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AN ANALYSIS OF MARSIS RADAR FLASH MEMORY DATA FROM LUNAE PLANUM, MARS: SEARCHING FOR SUBSURFACE STRUCTURES

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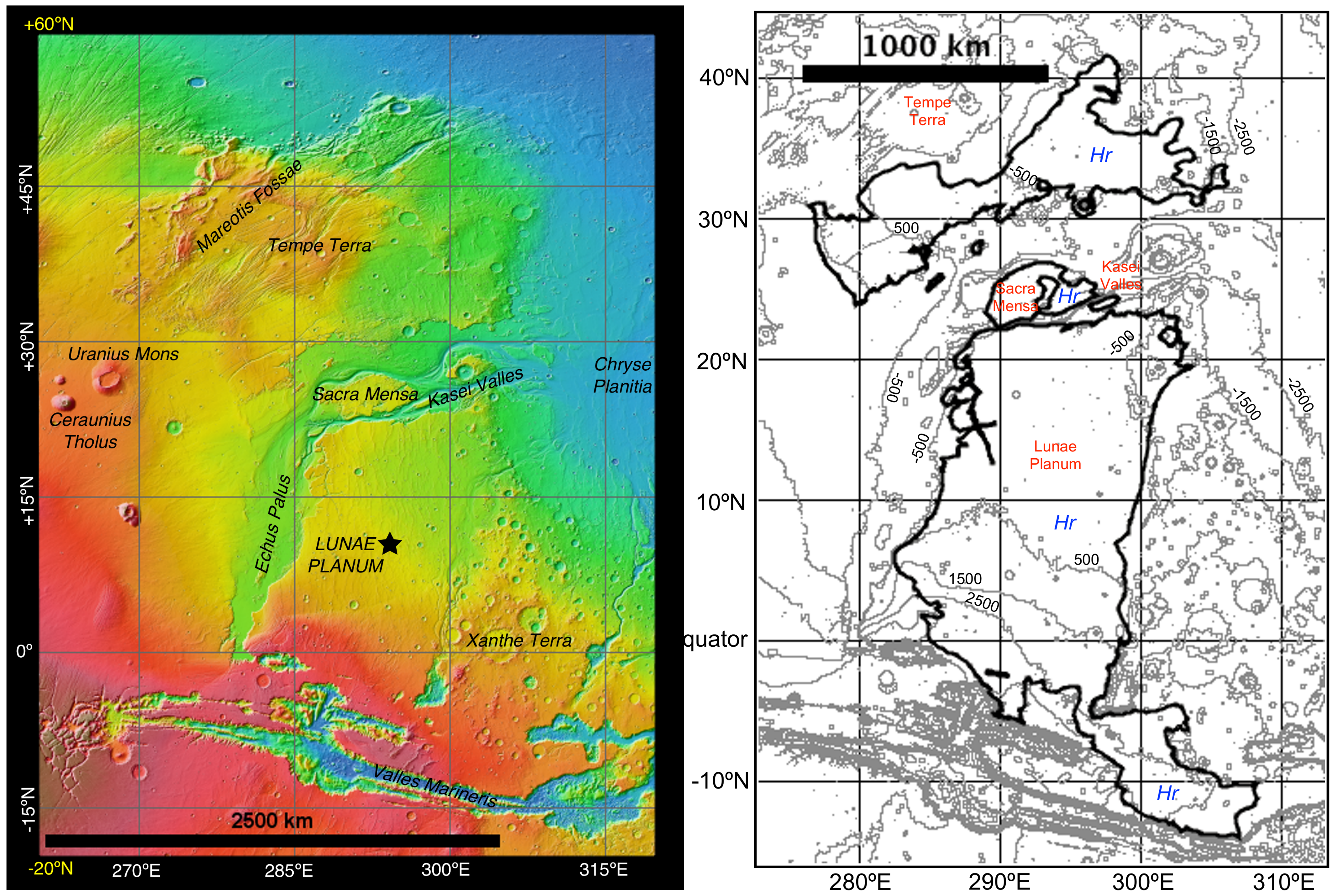
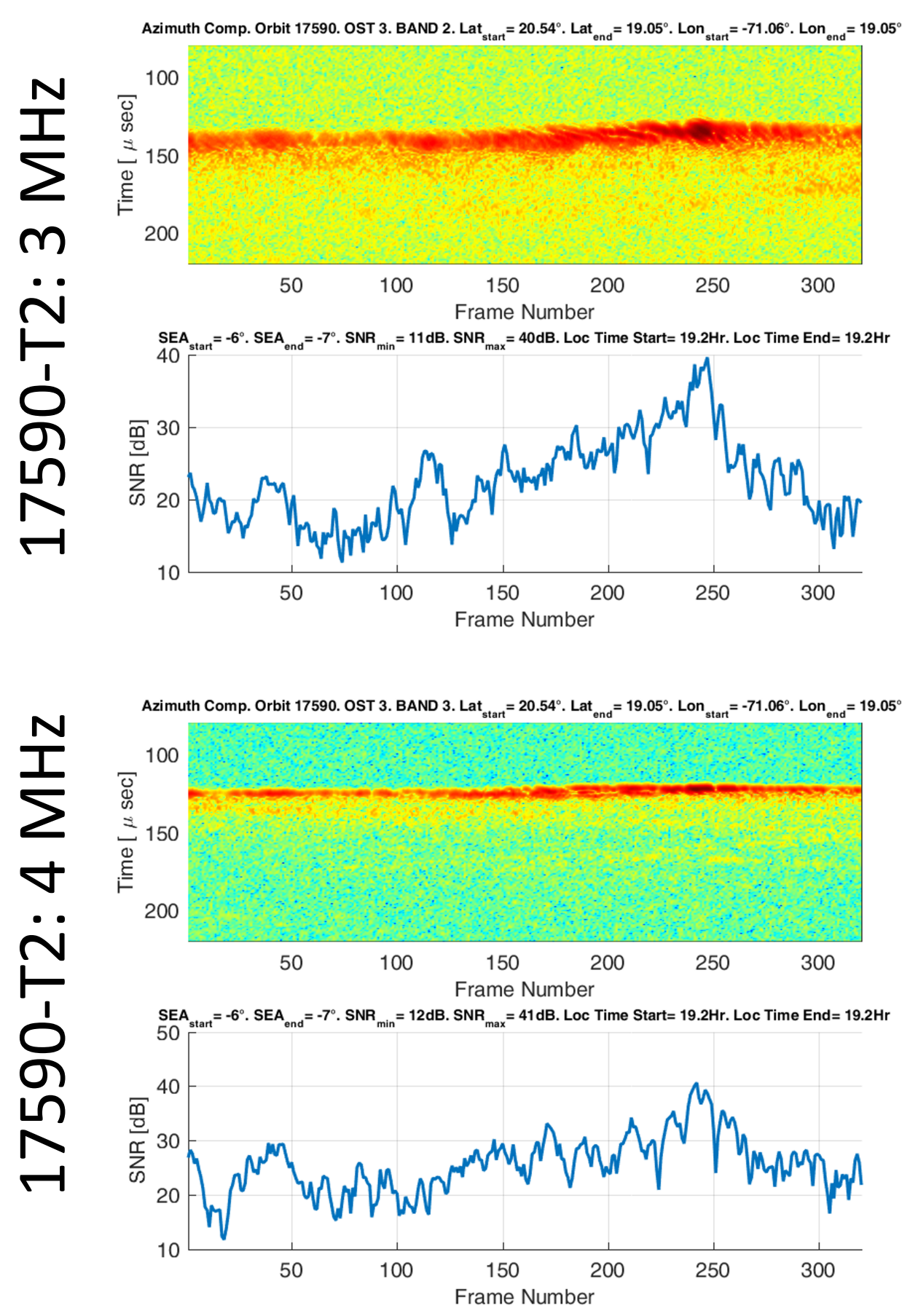
INTRODUCTION. We report the results of our study of Lunae Planum, a Martian plain centred at coordinates 294°E - 11°N, bounded by (Fig. 1) Echus Palus (west), Sacra Mensa and Kasei Valles (north), Xanthe Terra (east), and the northernmost chasmata of Valles Marineris (south). The planum is one of several provinces located between the southern highlands and the northern plains, that are transitional in character by age, elevation, and morphology. Overall, Lunae Planum appears to be morphologically uninteresting when compared to other geological features in the region. The presence of wrinkle ridges, grabens and impact craters with fluidised ejecta all over the plain however, indicates that Lunae Planum had a complex geological history, further evidence of which is likely buried under the surface. To obtain information about the nature of subsurface materials and the presence of subsurface structures, we have processed data from the Mars Express (MEX) Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS), which has been operating on board Mars Express since 2005. Through the duration of its mission, the sounder acquired hundreds of orbits over the approximately 1,500,000 km^2 areal extent of Lunae Planum. We processed 36 orbits in standard mode, but found no obvious reflectors, which we interpreted to indicate that: (a) similar material, or materials with similar values of dielectric constant (ε), form Lunae Planum at all depths of penetration of the radar signal; and/or (b) porous lithologies compaction by overburden pressure affect the ε values [1]. Here we provide preliminary results of additional processing on some selected orbits for recently acquired super-frame (SF) data. We are also analysing available Mars Reconnaissance Orbiter SHAllow RADar (SHARAD) orbits over tracts of interest.

