Radar Observations of Outlier Polar Ice Deposits on Mars

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Abstract

Martian ice likely holds the key to interpreting Mars' past climate, but much is still unknown regarding the distribution and properties of Mars' ice deposits. It is well known that Mars has extensive polar ice caps the size of Greenland. Included in these large polar caps are the north and south polar layered deposits (NPLD and SPLD, respectively), that are composed of kilometers-thick deposits of water ice. In addition, surveys by Conway et al. (2012) and Sori et al. (2019) identified craters in the surrounding terrains that contain "outlying" deposits of ice, which may or may not have formed concurrently with the polar caps. There are many differences between the NPLD and SPLD, including higher dust content and sequestered CO2 within the SPLD, a younger surface age of the NPLD, and properties in some locations of the SPLD that causes a 'fog-like' scattering in radar observations. These differences between the NPLD and SPLD may or may not be shared in these outlying deposits, and may provide clues to the climate conditions under which the PLDs and outlier deposits formed. We have analyzed a total of 517 SHARAD radar tracks across 24 ice deposits within craters. For the northern population, we detected subsurface layers in 3 out of 4 crater deposits. In the southern population, we detected subsurface layers in 4 of the 20 crater deposits. Of the 4 southern crater deposits that exhibited subsurface layers, 3 were contiguous with the SPLD. We also found deposits with radargrams that contain fog, and one that contains a low reflectance zone. After examining the subsurface radar observations, we determined that the northern outlier deposits share many common characteristics with the NPLD, and thus may have a shared depositional history or at least were emplaced under similar environmental conditions. The southern outlying crater deposits exhibit a variety of subsurface characteristics, and likely represent 2 or more populations that may have differing depositional histories.

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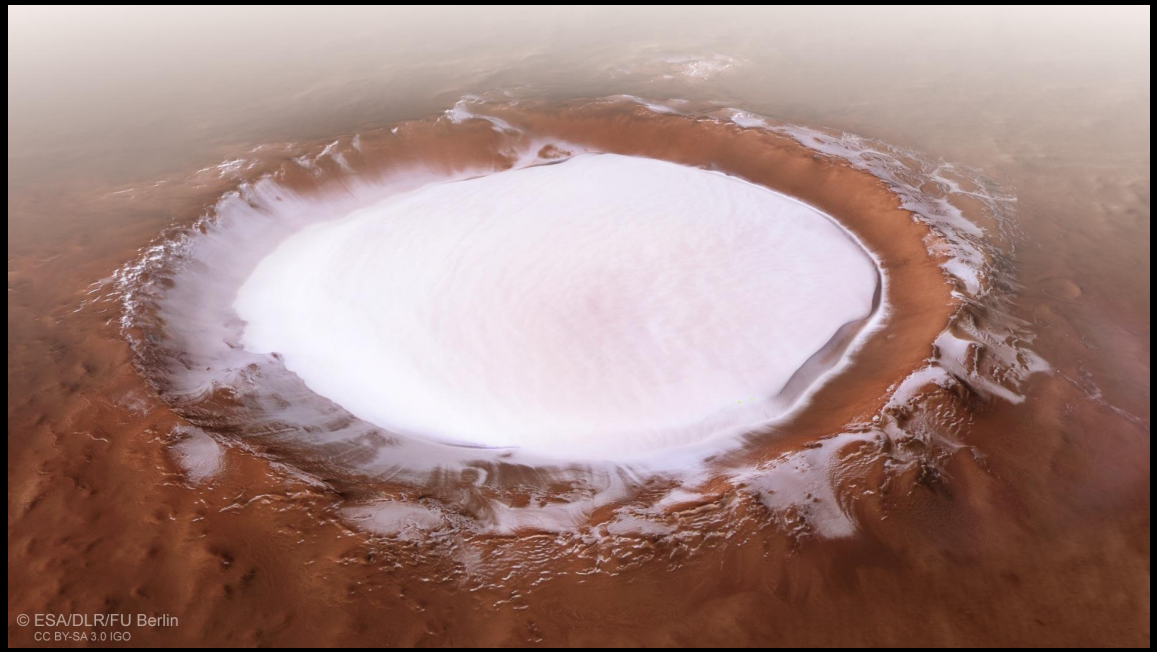
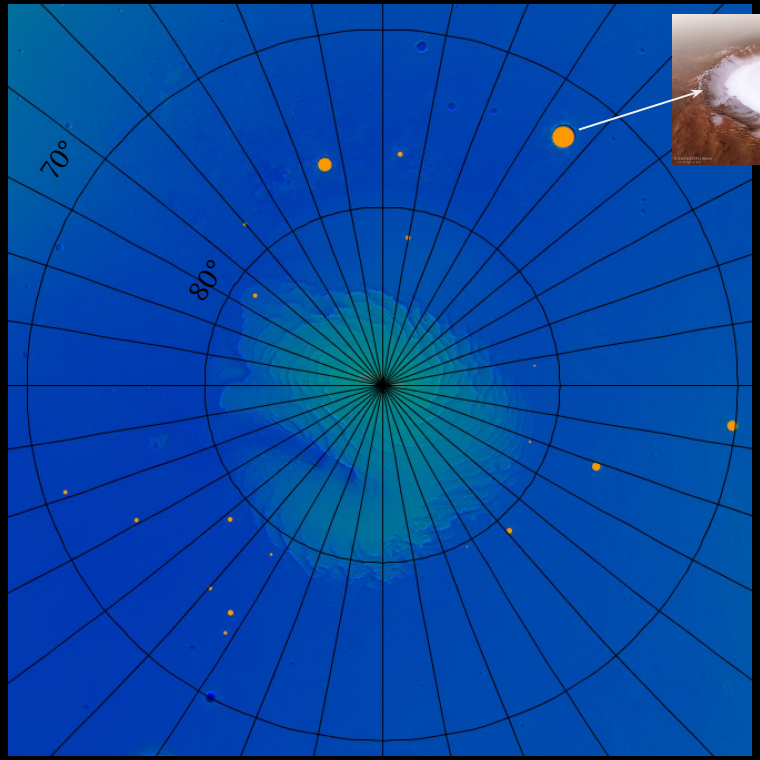


These ‘outlying’ ice deposits are located near the north and south polar layered deposits.

