INTERNAL STRUCTURE OF THE NORTH POLAR LAYERED DEPOSITS FROM RADAR SOUNDING

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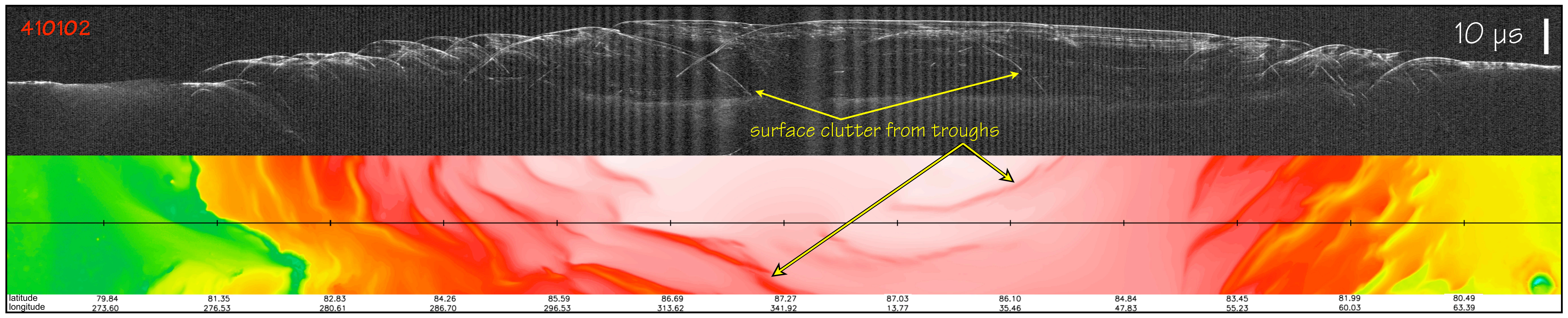
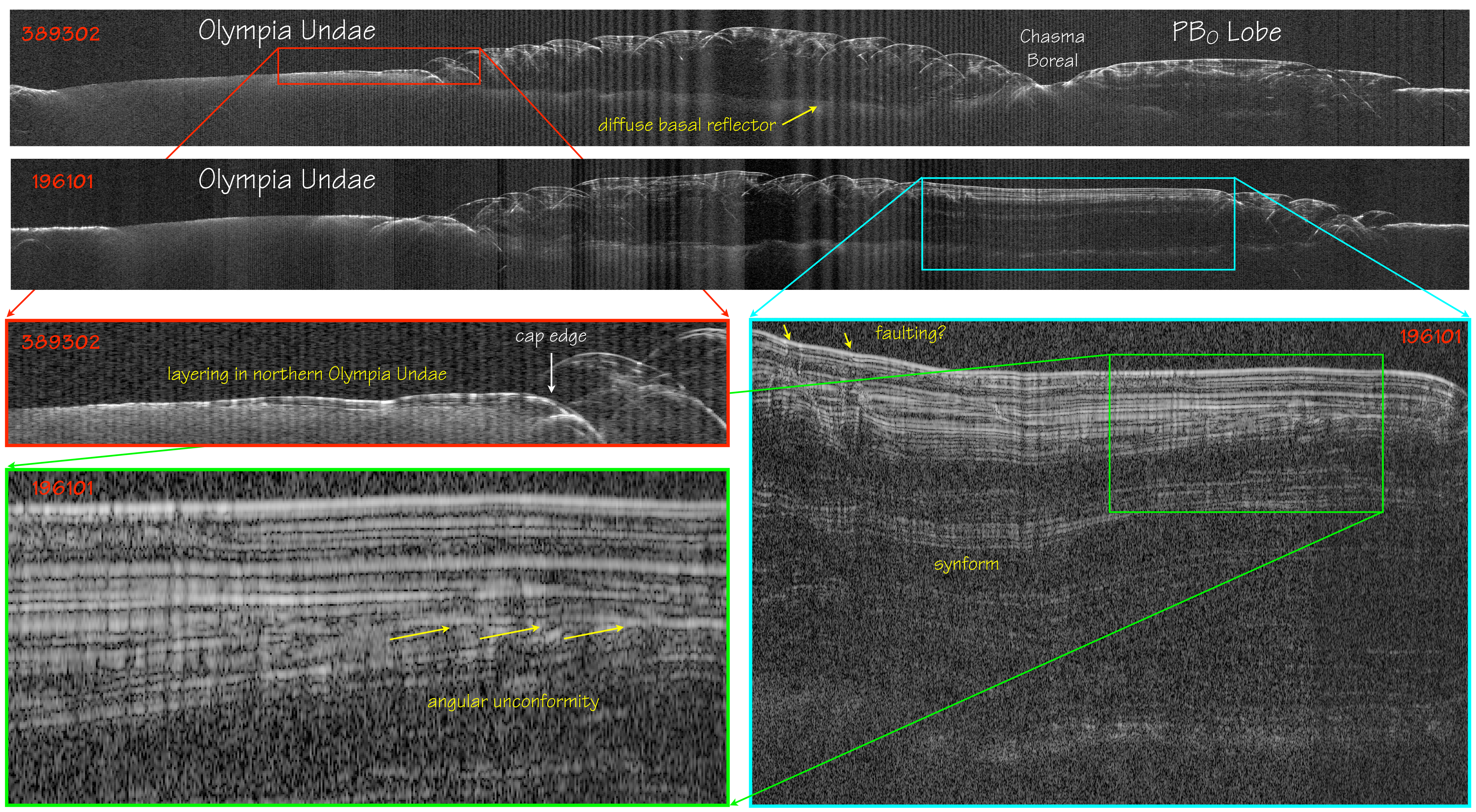
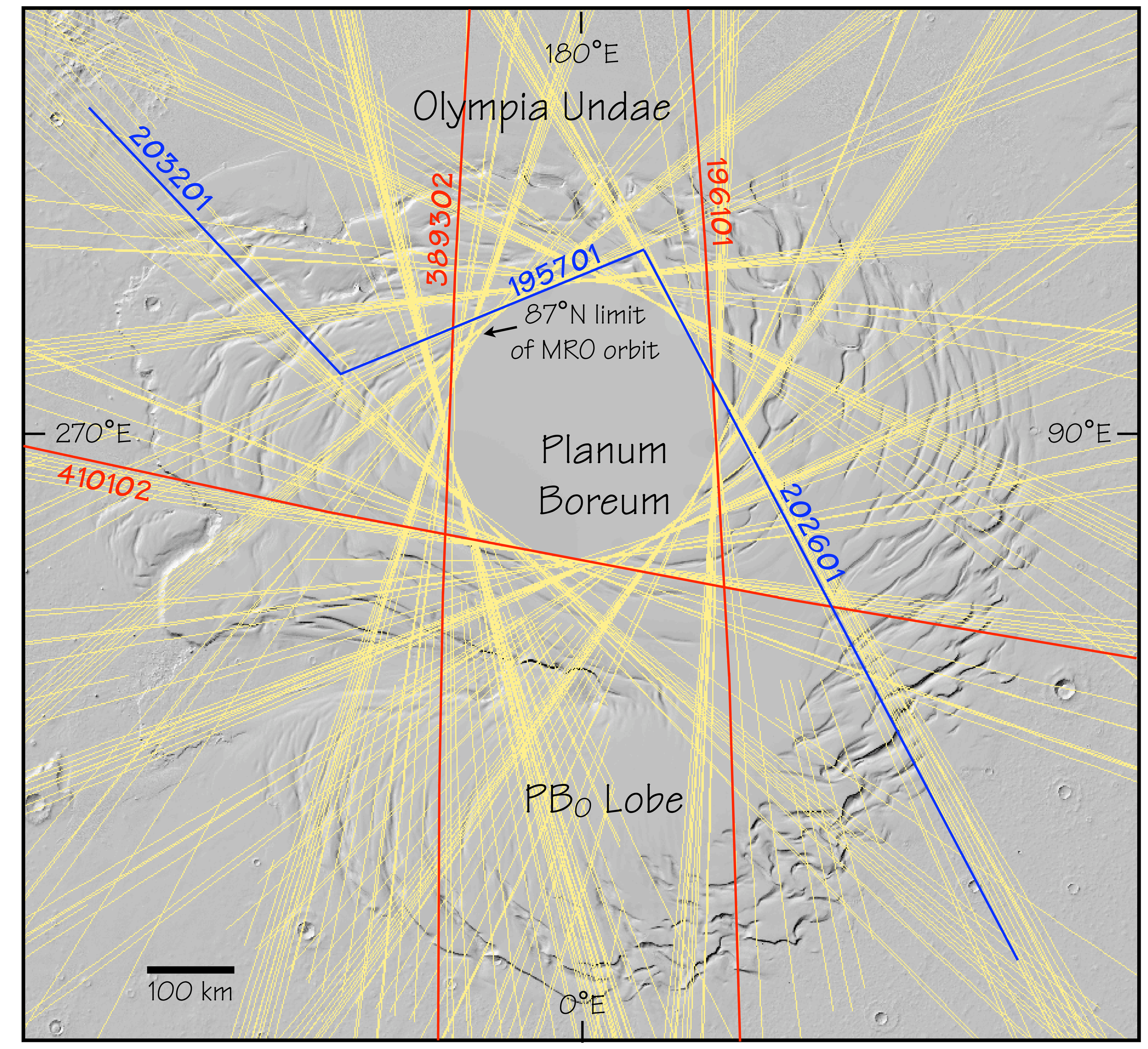
INTRODUCTION

