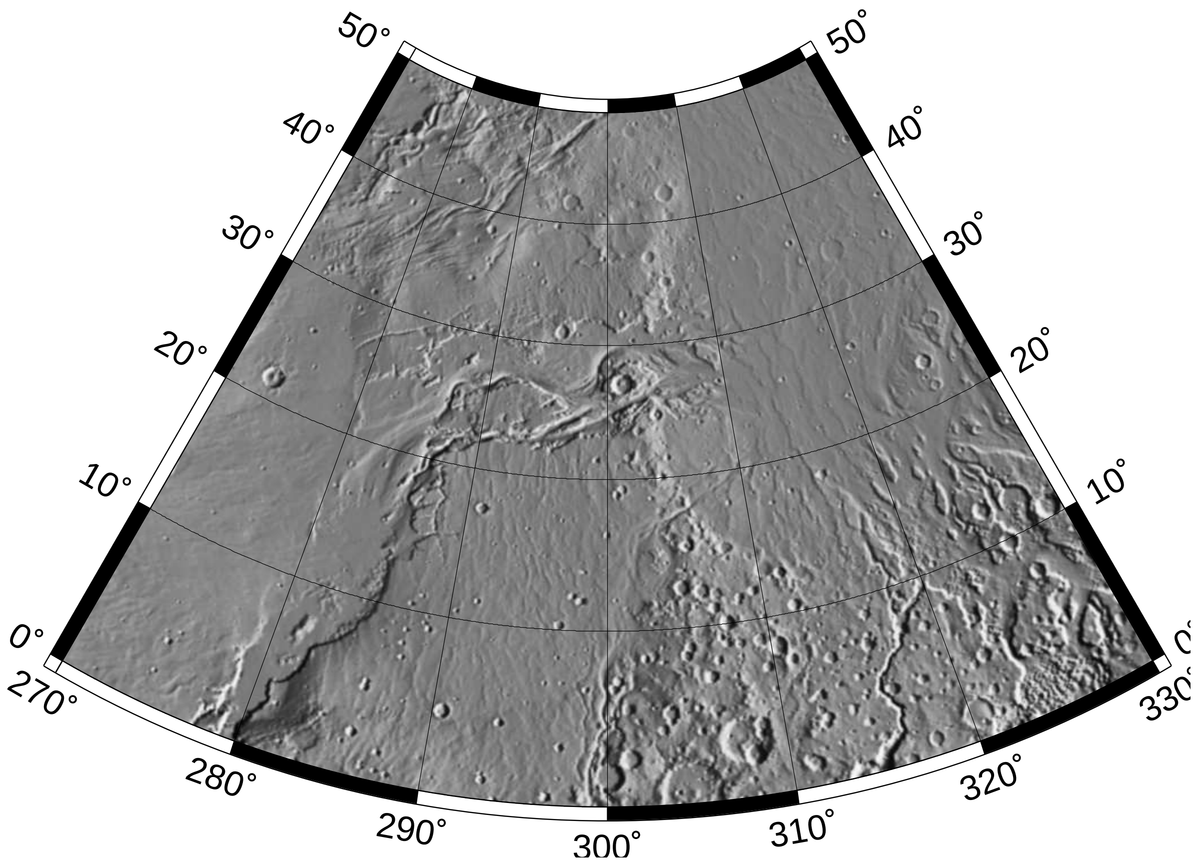
MOLA Data



Ridge Locations

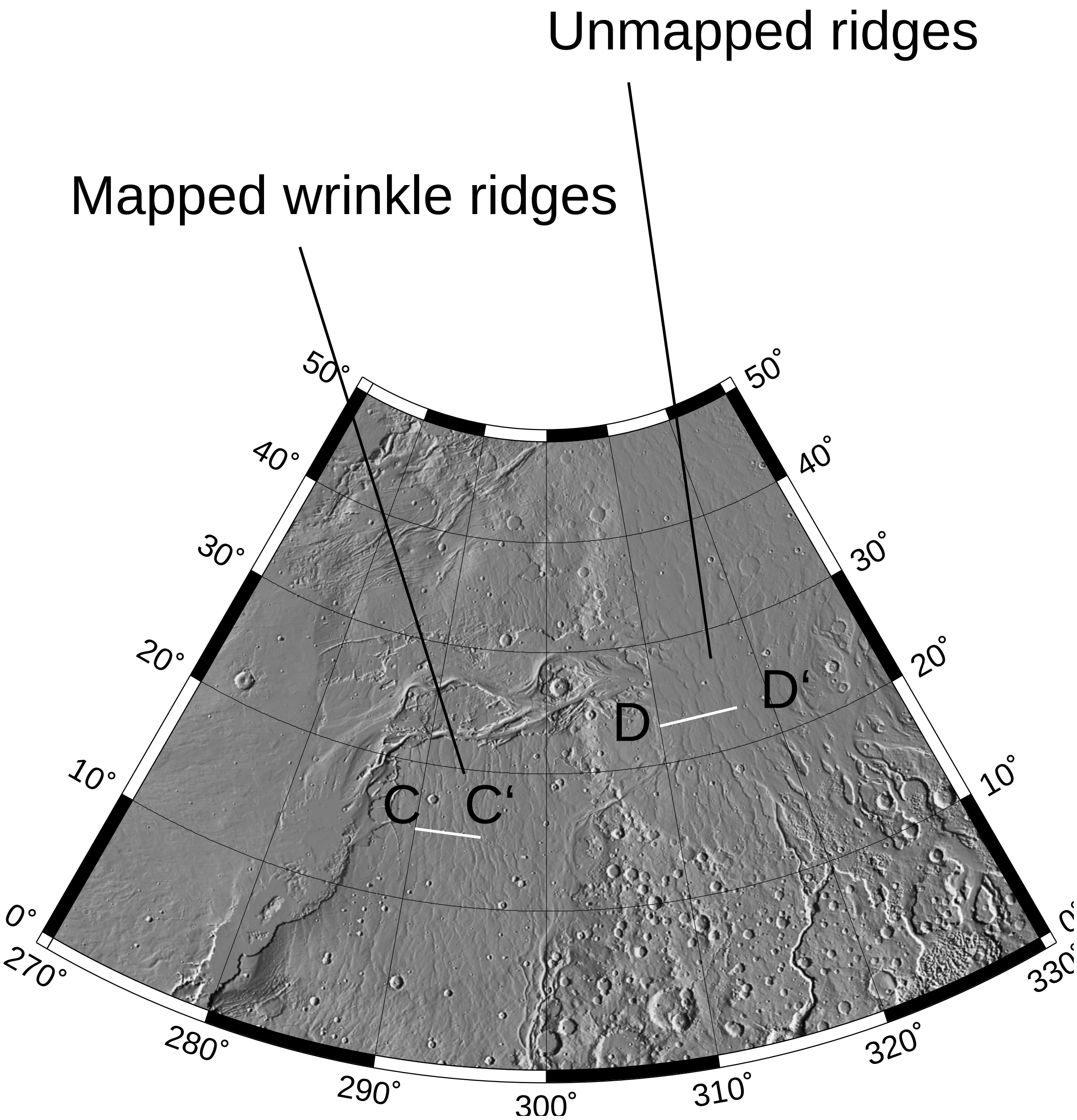


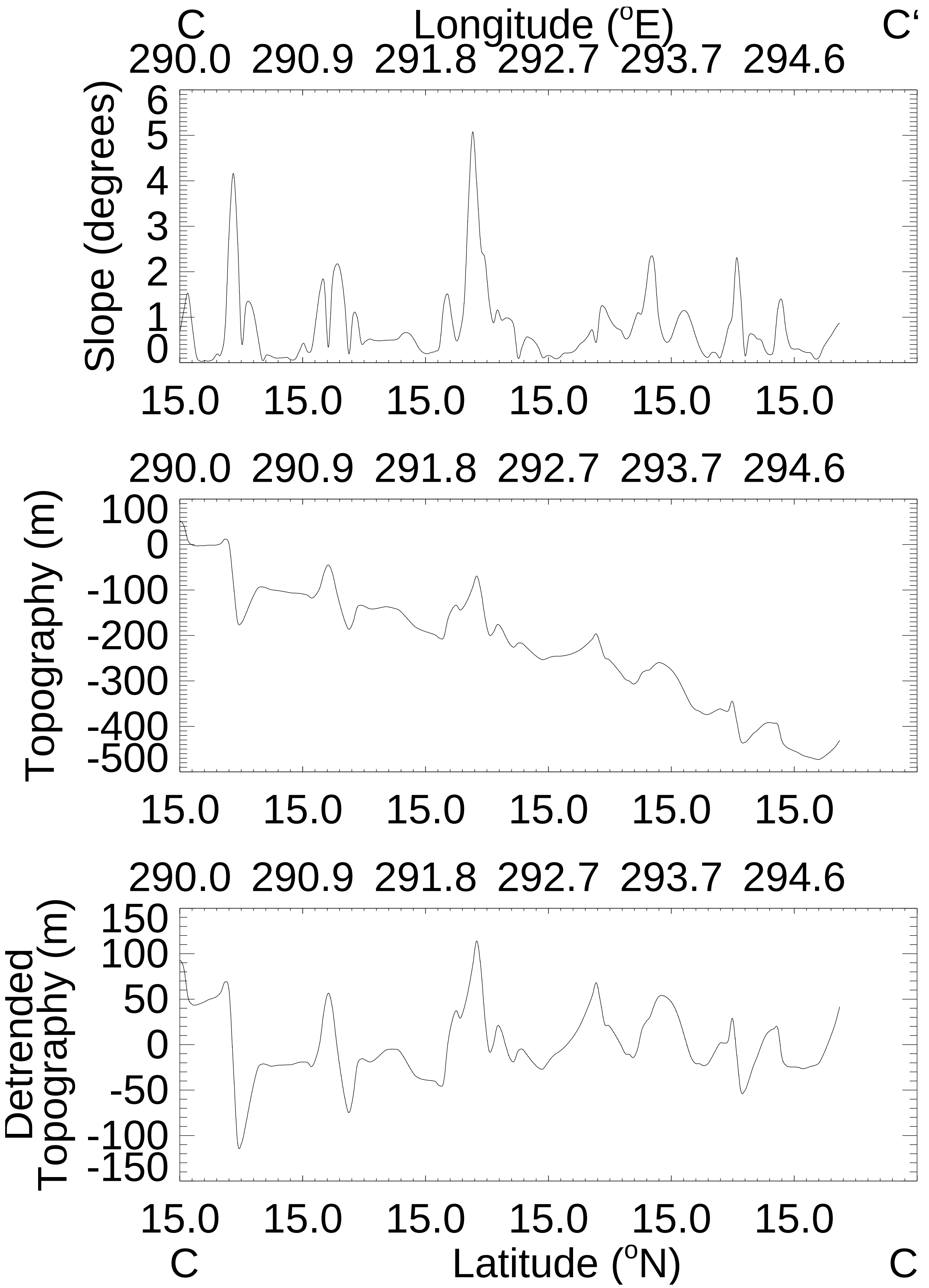
There are well-known wrinkle ridges in the highlands to the east of Tharsis and Alba. There are also ridges in Chryse that may be