Northern deposits: Conway et al. (2012) Southern deposits: Sori et al. (2019)

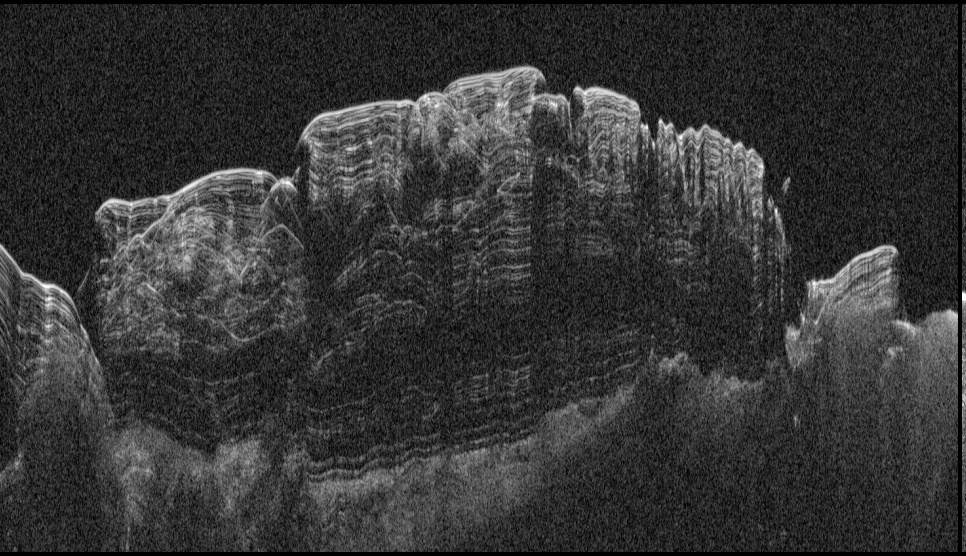


Northern craters

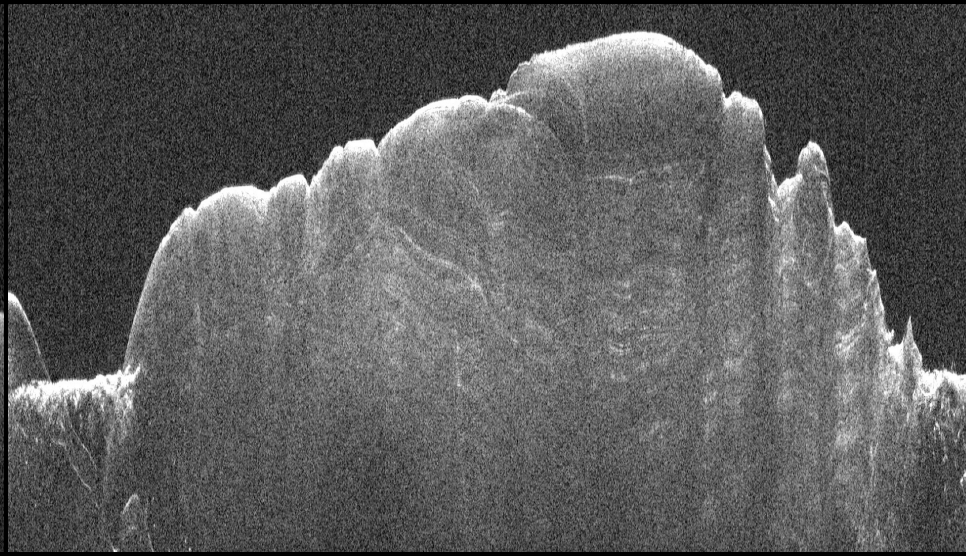
Southern craters

Do the outlier crater deposits share characteristics (and perhaps histories?) of their respective PLD?

We use SHARAD radargrams to examine the subsurface ice in these crater deposits.