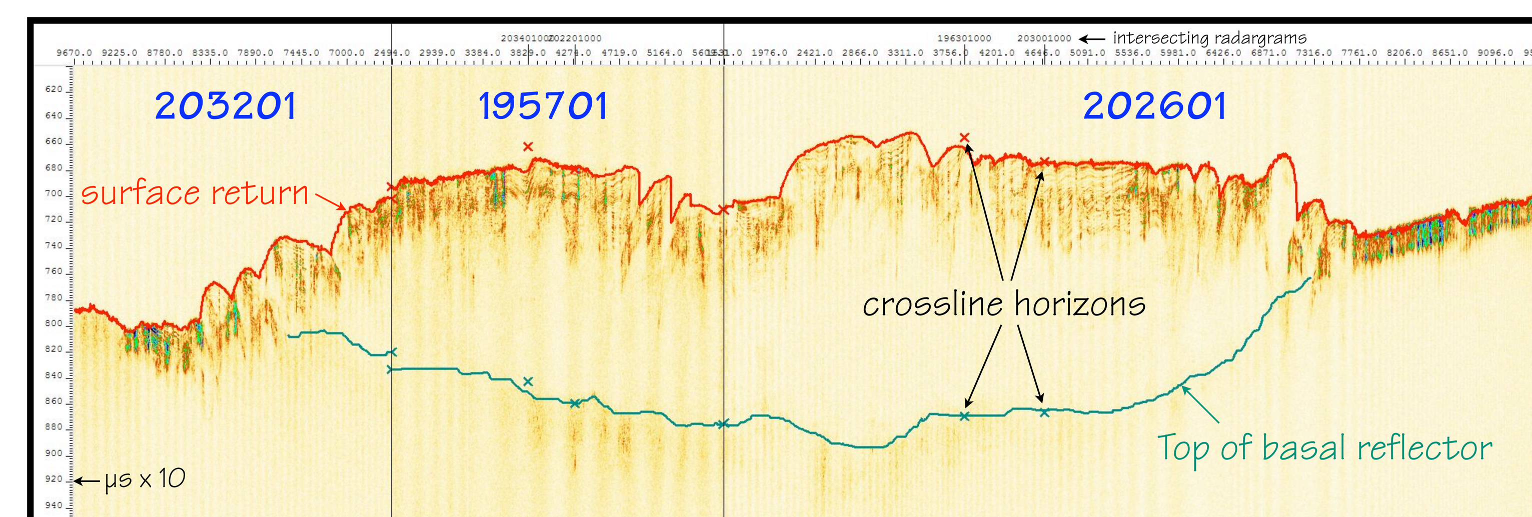
The structure and stratigraphy of polar ices is intimately tied to the history of their formation and its implications for past and present climate (e.g., [1, 2]). Earlier studies of the North Polar Layered Deposits (NPLD) in Planum Boreum (PB) on Mars have provided valuable insight into the nature of these materials [3], but a complete characterization of the layers has been precluded by a lack of subsurface data. Active-source radar instruments recently e in orbit around Mars are now providing direct information about subsurface electrical properties—the contrasts of which typically correspond to geological interfaces—to depths of several kilometers. The Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) onboard the Mars Express (MEX) spacecraft provided the first direct look into the martian subsurface, and observations over the NPLD showed strong radar returns that likely delineate the base of the deposits [4]. MARSIS yields a limited number of radar returns internal to the NPLD, which may prove to correspond to boundaries between major packages of layering within the deposits. In the Fall of 2006, the Shallow Radar (SHARAD) instrument onboard the Mars Reconnaissance Orbiter (MRO) began to acquire additional, higher frequency subsurface data in the polar regions, and the results show many more details within the NPLD, allowing a more direct comparison of image-based geologic interpretations with radar sounding results [5].