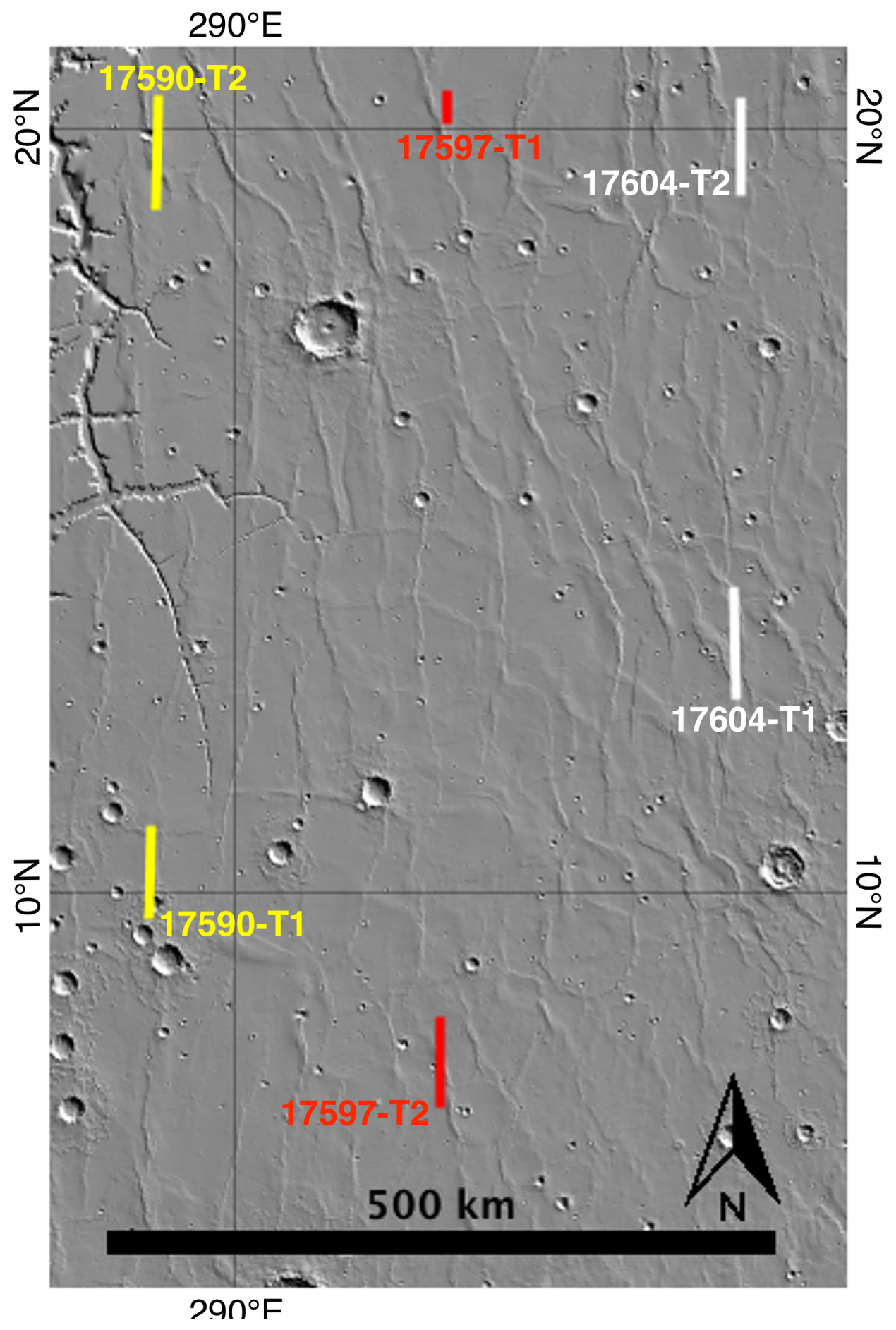


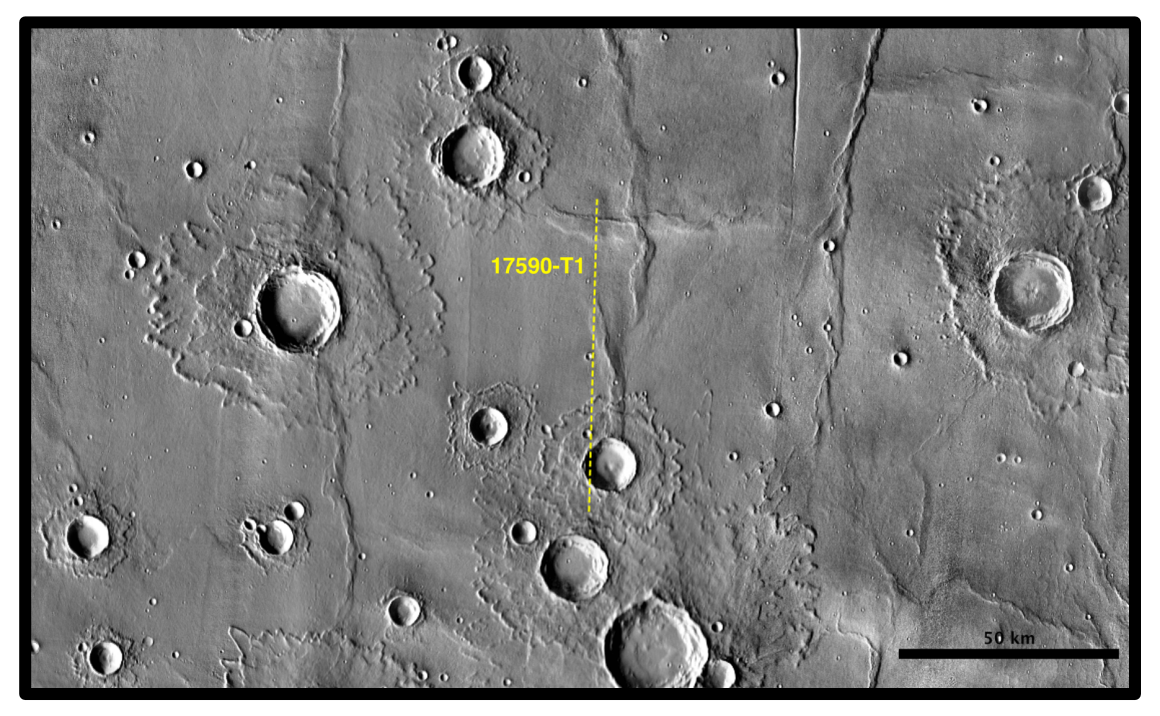
1. GEOLOGIC CONTEXT. Geographic and geologic setting of Lunae Planum, shown in the map on the left in relation to other major morphological features (labeled): Valles Marineris, Echus Palus, Sacra Mensa, Kasei Valles, Xanthe Terra, Chryse Planitia, Tempe Terra, Mareotis Fossae, Uranius Mons, and Ceraunius Tholus. The map on the right shows the extent of the Hesperian unit *Hr* (ridged plains material) after [2]. The contour lines (contour interval: 1000 m) overlain were calculated from MOLA gridded data (resolution: 463 m/pixel). Maps and figures were prepared using a combination of JMARS, QGIS, and Acorn software.

2. ACQUISITION OF NEW DATA. We conducted an initial search for geological features (e.g., wrinkle ridges, layered ejecta craters) that would suggest the presence of structures or geological discontinuities at depth and searched the MARSIS data archives for uncompressed data stored in on-board flash memory [3] over the areas of interest. We found 30 orbits with flash memory data. Given the discontinuous nature of flash memory tracks, however, we obtained no direct match with the specific locations identified for geological investigation. We therefore planned the acquisition of new data using the super-frame (SF) (continuous) mode along selected tracts of orbits 17590, 17597, and 17604, due to fly over Lunae Planum during the period Nov 20 – Nov 30, 2017. Technical constraints exist: the SF tracts must be < 100 km in length, there needs to be a gap of at least 240 km between two consecutive tracts, and the sun elevation angle (SEA) must be sufficiently high to ensure a large value of signal to noise ratio (SNR). Thus only two tracts were acquired per each orbit at band 2 (3 MHz) and band 3 (4 MHz).