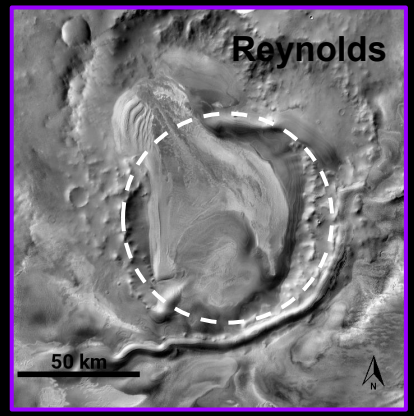


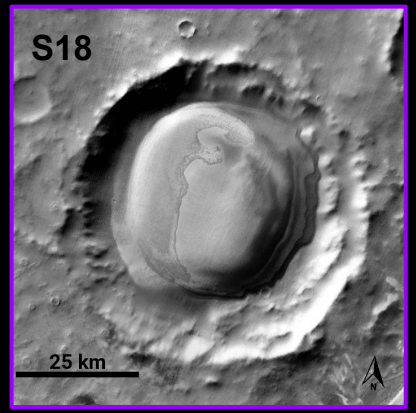
SHARAD radargram of the NPLD

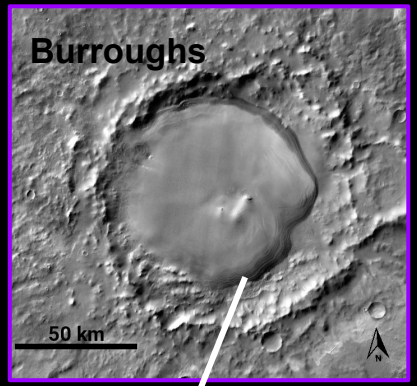


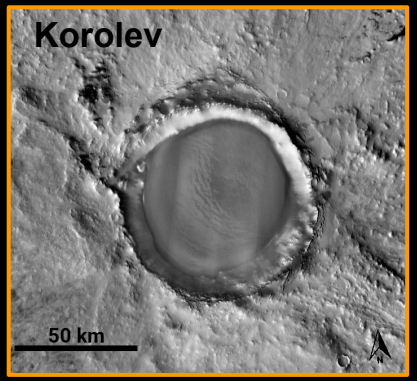
SHARAD radargram of the SPLD

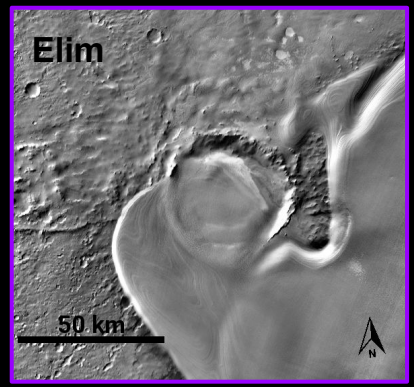
We selected the largest deposits (>25 km) identified by Conway et al. 2012 (North) and Sori et al. 2019 (South)