flow features. However, the Chryse ridges are parallel to the wrinkle ridges and have morphologies that are suggestive of wrinkle ridges.

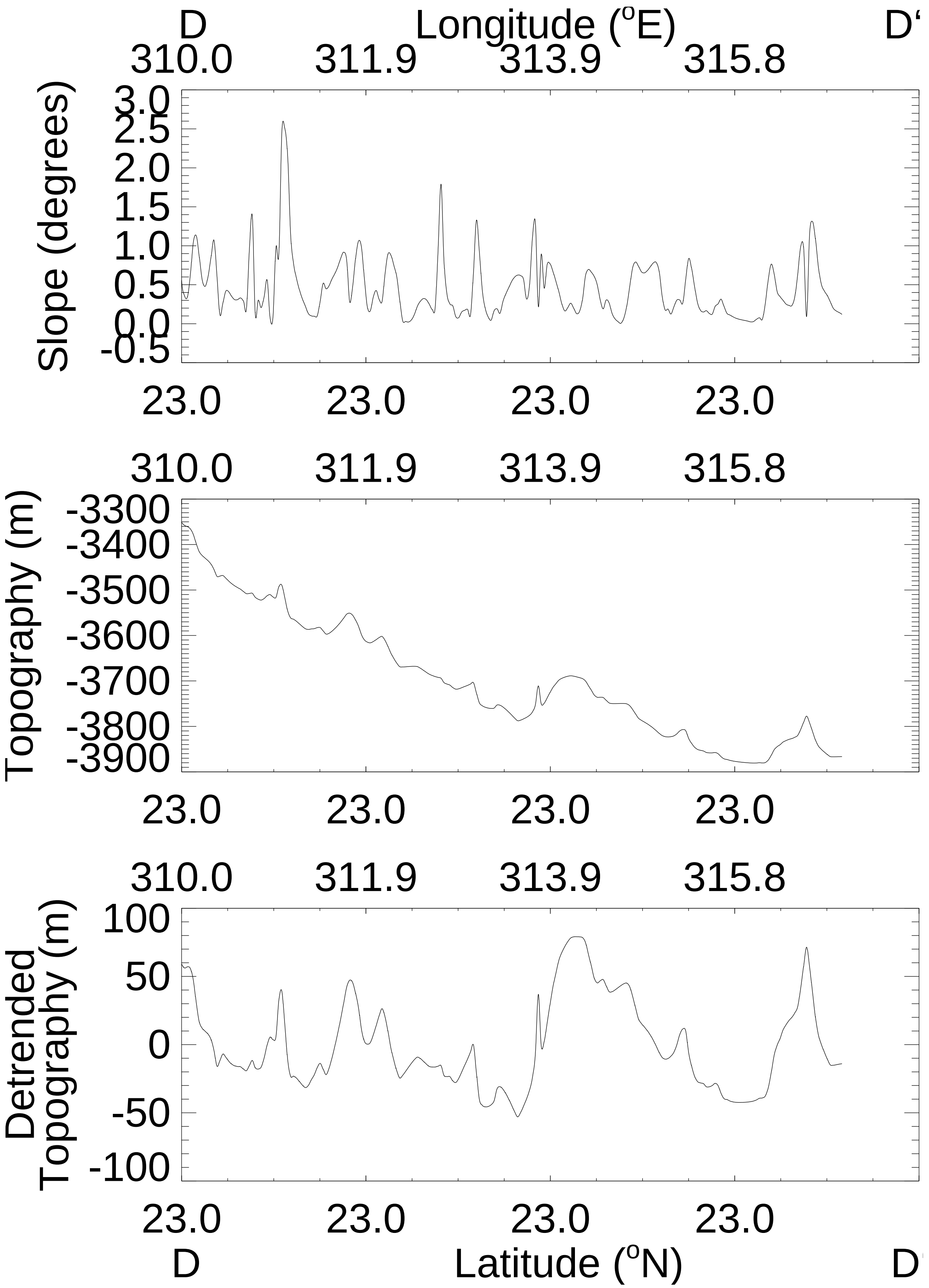


Ridges in plains parallel Lunae Planum wrinkle ridges. Ridges extend above level of outflow channel.