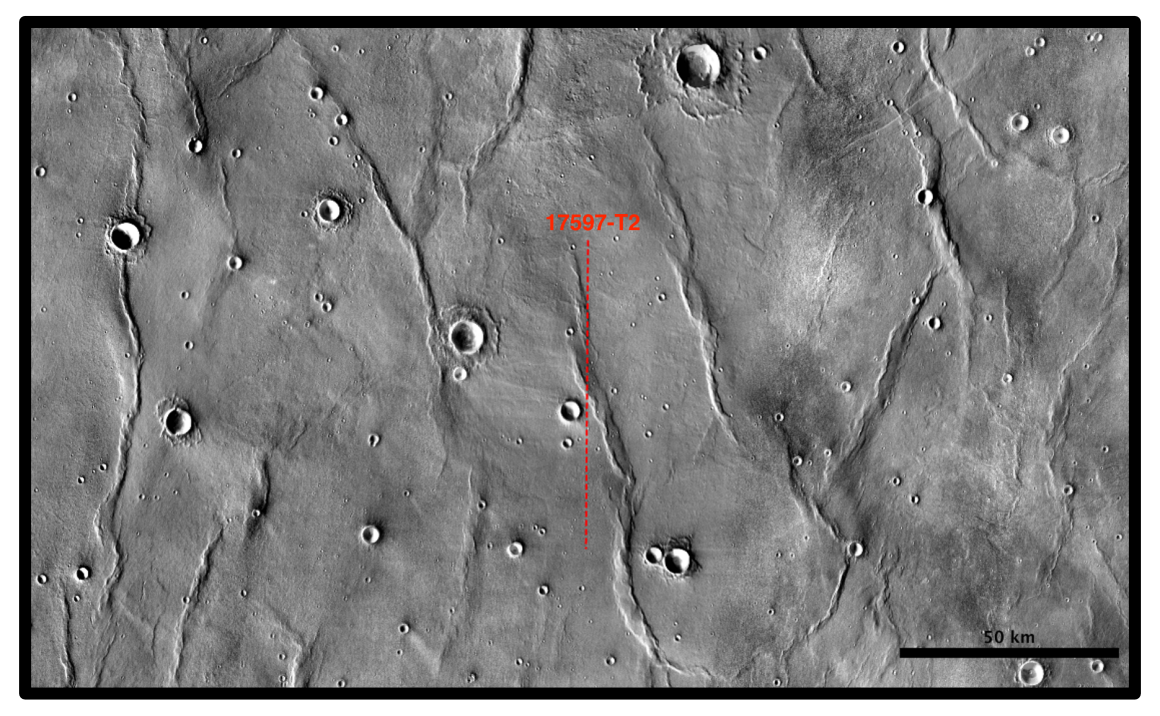
3. RESULTS. Super-frames were acquired on MEX-MARSIS orbits 17590 (yellow tracts on the context map), 17597 (red tracts) and 17604 (white tracts). Band 2 (3 MHz) and band 3 (4 MHz) radargrams are shown with their respective SNR profiles.