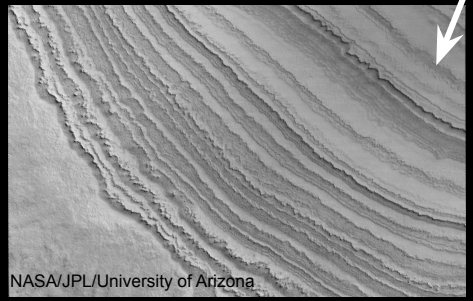


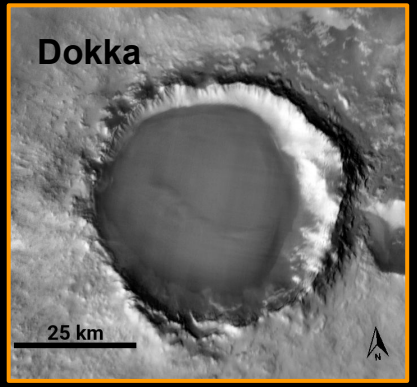




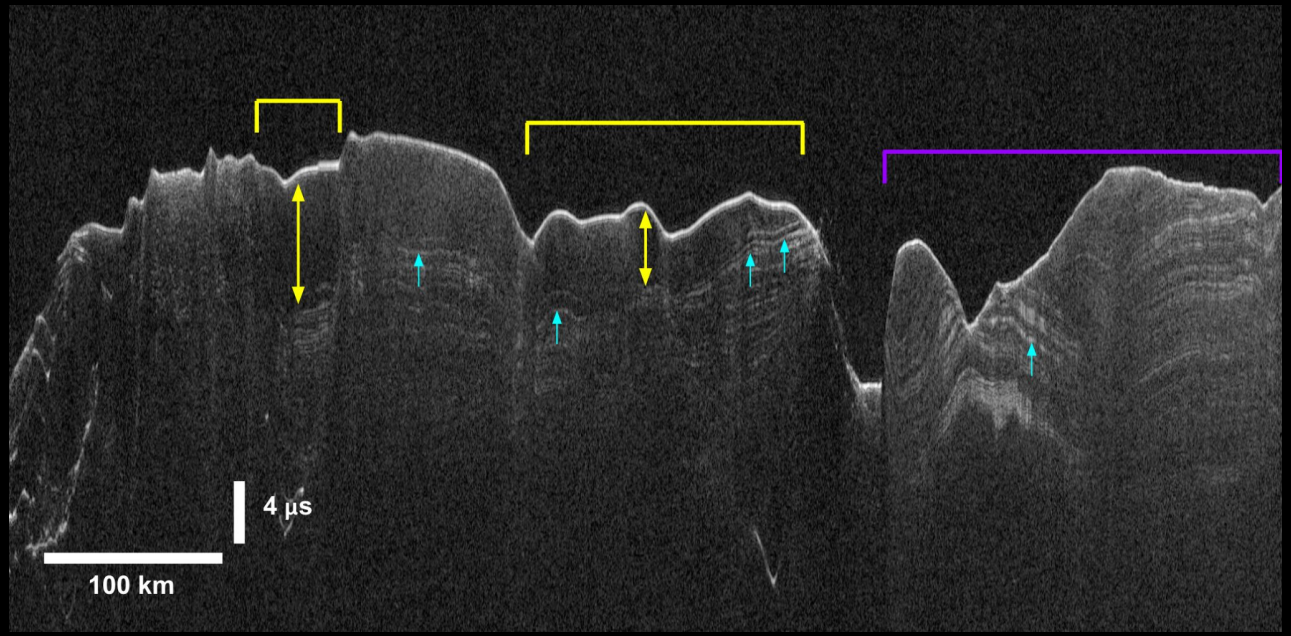








Subsurface features



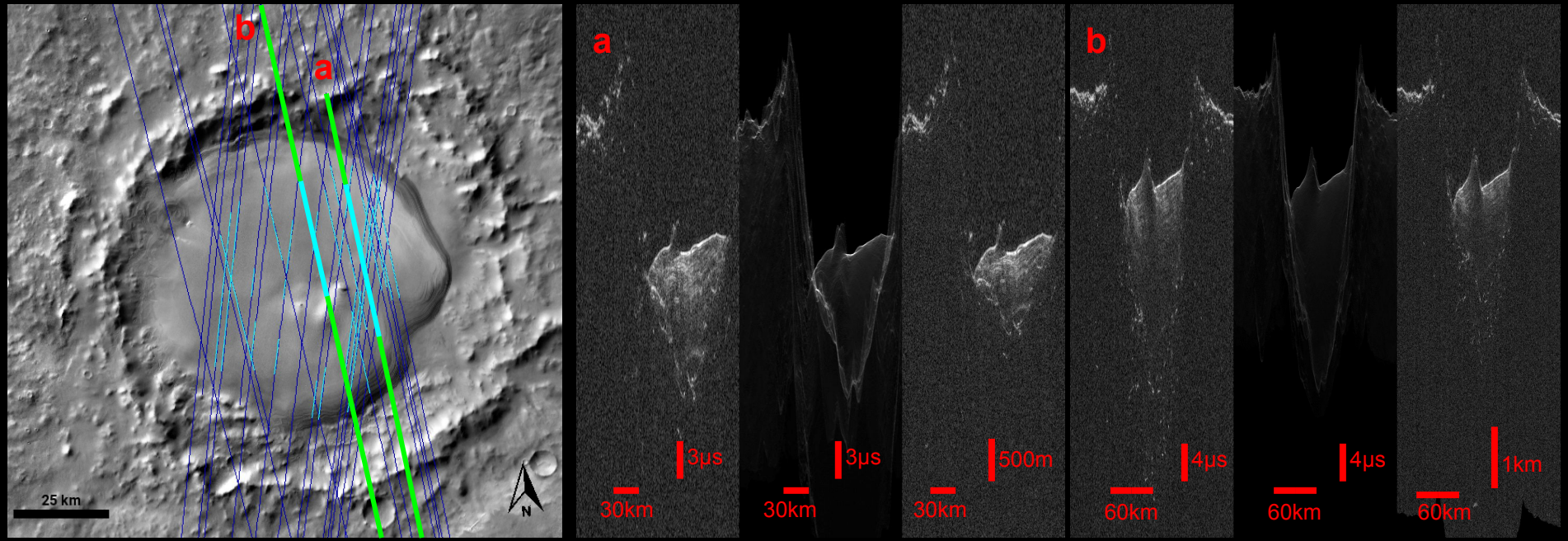
Light blue arrows point at subsurface radar reflectors.

The purple bracket marks the presence of radar fog.

Yellow brackets indicate the presence of a low reflectance zone (LRZ), with the yellow arrows denoting the vertical extent of the LRZ.

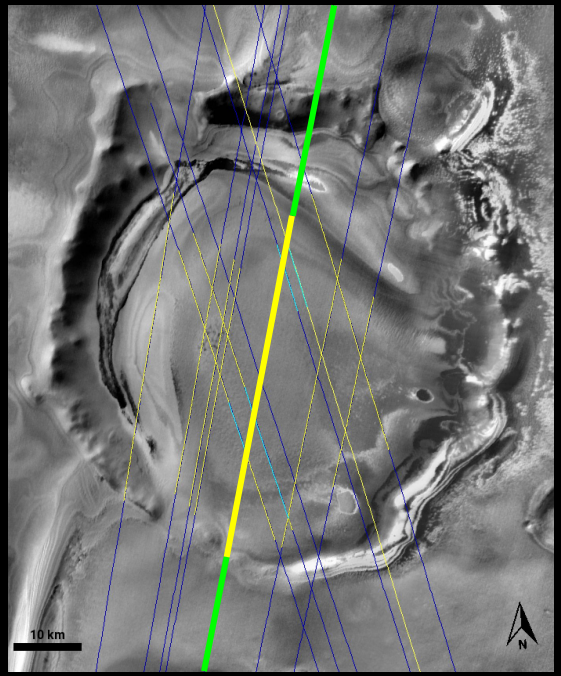
Radargrams

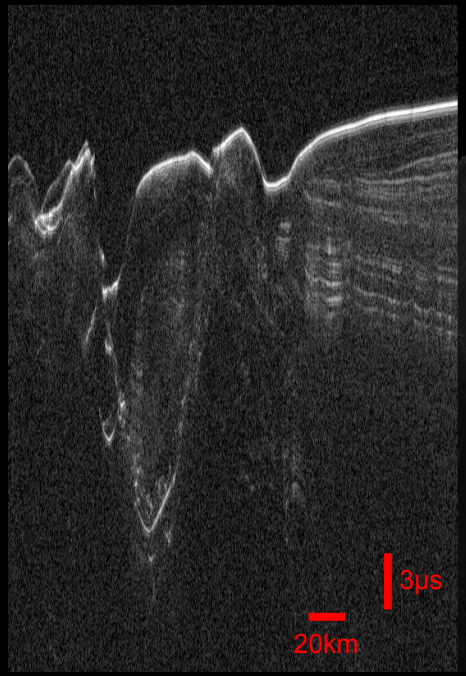
Burroughs crater (south)