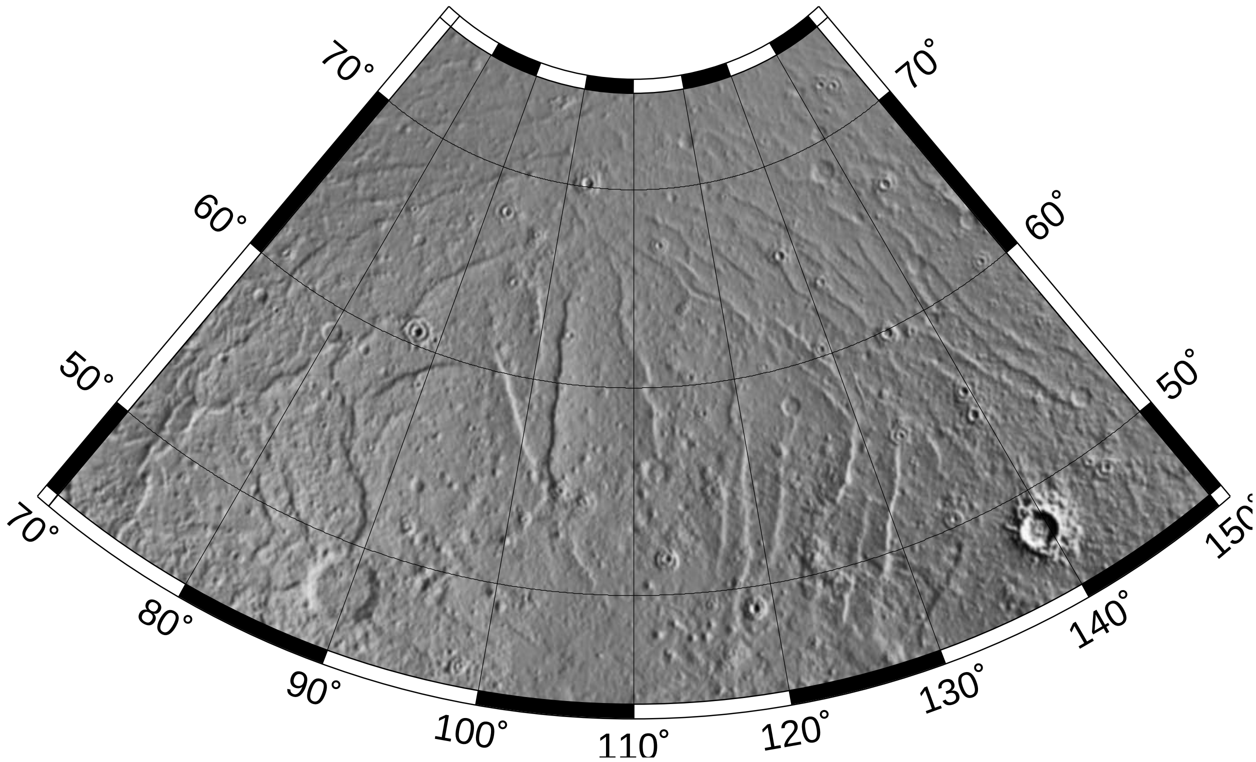
Compare profiles.



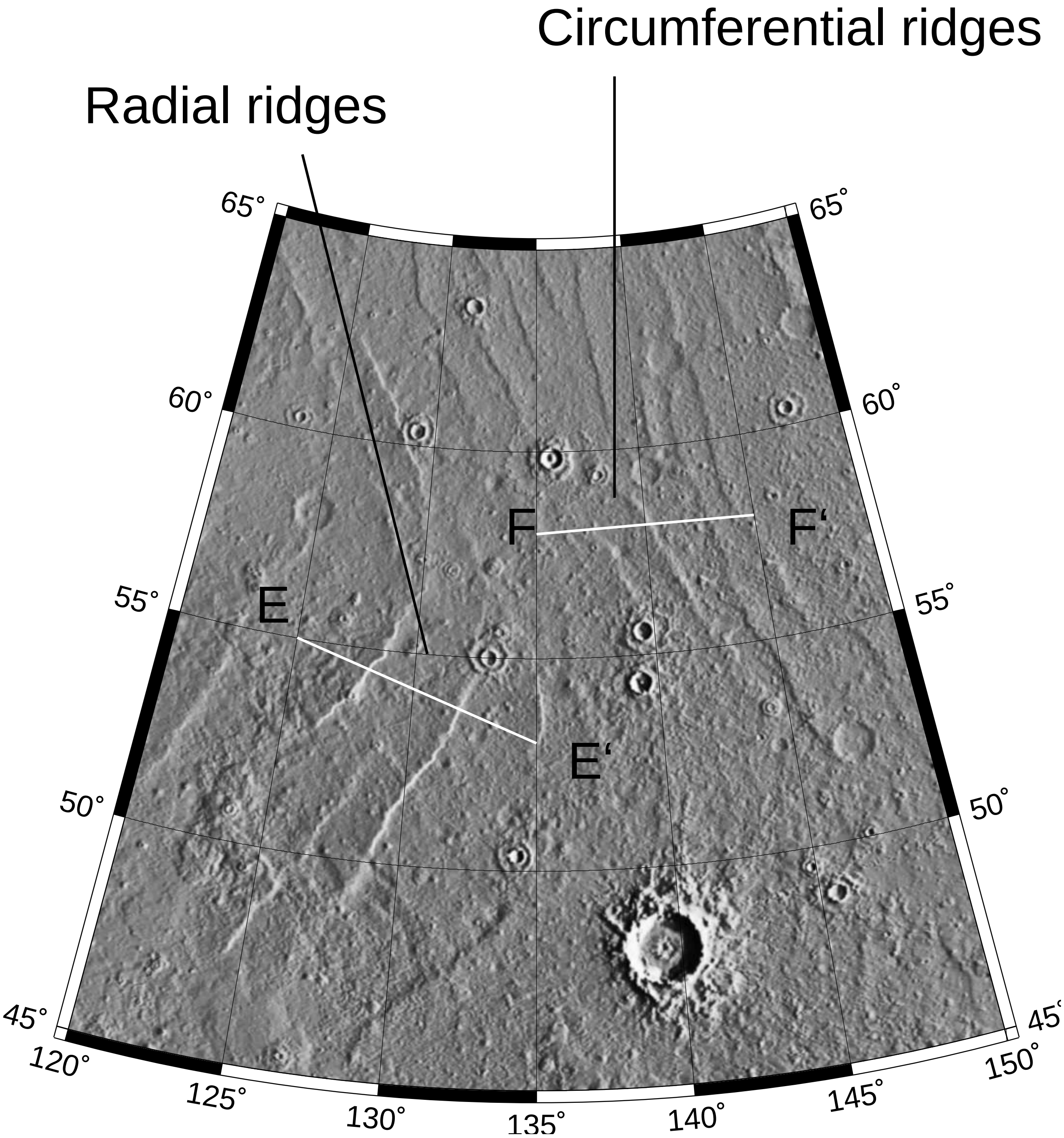

C
Longitude (°E)
C'
290.0 290.9 291.8 292.7 293.7 294.6
Slope (degrees)
0 1 2 3 4 5 6
15.0 15.0 15.0 15.0 15.0 15.0
290.0 290.9 291.8 292.7 293.7 294.6
Topography (m)
100 0 -100 -200 -300 -400 -500
15.0 15.0 15.0 15.0 15.0 15.0
290.0 290.9 291.8 292.7 293.7 294.6
Detrended Topography (m)
150 100 50 0 -50 -100 -150
15.0 15.0 15.0 15.0 15.0 15.0
C
Latitude (°N)
C