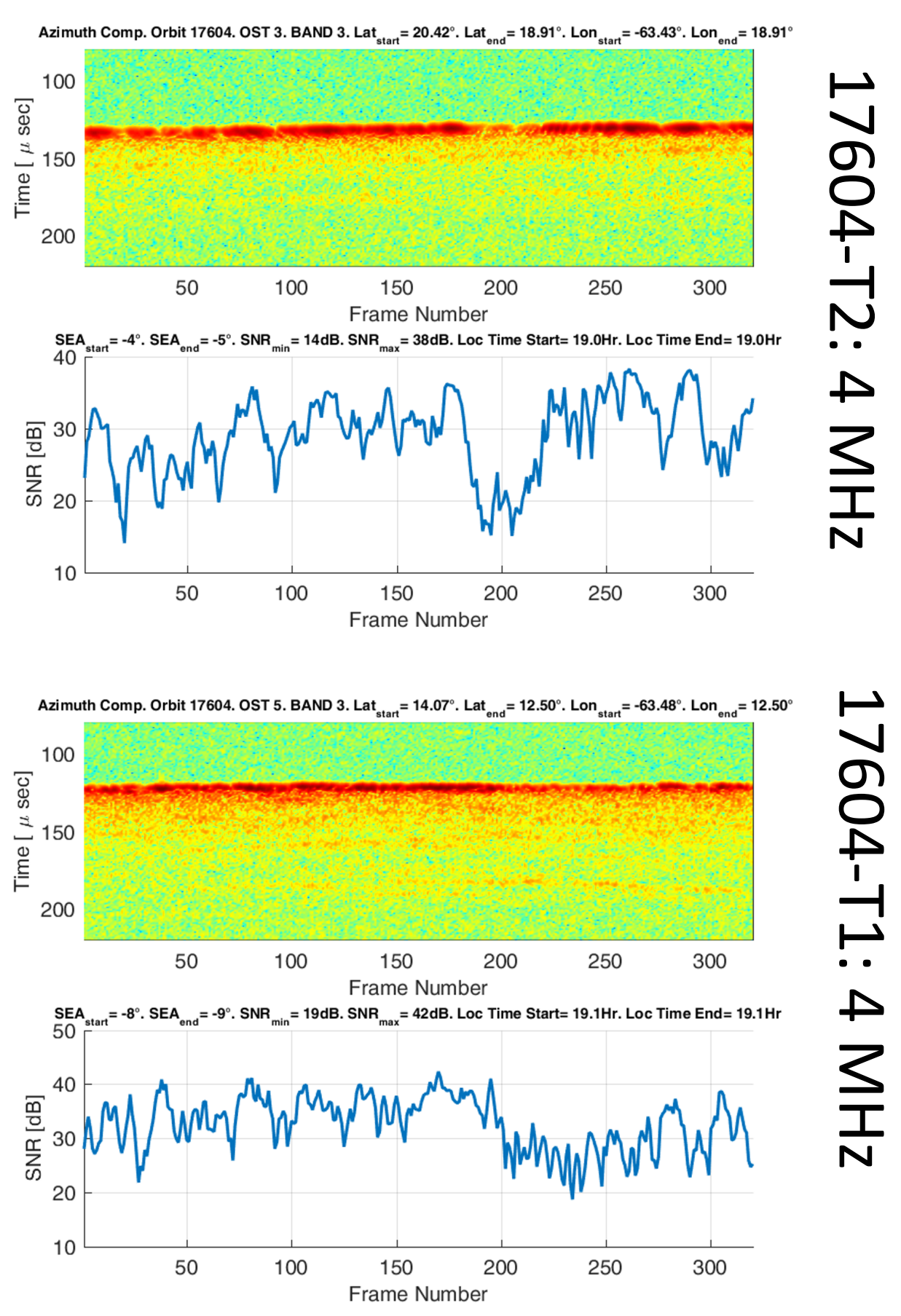


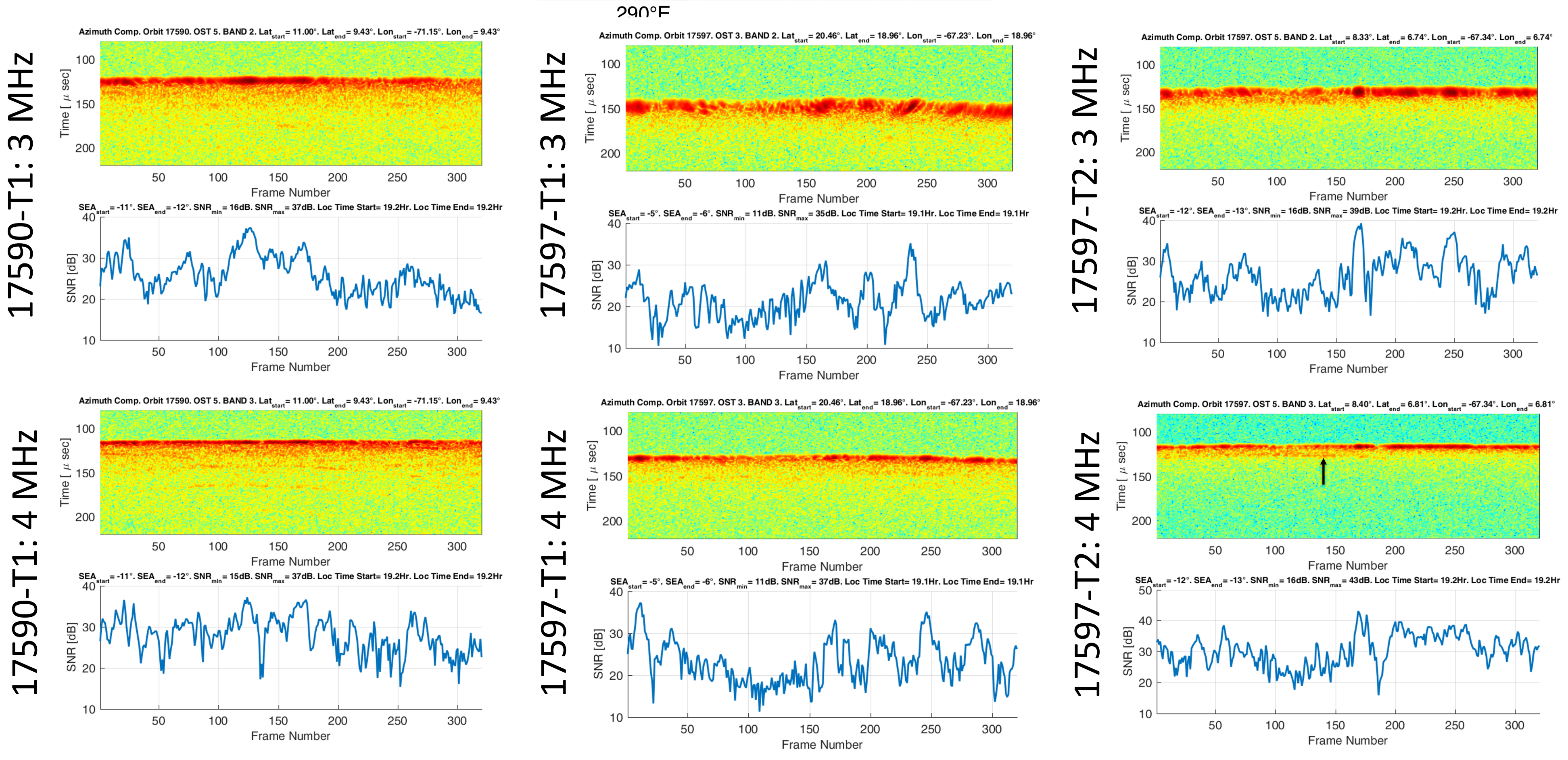




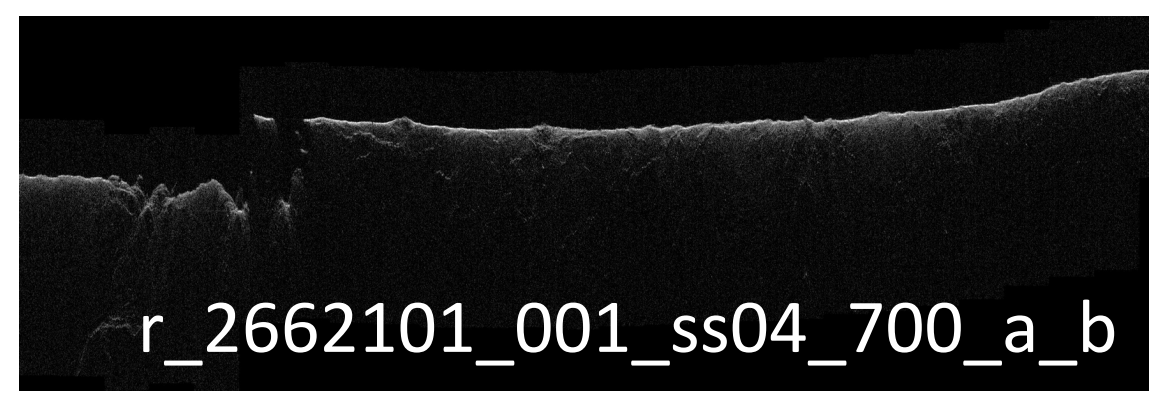
THEMIS daytime infrared view of areas surrounding SF tracts with possible reflectors.