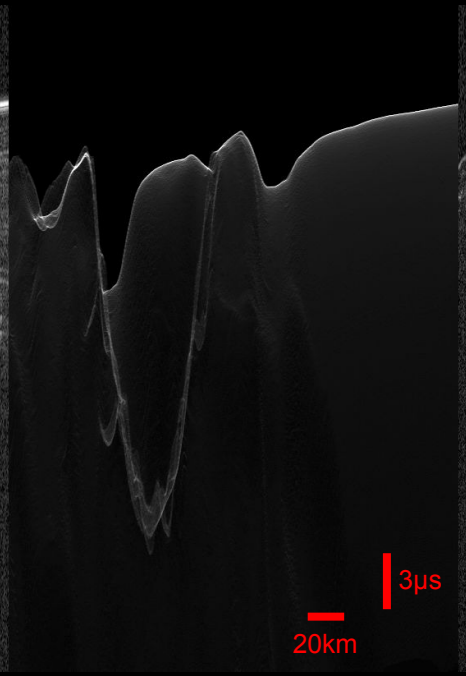


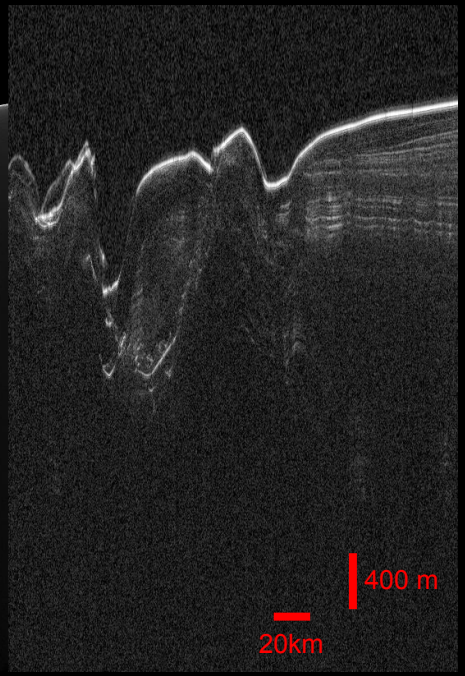
Radargrams

S37 (south)