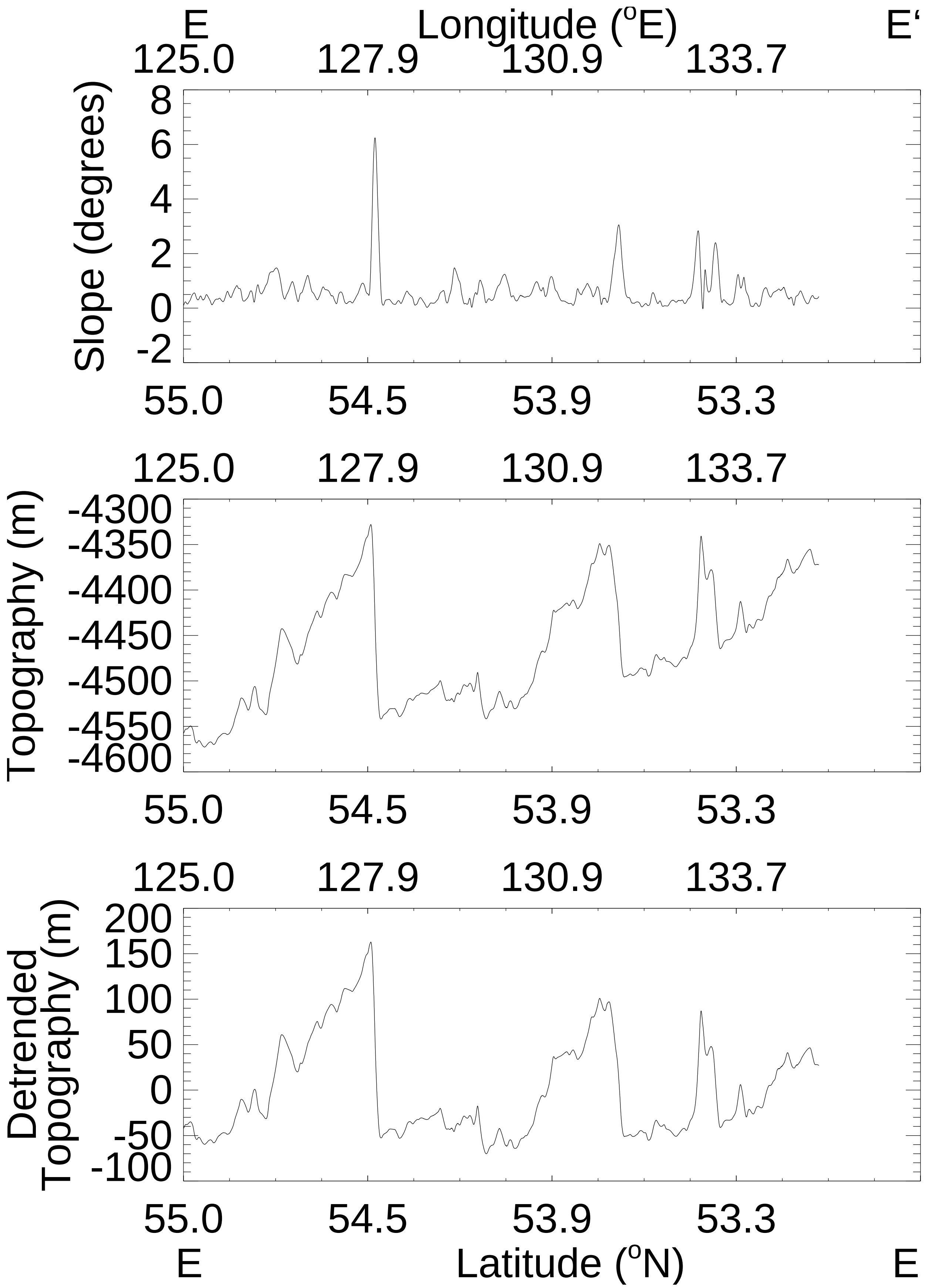

D
Longitude (°E)
D'
310.0
311.9
313.9
315.8
Slope (degrees)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
23.0
23.0
23.0
23.0
310.0
311.9
313.9
315.8
Topography (m)
-3300
-3400
-3500
-3600
-3700
-3800
-3900
23.0
23.0
23.0
23.0
310.0
311.9
313.9
315.8
Detrended Topography (m)
100
50
0
-50
-100
23.0
23.0
23.0
23.0
D
Latitude (°N)
D'

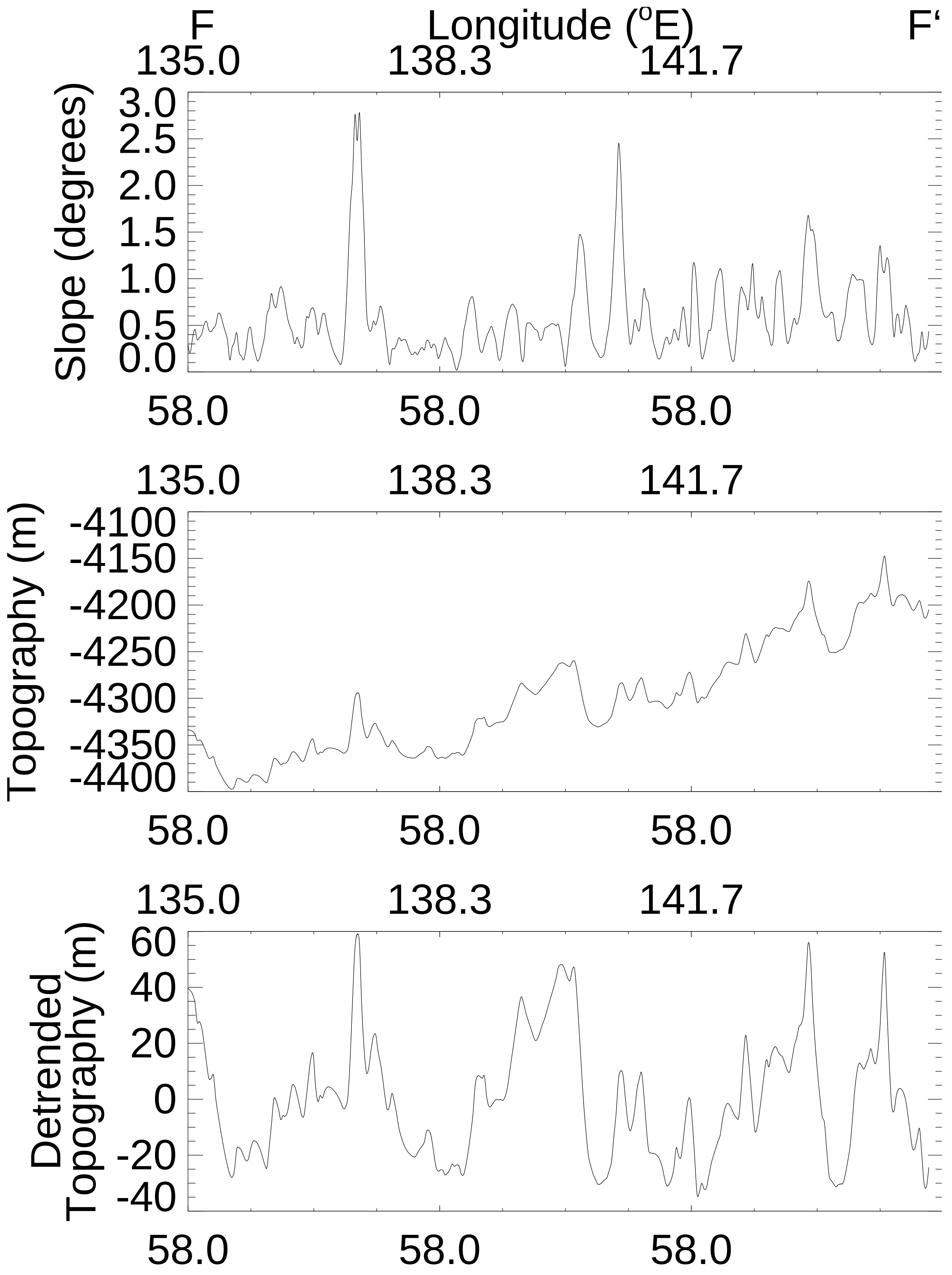
Many of the ridges are located near the Utopia Basin. Ridges in this region are either circumferential to, or radial to, the basin. This favours a tectonic origin for these ridges.