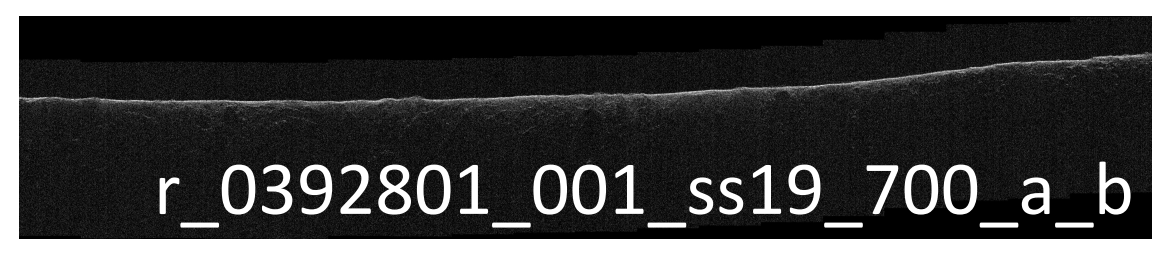




4. RESULTS. Examples of SHARAD radargrams acquired over Lunae Planum.

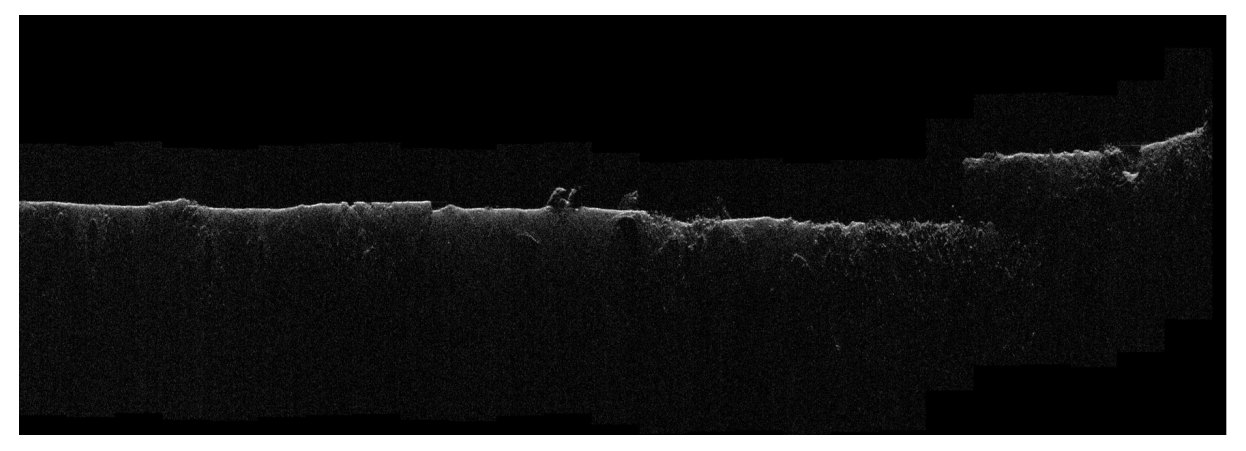


r_2662101_001_ss04_700_a_b



r_0392801_001_ss19_700_a_b

5. RESULTS. SHARAD radargram along same tract as 17597-T2.



r_2647502_001_ss04_700_a_b

6. PRELIMINARY INTERPRETATION. The new SF data are shown in RESULTS as standard radargrams. Simulations for surface clutter will be carried out later in December 2017 (and are therefore not presently available). Thus, even though there appear to be some recognizable reflectors in all radargrams, we refrain from any interpretation at this stage. An example of subsurface echo, particularly evident in band 3 (4 MHz), is shown by the black arrow in MARSIS orbit 17597-T2. This corresponds to a time delay of 11 μs. If additional processing confirms the time offset to correspond to subsurface echoes, then, assuming a putative value of $\varepsilon = 8$ (basalt [4]), this would indicate a reflector at a depth of 580 m in this location.

7. CONCLUSION. We have shown the current state of our ongoing investigation of Lunae Planum subsurface by ground penetrating radar. Our previous analysis of standard MARSIS radargrams revealed no reflectors [1]. We have now acquired new flash memory data in continuous mode (SF) along 6 tracts covering features of geological interest. While we need to carry out additional processing of the data (including surface clutter simulations), the SF radargrams show distinct time delayed echoes not previously recognized. We are complementing MARSIS SF data with SHARAD data as a way to validate possible interpretations for subsurface reflectors and to reveal additional shallower features should these be detectable. The ultimate goal of the study is to link surface morphologies, such as wrinkle ridges, to subsurface structures and to identify significant additional geophysical discontinuities.

References. [1] Caprarelli G. et al. (2017) *LPSC* **48**, # 1720. [2] Skinner J.A. et al. (2006) *LPSC* **37**, # 2331. [3] Watters T.R. et al. (2017) *LPSC* **48**, # 1693. [4] ElShafie A., Heggy E. (2012) *LPSC* **43**, # 2790.