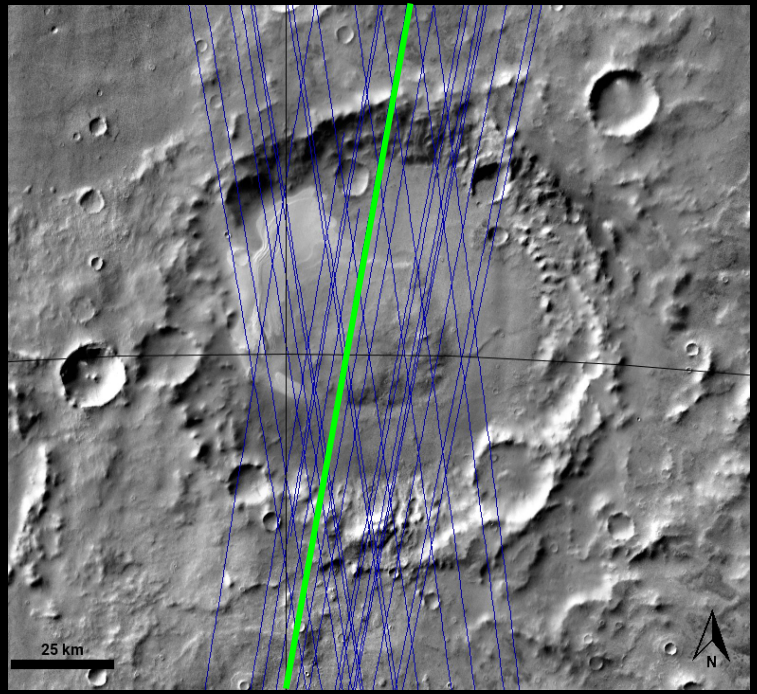


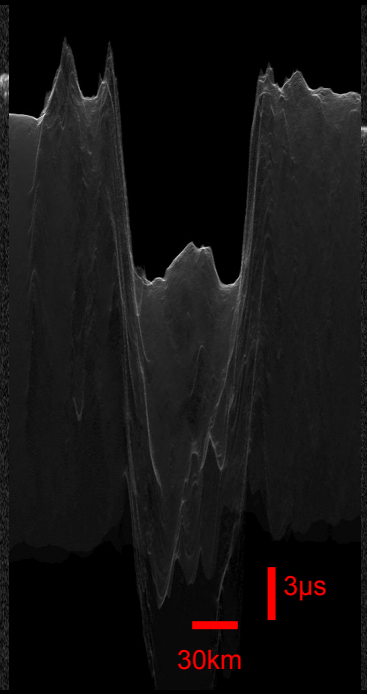


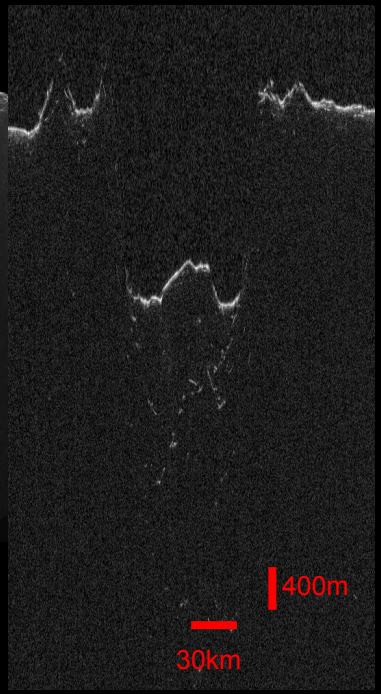




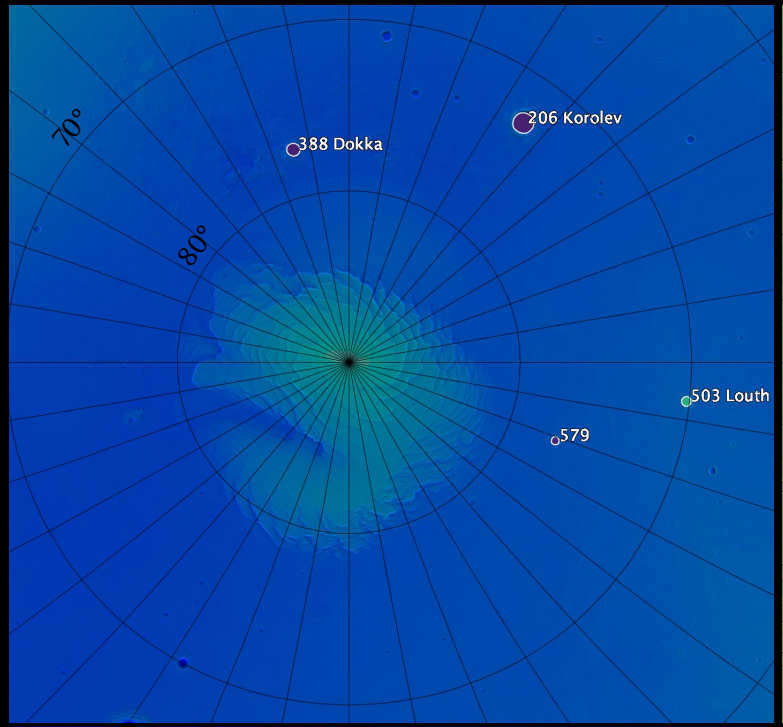
No radar layering – Agassiz crater (South)

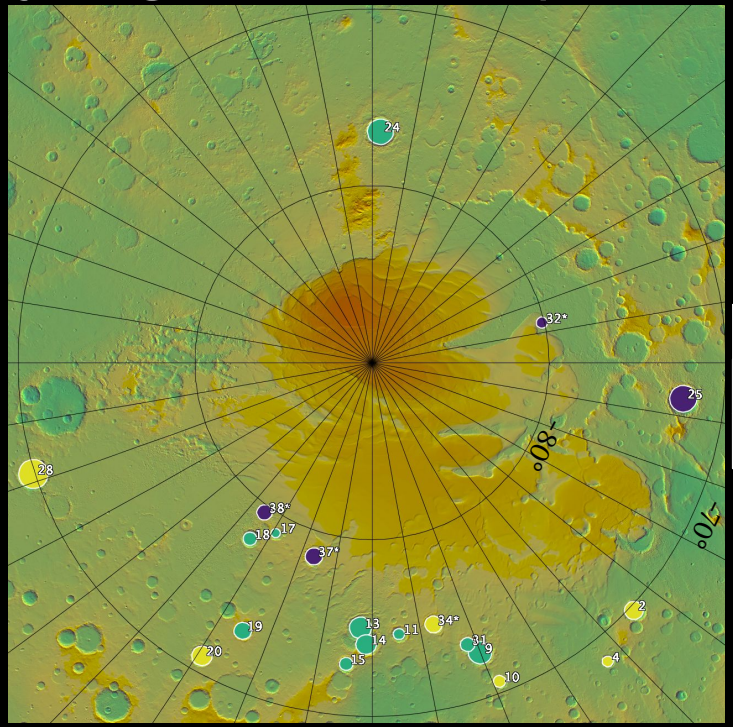






Subsurface layers are present in some, but not all, of the outlying crater deposits.