SHARAD coverage map for Planum Boreum (2007 June 23)

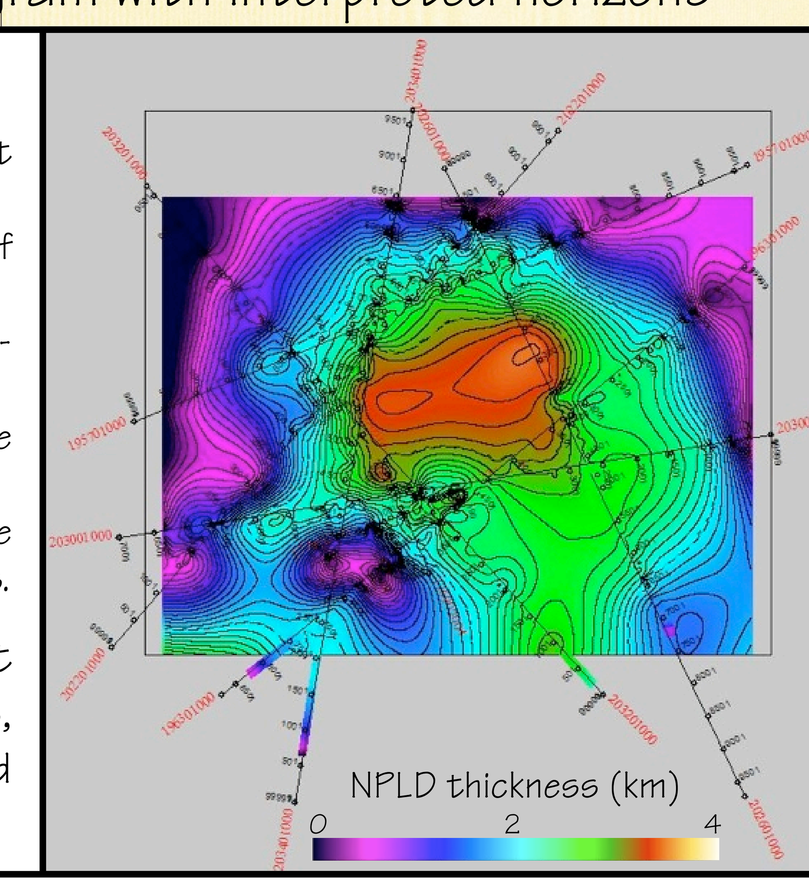


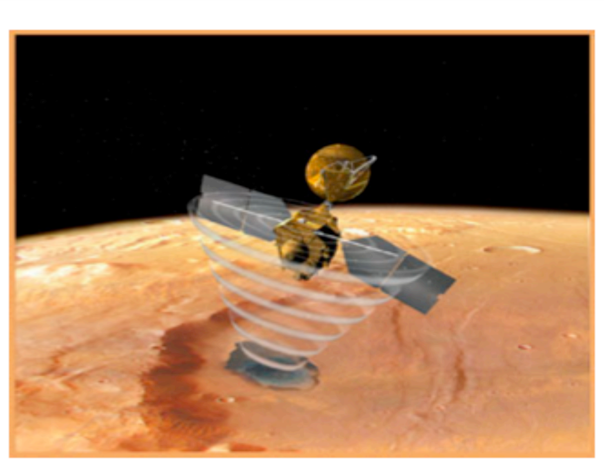
Multi-segment radargram with interpreted horizons

Interpretation method:

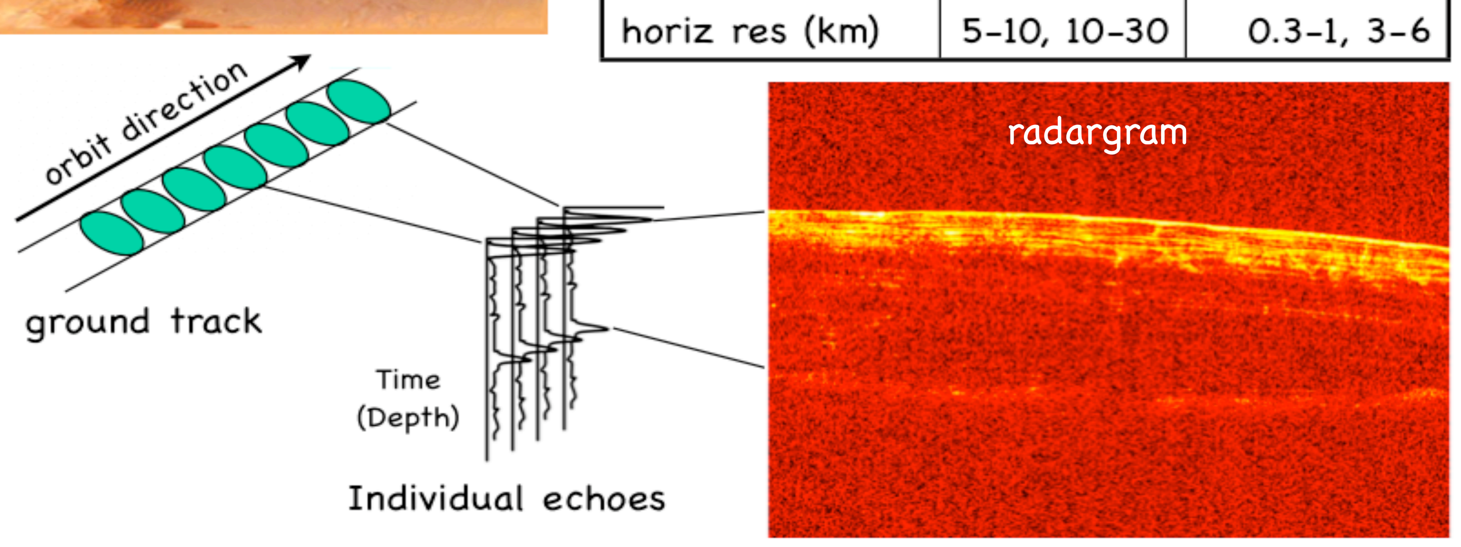
- Convert radargrams to SEG-Y format and load into SeisWare™ software;
- Adjust the relative timing and power of radargrams using grid balance tools;
- Interpret horizons and faults on radargrams using interactive picking tools;
- Grid and map individual horizons in time within a region of interest;
- Use grid calculator to difference time maps and convert to depth or thickness.

The NPLD thickness map at right was created using 9 radargrams, with a constant velocity assumed for the NPLD materials.





	MARSIS	SHARAD
orbit (km)	265-11550	255-320
center freq (MHz)	1-5	20
bandwidth (MHz)	1	10
chirp pulse (μs)	30, 250	85
pulse rate (Hz)	127	700
horiz res (km)	5-10, 10-30	0.3-1, 3-6



Radar sounding from orbit at Mars

RESULTS

- Near-basal reflections corresponding to those seen in MARSIS results support the assertion by Picardi et al. [4] that the NPLD materials must be cold and low-loss (and therefore relatively pure ice). However, the SHARAD returns are more diffuse and even absent in some areas where MARSIS sees strong, coherent reflections [5].
- Distinct, internal packages of laterally continuous reflectors can be traced throughout the NPLD. Some reflectors correlate to layered units identified in surface images, including the contact between the Apl and BU units ([7, 8]; see Phillips et al. [5], this conference).
- Shallow subsurface reflections extend beyond the primary residual cap edge approximately 1/3 of the way across the Olympia Undae region. These may represent residual BU deposits, ice-cemented layers within reworked dune-forming materials, or ice layers that formed relatively recently.
- Chasmata and troughs disrupt the radar returns, complicating interpretation, but elsewhere the NPLD surface is uninterrupted and allows a more cogent analysis. For example, SHARAD observation 196101 crosses the topographic saddle between the main cap and the PB$_0$ lobe and exhibits the following features:
    - An apparent angular unconformity separating an upper package of strong, laterally continuous near-surface reflectors that are conformal with the surface from a lower series of dipping reflectors. The unconformity may represent a major climatological shift or event [6, 9], where an earlier period of net loss through erosion or ablation was followed by a more recent period of net accumulation.
    - Poleward of the unconformity and at greater delay times, an increase in the concavity of the reflecting horizons at intermediate times ("synform" in blue box) occurs. Above these and slightly more poleward, aligned discontinuities in the dip angle and power of shallow reflectors likely represent faulting. These features may represent structural deformation within the NPLD.

REFERENCES: [1] Morse et al. (1998) *GRL 25(17)*, 3383-3386. [2] Welch B. C. and Jacobel R. W. (2003) *GRL, 30(8)*, 1444. [3] Fishbaugh K. E. and Head III J. W. (2005) *Icarus 174*, 444-474. [4] Picardi G. et al. (2005) *Science, 310*, 1925–1928. [5] Phillips R. J. et al. (2007) *7th Int. Mars Conf.* [6] Clifford S. M. et al. (2000) *Icarus 144*, 210-242. [7] Byrne and Murray (2002) *JGR 107(E6)*, 5044. [8] Fishbaugh and Head (2005) *Icarus 174*, 444-474. [9] Laskar J. et al. (2004) *Icarus 170*, 343-364.