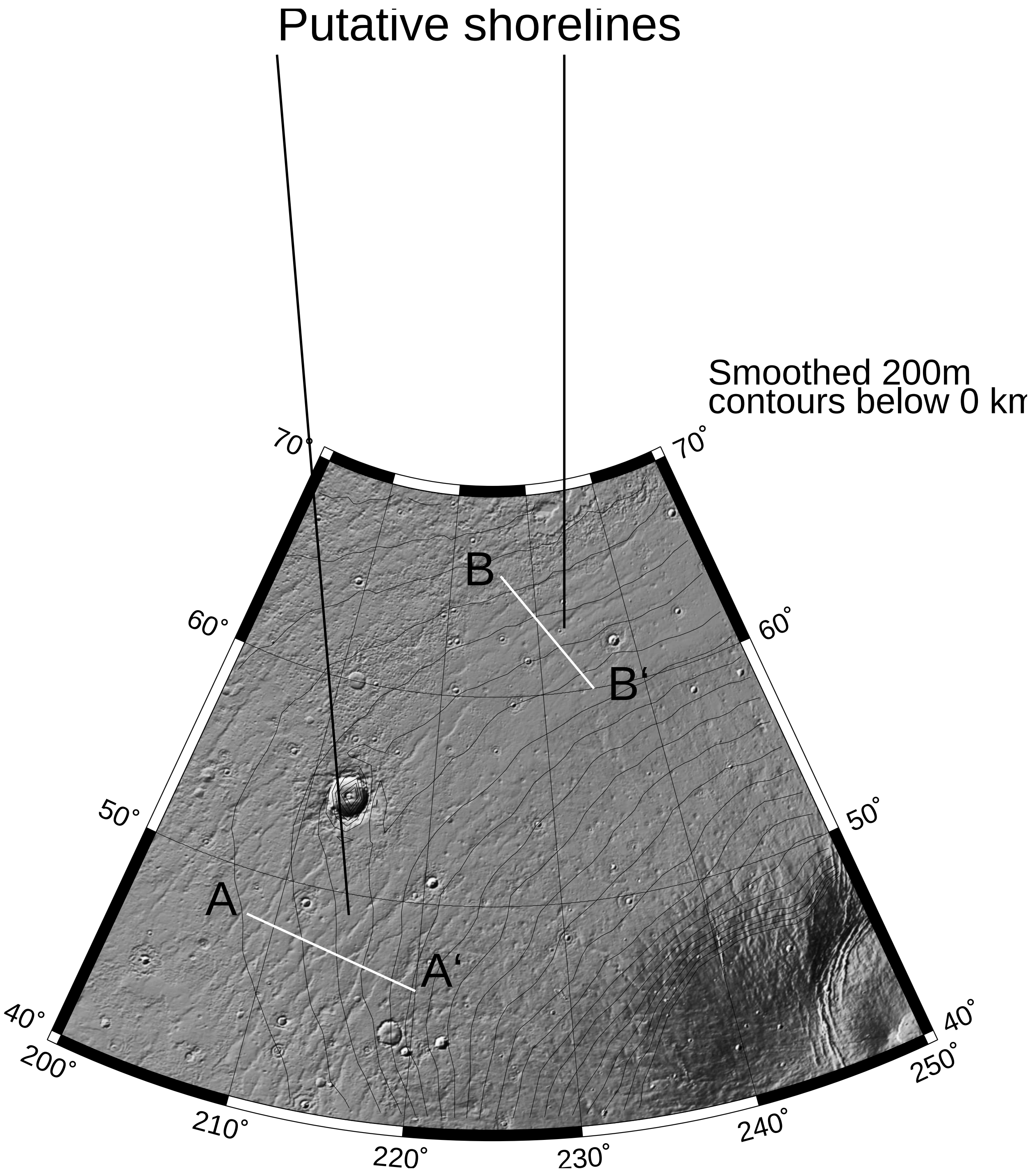


Ridges circumferential to and radial to the Utopia Basin.
Compare profiles.



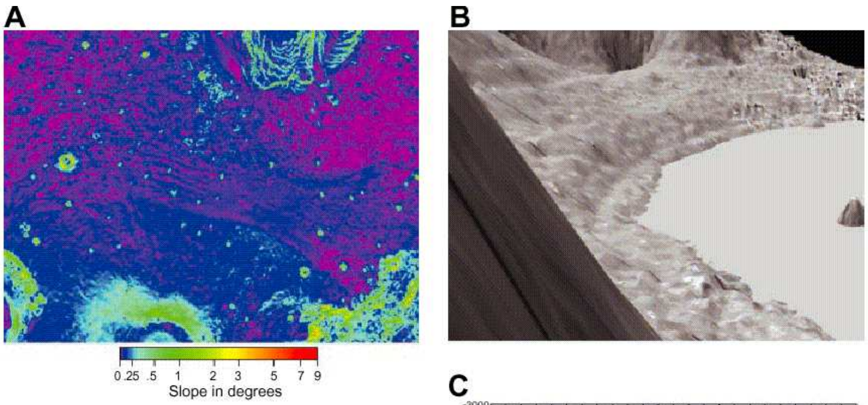

E
Longitude (°E)
E‘
125.0
127.9
130.9
133.7
Slope (degrees)
8
6
4
2
0
-2
55.0
54.5
53.9
53.3
Topography (m)
-4300
-4350
-4400
-4450
-4500
-4550
-4600
Detrended Topography (m)
200
150
100
50
0
-50
-100
Latitude (°N)
E
E


F
Longitude (°E)
F'
135.0
138.3
141.7
Slope (degrees)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
58.0
58.0
58.0
135.0
138.3
141.7
Topography (m)
-4100
-4150
-4200
-4250
-4300
-4350
-4400
58.0
58.0
58.0
135.0
138.3
141.7
Detrended Topography (m)
60
40
20
0
-20
-40
58.0
58.0
58.0
F
Latitude (°N)
F



Putative shorelines
Smoothed 200m
contours below 0 km
B
B'
A
A'
70°
60°
50°
40°
70°
60°
50°
40°
200°
210°
220°
230°
240°
250°

Linear slope changes have been interpreted as shorelines of an ocean. However, these changes are ubiquituous in the northern plains and are primarily seen in association with tectonic structures such as Alba or Utopia. They are not preferentially parallel to topographic contours. Specifically, terrace/ridge pairs have been interpreted as shoreline indicators. However, terraces are sometimes upslope from ridges and sometimes vice versa, which is hard to understand in the context of shorelines.