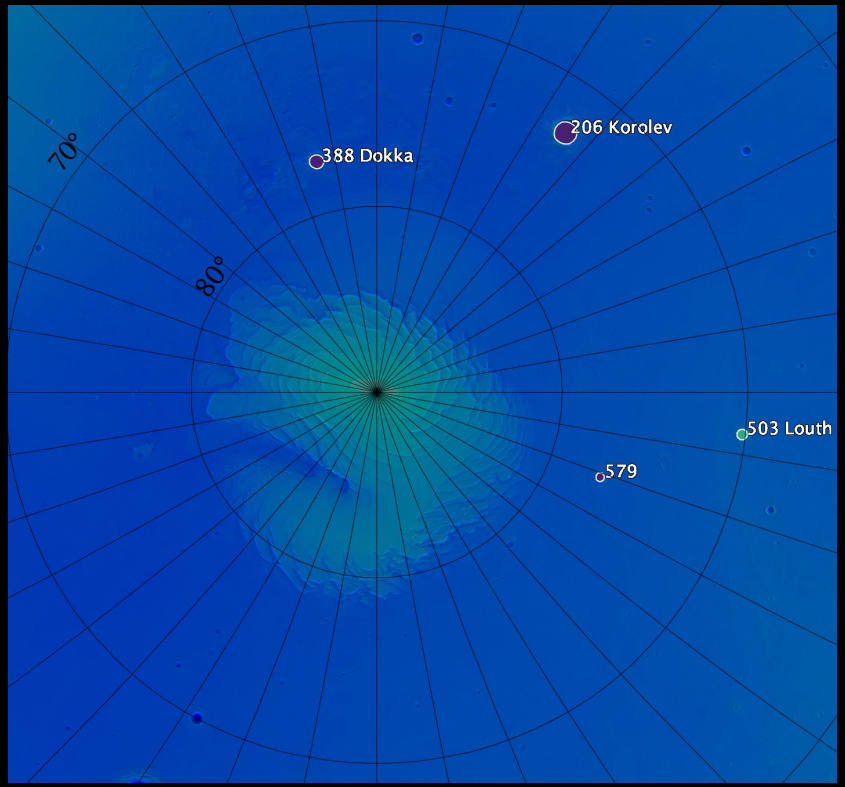


	Surface layers?	Subsurface layers?
	yes	yes
	yes	no
	no	no

North:
: 3 : 1

South:
: 4 : 10 : 6

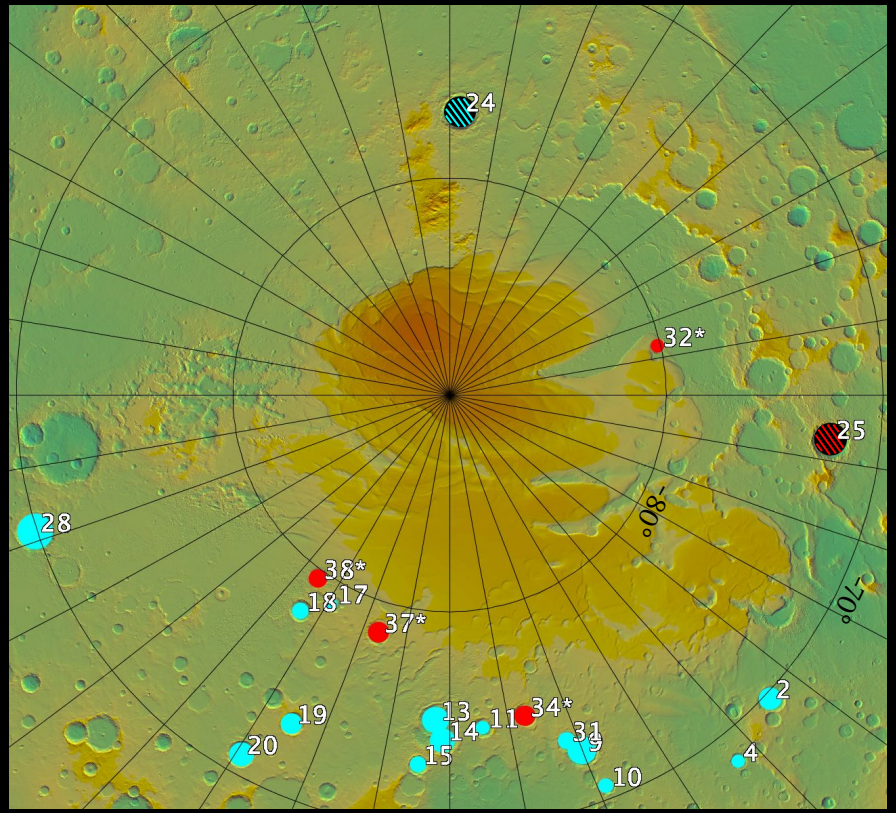
Northern Results



Conway et al. (2012) and Brothers and Holt (2016) propose they are likely NOT a remnant of a past extensive NPLD.

We find that the northern deposits share more common characteristics (clear layers, grouped layer packets, no fog) with the NPLD, so they **may have been emplaced concurrently or at least under similar environmental conditions**

Two groups emerge within the southern crater deposits



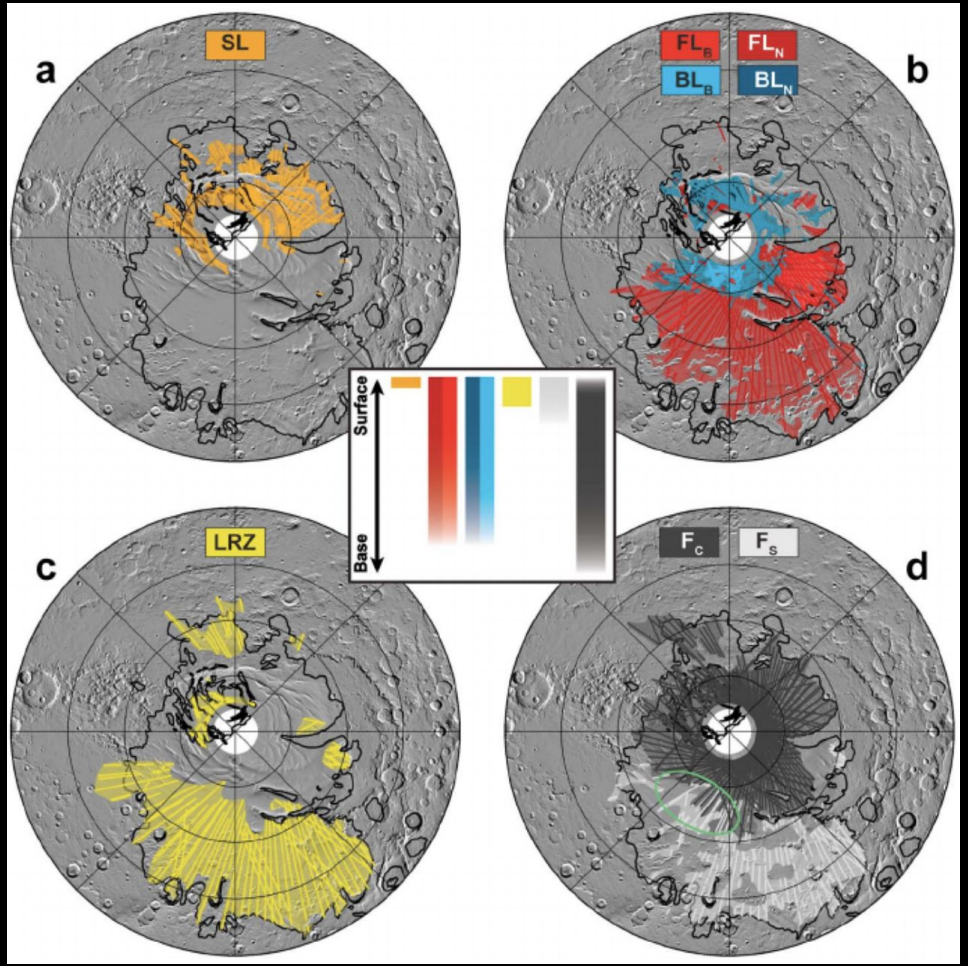
The southern population of outlying crater deposits, colored by deposit group.

The Reynolds cluster group is shown in blue, and the marginal deposit group is shown in red.

The two striped craters, crater 24 (South) and crater 25 (Burroughs) don't fit into either group, but the colored stripes indicate which group they are most similar to.

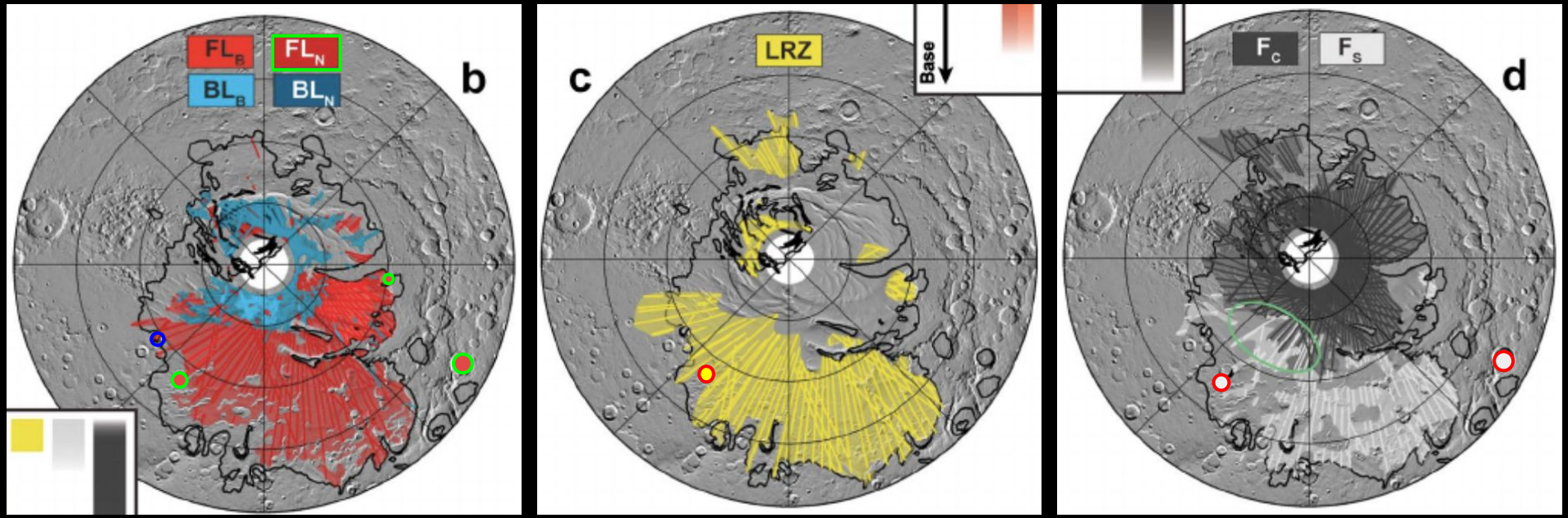
Whitten and Campbell (2018) produced SPLD maps of:

a. Shallow layer facies
b. Focused and blurred layer facies
c. Low reflectivity zones
d. Fogs



Whitten and Campbell (2018), Figure 4

Expanded Whitten and Campbell (2018) Maps



In summary:

We have analyzed a total of **517** SHARAD tracks across **24** craters (>25 km diameter)

- ➔ North: detected subsurface layers in **3** out of 4 crater deposits
- ➔ South: detected subsurface layers in **4** out of 20 crater deposits
  - 3 of these are contiguous with the SPLD

Southern interpretations:

- ➔ The marginal deposits likely formed as part of the SPLD
  - Burroughs crater likely formed under similar environmental conditions
- ➔ The Reynolds group deposits likely do not have a shared depositional history with the SPLD

Northern interpretations:

- ➔ Northern deposits were likely emplaced under similar environmental conditions as the NPLD.