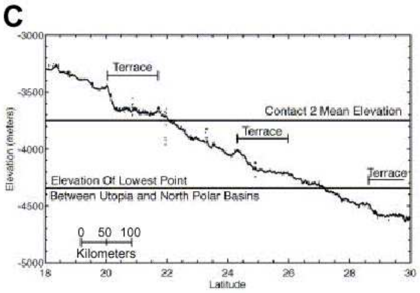


Fig. 4. (**A**) Slope map of the northern lower flanks of Alba Patera, showing the absolute value of surface slope at ~15-km baseline derived from the 1/8 degree per pixel digital elevation model (*15*). Parallel lines (middle) representing linear slope changes are seen between Alba Patera (bottom) and the North Polar cap (top). Width of map is ~3000 km. (**B**) Perspective view of the southern margin of Utopia Planitia looking west from the flank of Elysium Mons showing topographic terraces parallel to contact 2; MOLA digital elevation model with Viking Orbiter mosaic superposed, and the basin flooded to just below the −4350-m contour, the elevation where the Utopia and North Polar basins become interconnected. Vertical exaggeration is ~×200. (**C**) MOLA profile (10190) in southern Utopia Planitia.

Possible Ancient Oceans on Mars: Evidence from Mars Orbiter Laser Altimeter Data

James W. Head III,[1*] Harald Hiesinger,[1] Mikhail A. Ivanov,[1,2] Mikhail A. Kreslavsky,[1,3] Stephen Pratt,[1] Bradley J. Thomson[1]

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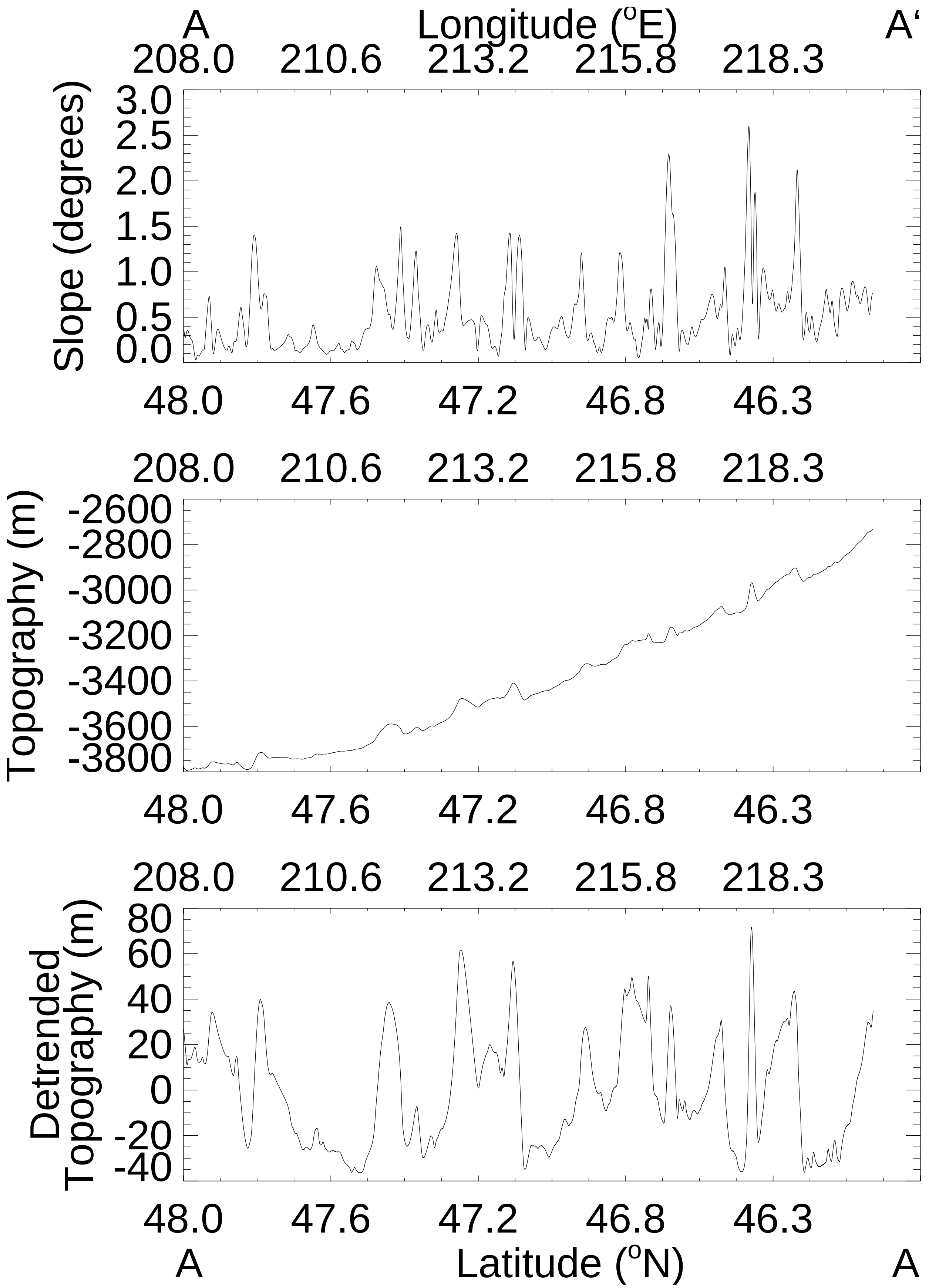
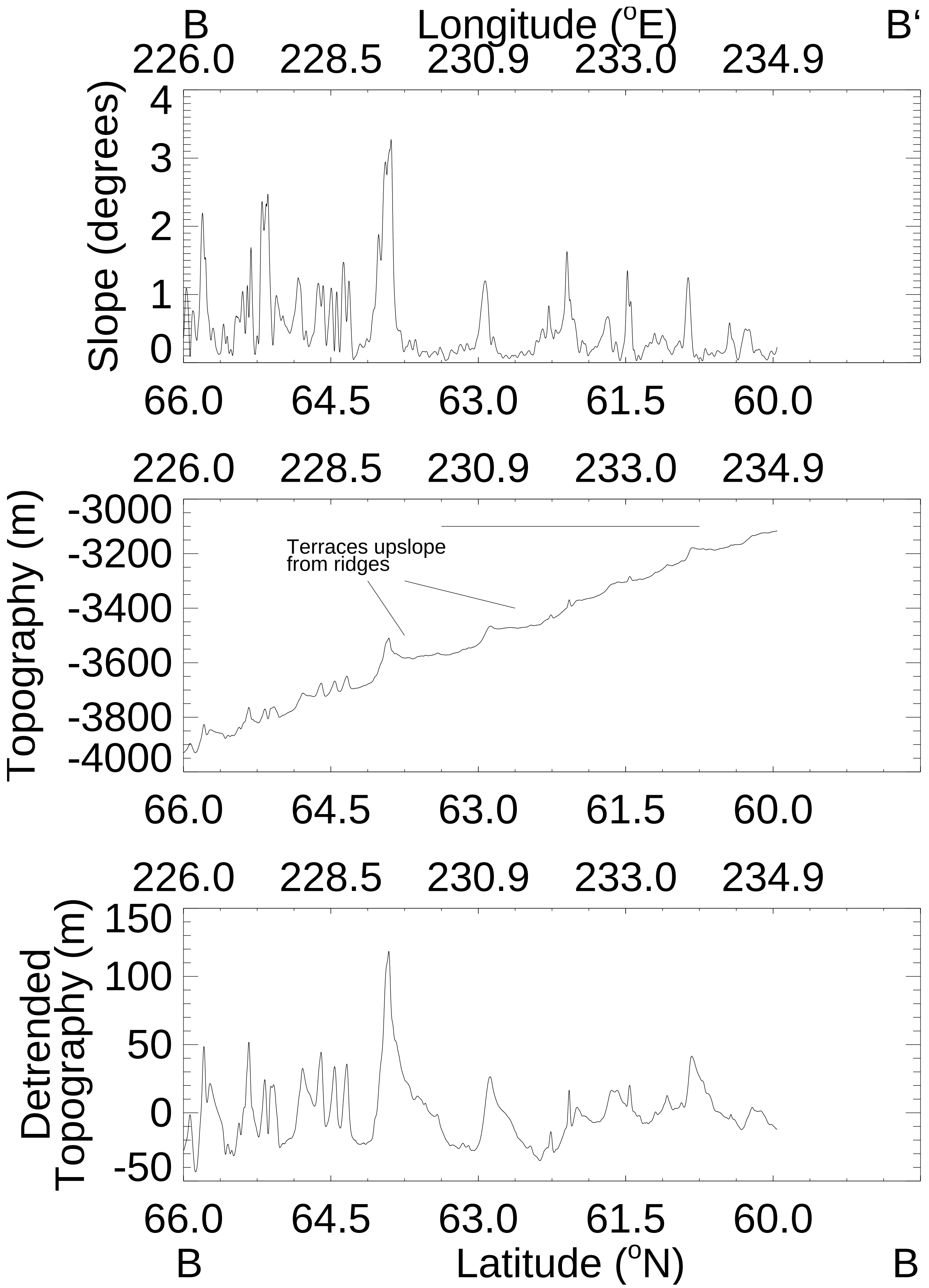
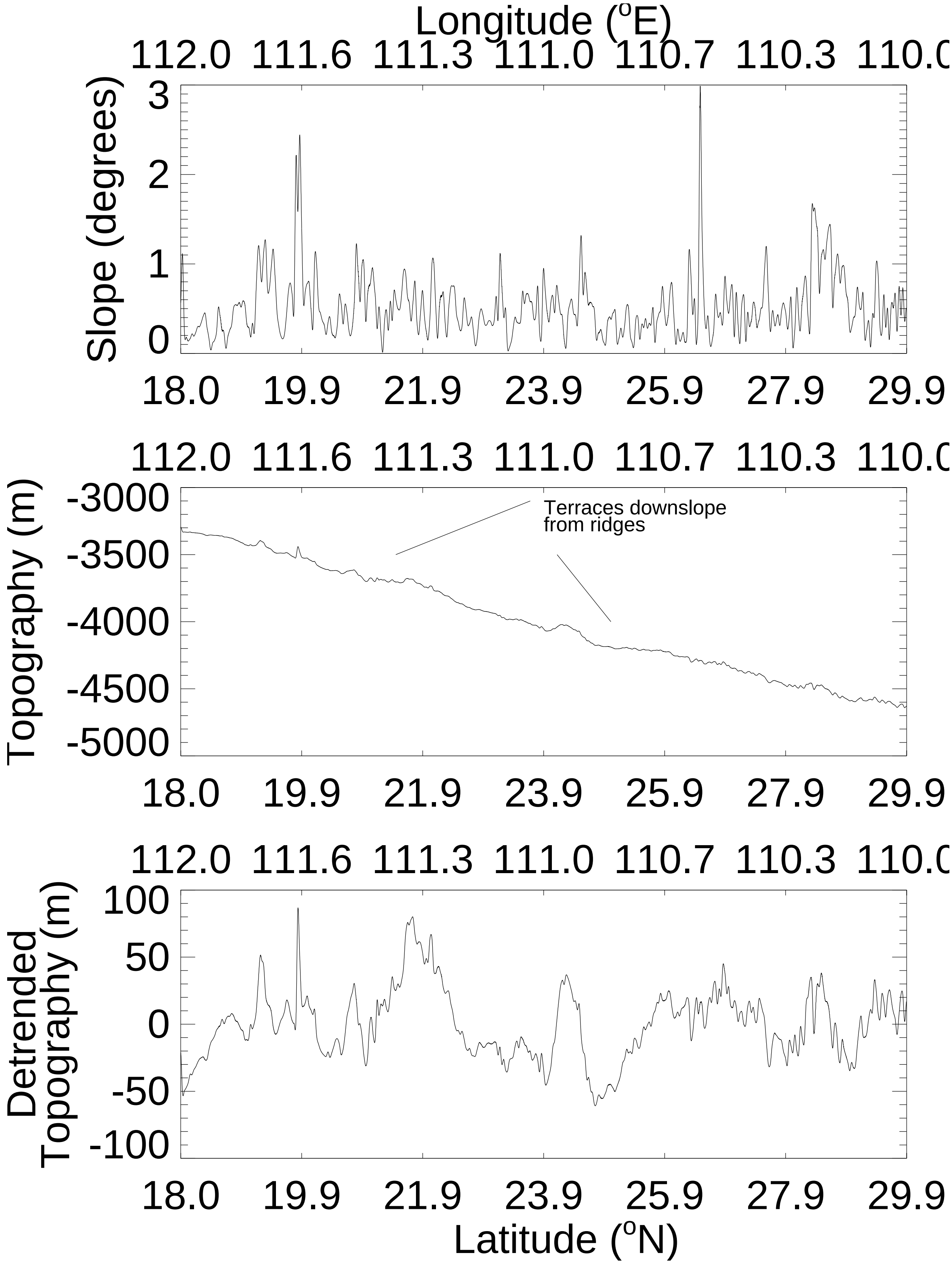

A
Longitude (oE)
A'
208.0
210.6
213.2
215.8
218.3
Slope (degrees)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
48.0
47.6
47.2
46.8
46.3
Topography (m)
-2600
-2800
-3000
-3200
-3400
-3600
-3800
Detrended Topography (m)
80
60
40
20
0
-20
-40
A
Latitude (oN)
A



B
Longitude (°E)
B'
226.0
228.5
230.9
233.0
234.9
Slope (degrees)
4
3
2
1
0
66.0
64.5
63.0
61.5
60.0
Topography (m)
-3000
-3200
-3400
-3600
-3800
-4000
Terraces upslope
from ridges
Detrended Topography (m)
150
100
50
0
-50
B
Latitude (°N)
B



Longitude (oE)
112.0
111.6
111.3
111.0
110.7
110.3
110.0
Slope (degrees)
3
2
1
0
18.0
19.9
21.9
23.9
25.9
27.9
29.9
Topography (m)
-3000
-3500
-4000
-4500
-5000
Terraces downslope
from ridges
Detrended Topography (m)
100
50
0
-50
-100
Latitude (oN)

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Some ridges are very shallow. They are only visible because the background terrain is very flat and the dataset is superb.

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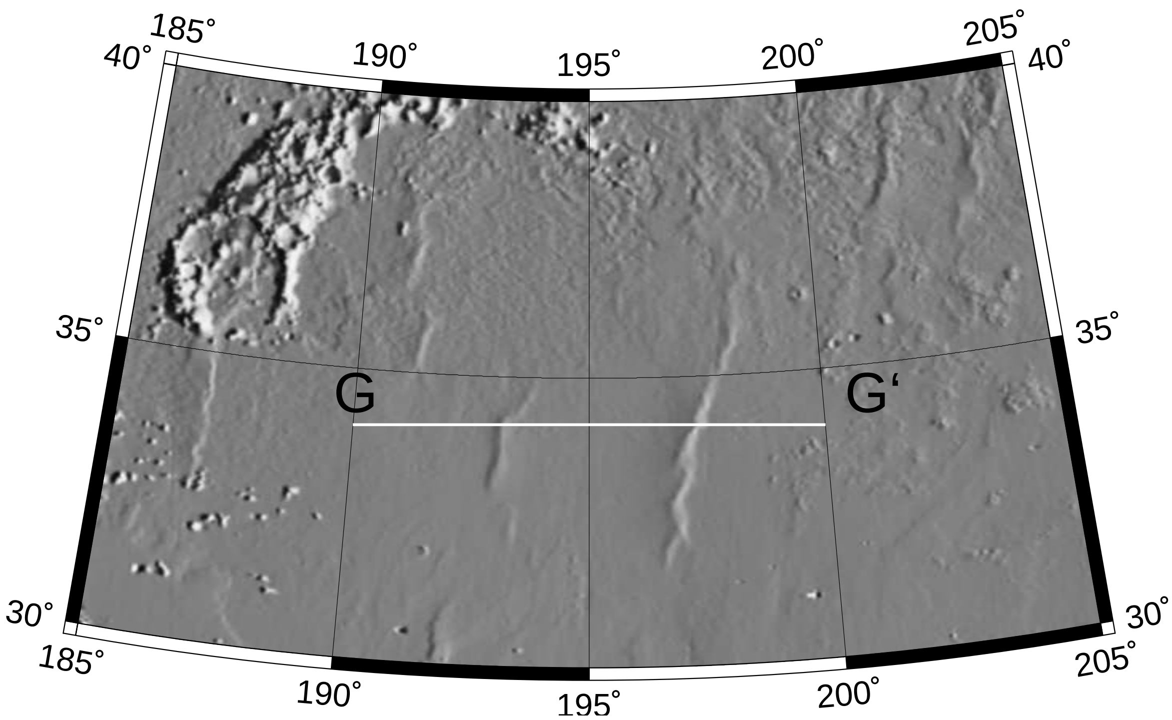

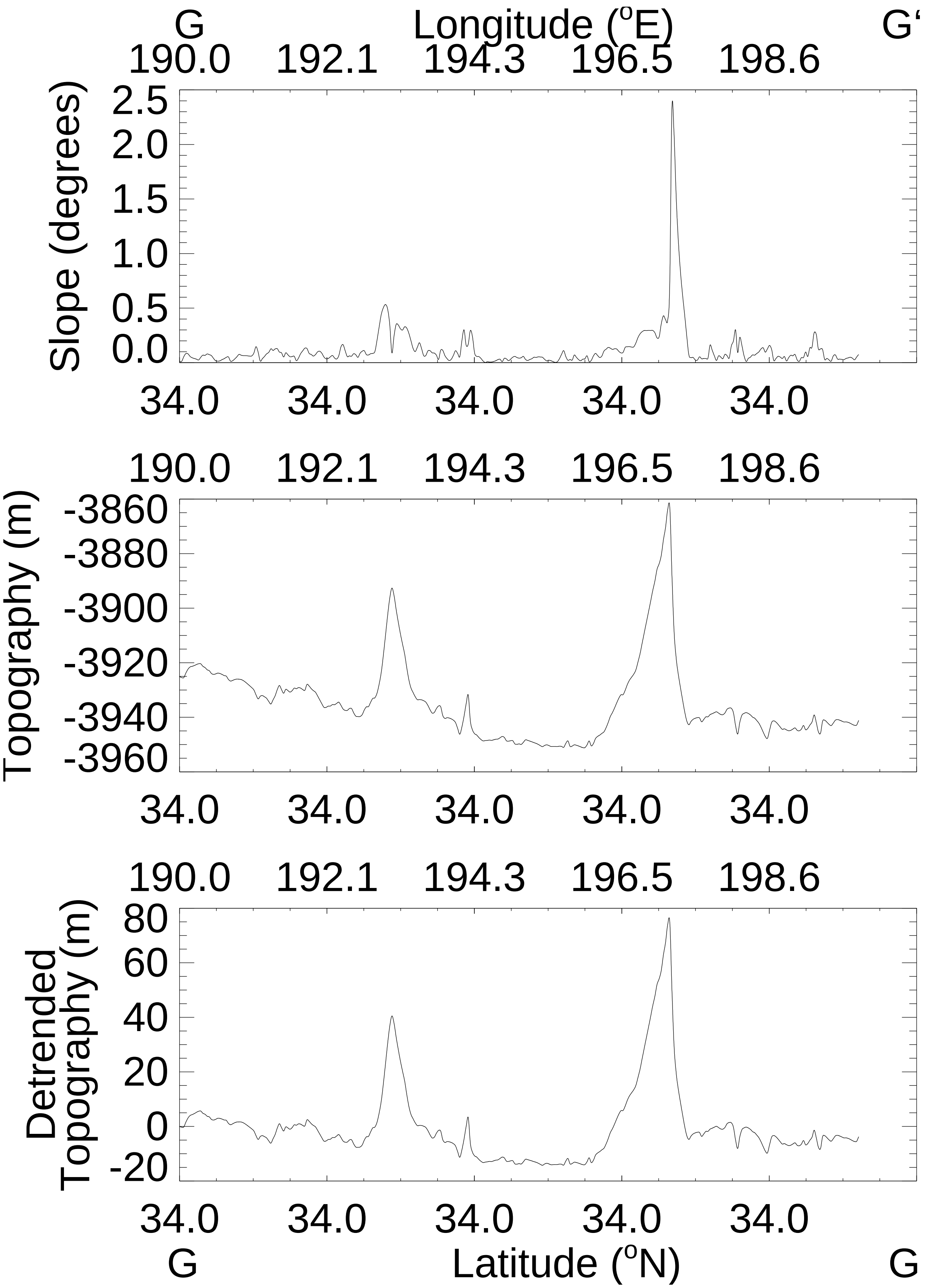
G
Longitude (°E)
G'
190.0
192.1
194.3
196.5
198.6
Slope (degrees)
2.5
2.0
1.5
1.0
0.5
0.0
34.0
34.0
34.0
34.0
34.0
Topography (m)
-3860
-3880
-3900
-3920
-3940
-3960
Detrended Topography (m)
80
60
40
20
0
-20
Latitude (°N)
G
G